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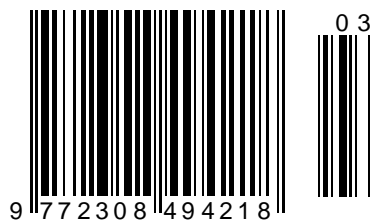
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THE INFLUENCE OF THE CUTTING TOOL GEOMETRY ON THE INTENSITY OF SHEAR STRESS OF THE BLANK MATERIAL

Abstract: The results of computer modeling the cutting process of the metal blank with cutters with different geometry are presented in the article. Cards were formed for the calculation file with the specification of materials properties of the cutting tool and the blank, conditions of the cutting process and other modeling parameters. Recommendations for the choice of the cutter geometry, taking into account calculated minimum shear stress of the blank material were given.
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Introduction

The cutting tool geometry affects the quality and accuracy of the machined blank. The cutting tool must have high strength by reducing the values of the rake and clearance angles during rough machining. However, this leads to an increase in the cutting force and vibrations of the blank and the cutting tool. Cutting edges of the tool must have rounding during finish machining. This geometry of the cutting tool ensures that the requirements for manufacturing the part according to the drawing are met in combination with the low feed speed and the high cutting speed.

On the example of planing, studies were carried out in the works [1-2]. The plastic strain coefficient, the temperature in the cutting zone, internal stresses of material and their effect on the destruction of the steel blank were determined after modeling the process. The material destruction with the generation of significant heat (for example, turning) was described in the works [3-10].

Modeling the dynamics of the cutting process of the metal blank of medium hardness with the planing cutters with the different cutting part geometry will allow you to determine the stress and strain state of deleted material and choose the most optimal option that reduces vibrations of the machine-device-tool-part system.

Materials and methods

The computer experiment was performed in the LS-DYNA special program. The cutting process of the model of the rectangular steel blank with the models of the cutters with the rake angle of 8 degrees and the clearance angle of 10 degrees was simulated. The radius was not performed at the nose of the cutter model in the first test. In the second and third tests, the nose radii of 5 mm and 10 mm, respectively, were performed on the cutters models. The cutting depth decreased with increasing the nose radius. The calculation of the cutting process was carried out in the three-dimensional formulation to visualize the stress and strain state of material in the entire volume of the blank. The statement of modeling the cutting process of the blank with the cutters is presented in the Fig. 1.
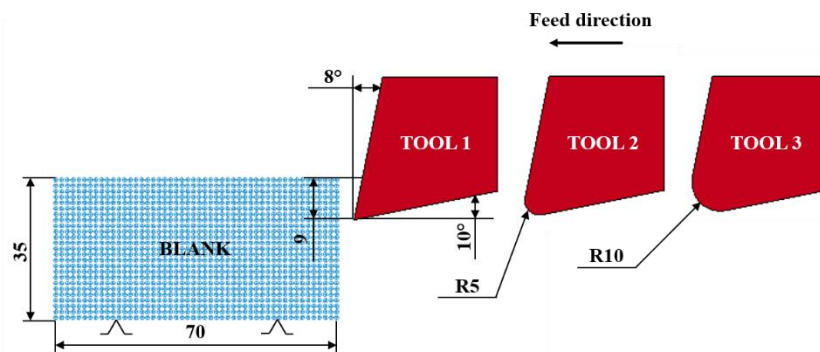
Figure 1 – The statement of the cutting process of the blank.

The calculation was carried out in the conditions as close as possible to the real conditions by setting all the parameters of the cutting process. The accuracy of the obtained results was characterized by the size of the finite element of the models of the blank and the cutter (0.3 mm). The initial conditions for three-dimensional modeling the process of machining the metal blank with the cutters with the different geometry were presented in the special text format, which is demonstrated below.

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*KEYWORD – The keyword, *KEYWORD, flags LS-DYNA that input deck is keyword deck rather than structured format, which has strictly defined format.

*CONTROL_CONTACT – Changing the defaults for computation with contact surfaces.

SLSFAC 0.5 – Scale factor for sliding interface penalties.
RWPNAL 0.0 – Scale factor for rigid wall penalties, which treat nodal points interacting with rigid walls.
ISLCHK 1 – Initial penetration check in contact surfaces with indication of initial penetration in output files. No checking (default).
SHLTHK 0 – Flag for consideration of shell thickness offsets in non-automatic surface-to-surface and non-automatic nodes-to-surface type contacts. Thickness is not considered.
PENOPT 1 – Penalty stiffness value option. Minimum of master segment and slave node (default for most contact types).
THKCHG 0 – Shell thickness changes considered in single surface contact. No consideration (default).

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ORIEN 1 – Optional automatic reorientation of contact interface segments during initialization. Active for automated (part) input only (default).

ENMASS 0 – Flag for treatment of eroded nodes in contact. Eroded node is defined as node that is no longer attached to any element owing to element deletion. Eroded nodes are not considered in contact algorithm.

USRSTR 0 – Storage per contact interface for user supplied interface control subroutine. If zero, no input data is read and no interface storage is permitted in the user subroutine.

USRFRC 0 – Storage per contact interface for user supplied interface friction subroutine. If zero, no input data is read and no interface storage is permitted in the user subroutine.

NSBCS 0 – Number of cycles between contact searching using three-dimensional bucket searches. Using the default value for this field is strongly recommended.

INTERM 0 – Flag for intermittent searching in old surface-to-surface contact using the interval specified (off).

XPENE 4.0 – Contact surface maximum penetration check multiplier. If the small penetration checking option, PENCHK, on the contact surface control card is active, then nodes whose penetration then exceeds the product of XPENE and the element thickness are set free. Set to default which is 4.0.

SSTHK 0 – Flag for determining default contact thickness for shells in single surface contact types. Default contact thickness may be controlled by shell thickness or by shell edge length.

ECDT 0 – Time step size override for eroding contact.

TIEDPRJ 0 – Bypass projection of slave nodes to master surface. Eliminate gaps by projection nodes.

SFRIC 0.0 – Default static coefficient of friction.

DFRIC 0.0 – Default dynamic coefficient of friction.

EDC 0.0 – Default exponential decay coefficient.

VFC 0.0 – Default viscous friction coefficient.

TH 0.0 – Default contact thickness.

TH_SF 0.0 – Default thickness scale factor.

PEN_SF 0.0 – Default local penalty scale factor.

IGNORE 0 – Ignore initial penetrations in the *CONTACT_AUTOMATIC options. The value defined here will be the default. Move nodes to eliminate initial penetrations in the model.

FRCENG 0 – Flag to activate the calculation of frictional sliding energy. Do not calculate.

SKIPRWG 0 – Flag not to display stationary rigid wall by default. Generate 4 extra nodes and 1 shell element to visualize stationary planar rigid wall.

OUTSEG 0 – Flag to determine whether to output each beam spot weld slave node and its master segment for contact type *CONTACT_SPOTWELD into the D3HSP file. Do not write out this information.

SPOTSTP 0 – Flag to determine whether the error termination should occur if the spot weld node or face, which is related to the *MAT_SPOTWELD beam or solid element, respectively, cannot be found on the master surface. No error termination. Silently delete the weld and continue.

SPOTDEL 0 – This option controls the behavior of spot welds when the parent element erodes. Do not delete the spot weld beam or solid element or SPR.

SPOTHIN 0.0 – Optional thickness scale factor. If active, define the factor greater than zero, but less than one. Premature failure of spot welds can occur due to contact of the spot welded parts in the vicinity of the spot weld. This contact creates tensile forces in the spot weld.

ISYM 0 – Symmetry plane option default for automatic segment generation when contact is defined by part IDs.

NSEROD 0 – Flag to invoke old method for ERODING_NODES_TO_SURFACE. Use two-way algorithm (default).

RWGAPS 1 – Flag to add rigid wall gap stiffness. Add gap stiffness.

RWGDTH 0.0 – Death time for gap stiffness. After this time, the gap stiffness is no longer added.

RWKSF 1.0 – Rigid wall penalty scale factor for contact with deformable parts during implicit calculations.

ICOV 0 – Invokes the covariant formulation of Konyukhov and Schweizerhof in the FORMING contact option. Standard formulation (default).

SWRADF 0.0 – Spot weld radius scale factor for neighbor segment thinning. Neighbor segments are not thinned (default).

ITHOFF 0 – Flag for offsetting thermal contact surfaces for thick thermal shells. No offset.

SHLEDG 0 – Flag for assuming edge shape for shells when measuring penetration. Shell edges are assumed round (default).

PSTIFF 0 – Flag to choose the method for calculating the penalty stiffness. Based on material density and segment dimensions (default).

ITHCNT 0 – Thermal contact heat transfer methodology. Set to default which is 1.

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JIF	= **1.500**	**SJIF** (Morocco) = **7.184**		**OAJI** (USA)	= **0.350**

TDCNOF 0 – Tied constraint offset contact update option. Update velocities and displacements from accelerations.

FTALL 0 – Option to output contact forces to RCFORC for all 2 surface force transducers when the force transducer surfaces overlap. Output to the first force transducer that matches (default).

SHLTRW 0.0 – Optional shell thickness scale factor for contact with rigid walls. Shell thickness is not considered.

*CONTROL_ENERGY – Providing the controls for energy dissipation options.

HGEN 2 – Hourglass energy calculation option. This option requires significant additional storage and increases cost by ten percent.

RWEN 2 – Rigid wall energy dissipation option. Energy dissipation is computed and included in the energy balance (default).

SLNTEN 2 – Sliding interface energy dissipation option. This parameter is always set to 2 if contact is active.

RYLEN 2 – Rayleigh energy dissipation option (damping energy dissipation). Energy dissipation is computed and included in the energy balance.

*CONTROL_SOLUTION – Specifying the analysis solution procedure if thermal only or combined thermal analysis is performed.

SOLN 2 – Analysis solution procedure. Combined structural, multiphysics, and thermal analysis.

NLQ 0 – Define the vector length used in the solution. The default vector length is printed at termination in the message file.

ISNAN 0 – Flag to check for the NaN in the force and moment arrays after the assembly of these arrays is completed. No checking.

LCINT 100 – Number of equally spaced points used in curve rediscretization. The minimum number of 100 is always used, that is, only larger input values are possible.

*CONTROL_TERMINATION – Stop the job.

ENDTIM 12.0 – Termination time.

ENDCYC 0 – Termination cycle. Cycle number is identical with the time step number.

DTMIN 0.0 – Reduction (or scale) factor to determine minimum time step.

ENDING 0.0 – Percent change in energy ratio for termination of calculation. If undefined, this option is inactive.

ENDMAS 1.000000E8 – Percent change in the total mass for termination of calculation.

*CONTROL_THERMAL_NONLINEAR – Setting the parameters for the nonlinear thermal or coupled structural/thermal analysis.

REFMAX 100 – Maximum number of matrix reformations per time step.

TOL 0.0 – Convergence tolerance for temperature.

DCP 1.0 – Divergence control parameter. Steady state problems $0.3 \leq DCP \leq 1.0$ default 1.0.

LUMPBC 0 – Lump thermal boundary conditions. Off (default).

THLSTL 0.0 – Line search convergence tolerance. No line search.

NLTHPR 0 – Thermal nonlinear print out level. No print out.

PHCHPN 0.0 – Phase change penalty parameter.

*CONTROL_THERMAL_SOLVER – Setting the options for the thermal solution in the thermal only or coupled structural-thermal analysis.

ATYPE 1 – Thermal analysis type. Transient analysis.

PTYPE 2 – Thermal problem type. Nonlinear problem with material properties evaluated at element average temperature. Iterative conjugate gradients method, diagonally scalable (default).

CGTOL 1.00000E-6 – Convergence error for type 3 and 4 solvers.

GPT 1 – Number of Gauss points to be used in the solid elements. One point quadrature is used.

EQHEAT 1.0 – Mechanical equivalent of heat. Default value 1.0.

FWORK 1.0 – Fraction of mechanical work converted into heat. Use default value 1.0.

SBC 0.0 – Stefan Boltzmann constant. Value is used with enclosure radiation surfaces.

MSGLVL 0 – Output message level. No output (default).

MAXITR 500 – Maximum number of iterations.

ABSTOL 1.0000E-13 – Absolute convergence tolerance.

RELTOL 1.00000E-4 – Relative convergence tolerance.

OMEGA 1.0 – Relaxation parameter omega for SOLVER 14 and 16. Use default value 1.0 for SOLVER 14.

TSF 1.0 – Thermal speedup factor. This factor multiplies all thermal parameters with units of time in the denominator (e.g., thermal conductivity, convection heat transfer coefficients).

*CONTROL_THERMAL_TIMESTEP – Setting the time step controls for the thermal solution in the thermal only or coupled structural/thermal analysis.

TS 0 – Time step control. Fixed time step.
TIP 0.5 – Time integration parameter. Crank-Nicolson scheme.
ITS 0.001 – Initial thermal time step.
TMIN 1.00000E-7 – Minimum thermal time step.
TMAX 0.0139 – Maximum thermal time step.
DTEMP 100.0 – Maximum temperature change in each time step above which the thermal time step will be decreased.
TSCP 0.5 – Time step control parameter.
LCTS 0 – Load curve ID which defines data pairs (thermal time breakpoint, new time step).

*CONTROL_TIMESTEP – Setting the structural time step size control using different options.

DTINIT 0.0 – Initial time step size.
TSSFAC 0.6 – Scale factor for computed time step.
ISDO 0 – Basis of time size calculation for 4-node shell elements.
TSLIMT 0.0 – Shell element minimum time step assignment.
DT2MS 0.0 – Time step size for mass scaled solutions.
LCTM 0 – Load curve ID that limits the maximum time step size (optional).
ERODE 0 – Erosion flag for elements with small time step. Calculation will terminate if the solution time step drops to TSMIN.
MS1ST 0 – Option for mass scaling that applies when DT2MS < 0.
DT2MSF 0.0 – Reduction (or scale) factor for initial time step size to determine the minimum time step size permitted.
DT2MSLC 0 – Load curve for determining the magnitude of DT2MS as the function of time during the explicit solutions phase.
IMSCL 0 – Flag for selective mass scaling if and only if mass scaling active.
RMSCL 0.0 – Flag for using rotational option in selective mass scaling only translational inertia are selectively mass scaled.

*DATABASE_GLSTAT – Global statistics and energies.

DT 0.0 – Time interval between outputs. If DT is zero, no output is printed.
BINARY 0 – Flag for binary output.
LCUR 0 – Optional curve ID specifying time interval between outputs.
IOOPT 1 – Flag to govern behavior of the output frequency load curve defined by LCUR. This is the default behavior.

*DATABASE_MATSUM – Part energies.

DT 0.0 – Time interval between outputs. If DT is zero, no output is printed.
BINARY 0 – Flag for binary output.
LCUR 0 – Optional curve ID specifying time interval between outputs.
IOOPT 1 – Flag to govern behavior of the output frequency load curve defined by LCUR. This is the default behavior.

*DATABASE_RCFORC – Resultant contact interface forces.

DT 0.0 – Time interval between outputs. If DT is zero, no output is printed.
BINARY 0 – Flag for binary output.
LCUR 0 – Optional curve ID specifying time interval between outputs.
IOOPT 1 – Flag to govern behavior of the output frequency load curve defined by LCUR. This is the default behavior.

*DATABASE_BINARY_D3DUMP – Database for restarts. Defining the output frequency in cycles.

CYCL 100000.0 – For D3DUMP and RUNRSF options this field is the number of time steps between output states.
LCDT 0 – Optional load curve ID specifying time interval between dumps.

BEAM 0 – Discrete element option flag. Discrete spring and damper elements are added to the D3PLOT database where they are displayed as beam elements.

NPLTC 0 – DT = ENDTIM/NPLTC.

PSETID 0 – Part set ID.

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*DATABASE_BINARY_D3PLOT – Database for entire model. Control to some extent the content of binary output databases D3PLOT, D3THDT, and D3PART.

DT 0.0 – This field defines the time interval between output states.

LCDT 0 – Optional load curve ID specifying time interval between dumps.

BEAM 0 – Discrete element option flag. Discrete spring and damper elements are added to the D3PLOT database where they are displayed as beam elements.

NPLTC 100 – DT = ENDTIM/NPLTC.

PSETID 0 – Part set ID.

IOOPT 0 – This variable applies to the D3PLOT option only and governs how the plot state frequency is determined from curve LCDT.

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*BOUNDARY_PRESCRIBED_MOTION_RIGID – Defining the imposed nodal motion (velocity, acceleration, or displacement) on the node or the set of nodes.

PID 1 – Prescribed motion set ID to which this node, node set, segment set, or rigid body belongs. This ID does not need to be unique.

DOF 1 – Applicable degrees-of-freedom, x-translational degree-of-freedom.

VAD 0 – Velocity/Acceleration/Displacement flag. Velocity (rigid bodies and nodes).

LCID 1 – Curve ID or function ID to describe motion value as the function of time.

SF 1.0 – Load curve scale factor. Default set to 1.0.

VID 0 – Vector ID for DOF values of 4 or 8.

DEATH 1.00000E28 – Time imposed motion/constraint is removed.

BIRTH 0.0 – Time that the imposed motion/constraint is activated.

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*BOUNDARY_SPC_SET – Defining the nodal single point constraints.

NSID 2 – Node ID or nodal set ID.

CID 0 – Coordinate system ID.

DOFX 1 – Insert 1 for translational constraint in local x-direction.

DOFY 1 – Insert 1 for translational constraint in local y-direction.

DOFZ 1 – Insert 1 for translational constraint in local z-direction.

DOFRX 1 – Insert 1 for rotational constraint about local x-axis.

DOFRY 1 – Insert 1 for rotational constraint about local y-axis.

DOFRZ 1 – Insert 1 for rotational constraint about local z-axis.

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*SET_NODE_LIST_TITLE & *SET_NODE_LIST – Defining the nodal set with some identical or unique attributes.

SID 1 & 2 – Set identification. All node sets should have the unique set ID.

DA1 0.0 – The first nodal attribute default value.

DA2 0.0 – The second nodal attribute default value.

DA3 0.0 – The third nodal attribute default value.

DA4 0.0 – The fourth nodal attribute default value.

SOLVER MECH – Name of solver using this set.

NID1 – Nodal ID 1.

NID2 – Nodal ID 2.

NID3 – Nodal ID 3.

NID4 – Nodal ID 4.

NID5 – Nodal ID 5.

NID6 – Nodal ID 6.

NID7 – Nodal ID 7.

NID8 – Nodal ID 8.

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*CONTACT_AUTOMATIC_NODES_TO_SURFACE_THERMAL_ID – Defining the contact interface in the 3D model.

CID 1 – Contact interface ID.

SSID 1 – Slave segment set ID, node set ID, part set ID, part ID, or shell element set ID.

MSID 1 – Master segment set ID, node set ID, part set ID, part ID, or shell element set ID.

SSTYP 4 – ID type of SSID. Node set ID for nodes-to-surface contact.

MSTYP 3 – ID type of MSID. Part ID.

SBOXID 0 – Include in contact definition only those slave nodes/segments within box SBOXID. SBOXID is not available for ERODING contact options.

MBOXID 0 – Include in contact definition only those master segments within box MBOXID. MBOXID is not available for ERODING contact options.

SPR 0 – Include the slave side in the *DATABASE_NCFORC and the *DATABASE_BINARY_INTFOR interface force files, and optionally in the DYNA in file for wear.

MPR 0 – Include the master side in the *DATABASE_NCFORC and the *DATABASE_BINARY_INTFOR interface force files, and optionally in the DYNA in file for wear.

FS 0.2 – Static coefficient of friction.

FD 0.0 – Dynamic coefficient of friction.

DC 0.0 – Exponential decay coefficient.

VC 0.0 – Coefficient for viscous friction.

VDC 20.0 – Viscous damping coefficient in percent of critical or the coefficient of restitution expressed as percentage.

PENCHK 0 – Small penetration in contact search option.

BT 0.0 – Birth time (contact surface becomes active at this time).

DT 1.00000E20 – Death time (contact surface is deactivated at this time).

SFS 1.0 – Scale factor on default slave penalty stiffness.

SFM 1.0 – Scale factor on default master penalty stiffness.

SST 0.0 – Optional contact thickness for slave surface (overrides default contact thickness).

MST 0.0 – Optional contact thickness for master surface (overrides default contact thickness).

SFST 1.0 – Scale factor applied to contact thickness of slave surface.

SFMT 1.0 – Scale factor applied to contact thickness of master surface.

FSF 1.0 – Coulomb friction scale factor.

VSF 1.0 – Viscous friction scale factor.

CF 0.0 – Thermal conductivity of fluid between the contact surfaces.

FRAD 0.0 – Radiation factor between the contact surfaces.

HTC 4.70000E-5 – Heat transfer conductance for closed gaps.

LMIN 2.0 – Minimum gap.

LMAX 10000.0 – No thermal contact if the gap is greater than this value.

FTOSLV 1.0 – Fraction of sliding friction energy partitioned to the slave surface.

BC_FLG 0 – Thermal boundary condition flag. Thermal boundary conditions are on when parts are in contact.

ALGO 0 – Contact algorithm type. Two-way contact, both surfaces change temperature due to contact.

*PART – Defining the parts, that is, combine material information, section properties, hourglass type, thermal properties, and the flag for part adaptivity.

Solid1 & SphNode

PID 1 & 2 – Part identification.

SECID 1 & 2 – Section identification defined in the *SECTION keyword.

MID 1 & 2 – Material identification defined in the *MAT section.

EOSID 0 & 1 – Equation of state identification defined in the *EOS section. Nonzero only for solid elements using the equation of state to compute pressure.

HGID 0 – Hourglass/bulk viscosity identification defined in the *HOURGLASS section. Default values are used.

GRAV 0 – Flag to turn on gravity initialization according to *LOAD_DENSITY_DEPTH.

ADPOPT 0 – Indicate if this part is adapted or not.

TMID 1 – Thermal material property identification defined in the *MAT_THERMAL section.

*SECTION_SOLID – Defining the section properties for solid continuum and fluid elements.

SECID 1 – Section ID.

ELFORM 1 – Element formulation options. Constant stress solid element.

AET 0 – Ambient element type. Non-ambient.

*MAT_RIGID_TITLE – This is material 20. Parts made from this material are considered to belong to the rigid body (for each part ID).

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JIF = **1.500**	**SJIF** (Morocco) = **7.184**	**OAJI** (USA) = **0.350**	

Tool
MID 2 – Material identification.
RO 7.85000E-6 – Mass density.
E 200.0 – Young's modulus.
PR 0.3 – Poisson's ratio.
N 0.0 – MADYMO3D 5.4 coupling flag, *n*.
COUPLE 0.0 – Coupling option if applicable. The finite element mesh is input.
M 0.0 – MADYMO3D 5.4 coupling flag, *m*.
ALIAS – VDA surface alias name.
CMO 1.0 – Center of mass constraint option. Constraints applied in global directions.
CON1 5 – Global translational constraint. Constrained *y* and *z* displacements.
CON2 7 – Global rotational constraint. Constrained *x*, *y*, and *z* rotations.
A1, A2, A3, V1, V2, V3 0.0 – Alternative method for specifying local system. Define two vectors **a** and **v**, fixed to the rigid body, which are used for output and the user defined airbag sensor subroutines.

*SECTION_SPH_TITLE – Defining the section properties for SPH particles.

SPH
SECID 2 – Section ID.
CSLH 1.2 – Constant used to calculate the initial smoothing length of the particles. The default value works for most problems.
HMIN 0.2 – Scale factor for the minimum smoothing length.
HMAX 2.0 – Scale factor for the maximum smoothing length.
SPHINI 0.0 – Optional initial smoothing length (overrides true smoothing length).
DEATH 1.00000E20 – Time imposed SPH approximation is stopped.
START 0.0 – Time imposed SPH approximation is activated.

*MAT_JOHNSON_COOK_TITLE – This is material type 15. The Johnson/Cook strain and temperature sensitive plasticity is sometimes used for problems where the strain rates vary over the large range and adiabatic temperature increases due to plastic heating cause material softening.

Blank
MID 1 – Material identification.
RO 7.81000E-6 – Mass density.
G 78.5 – Shear modulus.
E 204.0 – Young's modulus.
PR 0.3 – Poisson's ratio.
DTF 1.80000E-7 – Minimum time step size for automatic element deletion.
VP 0.0 – Formulation for rate effects. Scale yield stress (default).
RATEOP 0.0 – Form of strain-rate term. Log-linear Johnson-Cook (default).
A 0.553 – Input constant.
B 0.601 – Input constant.
N 0.234 – Input constant.
C 0.0134 – Input constant.
M 1.0 – Input constant.
TM 1480.0 – Melt temperature.
TR 20.0 – Room temperature.
EPSO 0.001 – Quasi-static threshold strain rate.
CP 642.0 – Specific heat.
PC 0.0 – Tensile failure stress or tensile pressure cutoff.
SPALL 2.0 – Spall type. Shell elements are deleted.
IT 0.0 – Plastic strain iteration option. No iterations (default).
D1 1.2 – Failure parameter.
D2 0.0 – Failure parameter.
D3 0.0 – Failure parameter.
D4 0.0 – Failure parameter.
D5 0.0 – Failure parameter.
C2/P 0.0 – Optional strain-rate parameter.
EROD 0 – Erosion flag. Element erosion allowed (default).
EFMIN 1.00000E-6 – The lower bound for calculated strain at fracture.

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*EOS_LINEAR_POLYNOMIAL – Defining the coefficients for the linear polynomial EOS, and initialization of the thermodynamic state of material by defining E0 and V0 below.

EOSID 1 – Equation of state ID.
C0 0.0 – The 0th polynomial equation coefficient.
C1 170.0 – The 1st polynomial equation coefficient.
C2 0.0 – The 2nd polynomial equation coefficient.
C3 0.0 – The 3rd polynomial equation coefficient.
C4 0.0 – The 4th polynomial equation coefficient.
C5 0.0 – The 5th polynomial equation coefficient.
C6 0.0 – The 6th polynomial equation coefficient.
E0 0.0 – Initial internal energy per unit reference volume.
V0 1.0 – Initial internal energy per unit reference volume.

*MAT_THERMAL_ISOTROPIC – This is thermal material type 1. With this material, isotropic thermal properties can be defined.

TMID 1 – Thermal material identification.
TRO 0.0 – Thermal density. Default to structural density.
TGRLC 0.0 – Thermal generation rate. Load curve ID defining the thermal generation rate as the function of time.
TGMULT 0.0 – Thermal generation rate multiplier. No heat generation.
TLAT 0.0 – Phase change temperature.
HLAT 0.0 – Latent heat.
HC 642.0 – Specific heat.
TC 4.70000E-5 – Thermal conductivity.

*INITIAL_TEMPERATURE_SET – Defining the initial nodal point temperatures using nodal set IDs or node numbers.

NSID 0 – Nodal set ID or nodal point ID.
TEMP 20.0 – Temperature at node or node set.
LOC 0 – Middle surface of thermal shell element.

*DEFINE_CURVE – Defining the curve (for example, load as the function of time, often loosely referred to as the load curve).

LCID 1 – Load curve identification.
SIDR 0 – Flag controlling use of curve during dynamic relaxation.
SFA 1.0 – Scale factor for abscissa value. This is useful for simple modifications.
SFO 1.0 – Scale factor for ordinate value (function). This is useful for simple modifications.
OFFA 0.0 – Offset for abscissa values.
OFFO 0.0 – Offset for ordinate values (function).
DATTYP 0 – Data type. This affects how offsets are applied.
A1 0.0, 0.02, 5.0 – Abscissa values.
O1 0.0, -5.0, -5.0 – Ordinate (function) values.

*ELEMENT_SOLID – Defining the three-dimensional solid elements.

EID – Element ID.
PID – Part ID.
N1 – Nodal point 1.
N2 – Nodal point 2.
N3 – Nodal point 3.
N4 – Nodal point 4.
N5 – Nodal point 5.
N6 – Nodal point 6.
N7 – Nodal point 7.
N8 – Nodal point 8.

*ELEMENT_SPH – Defining the lumped mass element assigned to the nodal point.

NID – Node ID and Element ID are the same for the SPH option.
PID – Part ID to which this node (element) belongs.
MASS – Mass/volume.

*NODE – Defining the node and its coordinates in the global coordinate system.

NID – Node number.
X – *x* coordinate.
Y – *y* coordinate.
Z – *z* coordinate.
TC – Translational constraint.
RC – Rotational constraint.

*CHANGE_CURVE_DEFINITION – Changing the solution options. The new load curve must contain the same number of points as the curve it replaces.

LCID 1 – Load curve ID.

Results and discussion

The contours of maximum shear stress were selected after the calculation in the program. The red color of the contours on the blank model characterizes the maximum value of shear stress, the blue color characterizes the minimum value of shear stress. The contours of maximum shear stress of the blank material during cutting with the cutters with the different geometry are presented in the Fig. 2.

Machining with the cutter without the nose radius leads to significant compression deformations of the blank from the side of the rake face of the tool and tensile deformations from the side of the flank face. The volume of maximum stress is formed on the chipping plane of material from the blank in the cutting zone. It undergoes significant deformation, as evidenced by the change in the geometric shape of the rectangle during machining.
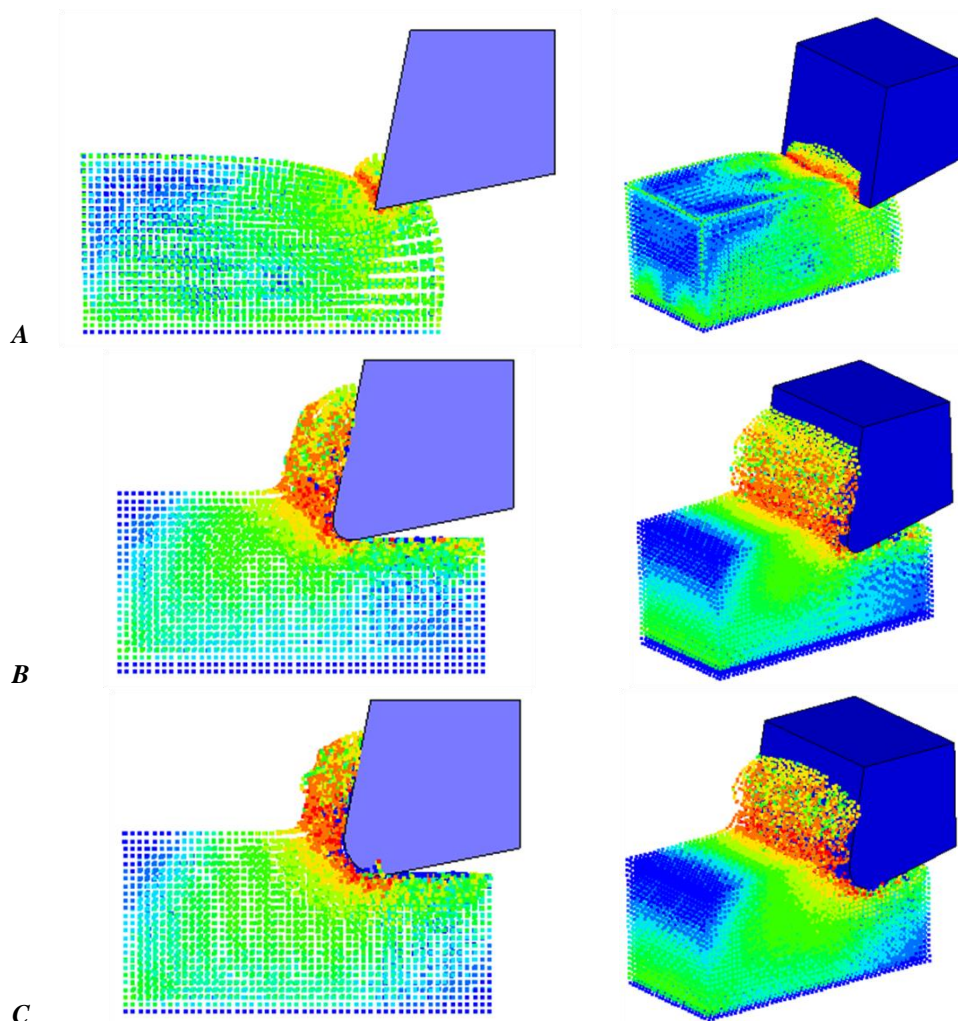

A

B

C

Figure 2 – The contours of maximum shear stress of the blank material during cutting: *A* – the cutter without the nose radius; *B* – the cutter with the nose radius of 5 mm; *C* – the cutter with the nose radius of 10 mm.

Machining with the cutters with the nose radii of 5 mm and 10 mm is accompanied by the permanent formation of maximum shear stresses in the blank volumes, as close as possible to the cutting edge. The intensity distribution of shear stress during cutting with the cutter with the nose radius of 10 mm occurs on the larger volume of the blank than during cutting with the cutter with the nose radius of 5 mm. The average value of shear stress of the blank material during machining with the cutters with the different nose radii is almost the same. Thus, the most preferred option is the cutter with the nose radius of 5 mm, since with less deformation of the blank, you can perform machining with the greater productivity by increasing the cutting depth.

Conclusion

The cutter without the nose radius is not recommended for roughing due to lower strength of the tool and significant deformations of the blank. The nose radius of the cutter facilitates the cutting process of the metal blanks. At the same time, increasing the nose radius in the studied range does not lead to an increase in the cutting forces. The deformation intensity of the inner layers of the blank material will be higher in the conditions of planing with the cutter with the large nose radius.

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IMPLEMENTATION IN MAPLE THE SEQULAR TERMS ELIMINATION METHOD FOR NONLINEAR OSCILLATIONS

Abstract: *In the paper we consider questions concerning computer interpretation of known results in the asymptotic theory of nonlinear differential equations admitting periodic solutions. The main subject of our consideration is Duffing equation describing regularly perturbed nonlinear oscillations. In the paper we suggest a computer program, which perform asymptotic expansions of Duffing equation's solution by degrees of small parameter. For seqular terms of such expansions a computer implementation of well known elimination approach is shown. Series of numerical computations are conducted and results are depicted in graphs.*

Key words: *nonlinear oscillations, perturbation method, small parameter, seqular term, Lindstedt-Poincare method.*

Language: *Russian*

РЕАЛИЗАЦИЯ В СРЕДЕ MAPLE МЕТОДА УСТРАНЕНИЯ СЕКУЛЯРНЫХ ЧЛЕНОВ НЕЛИНЕЙНЫХ КОЛЕБАНИЙ

Аннотация: *В данной статье мы затрагиваем вопросы компьютерной интерпретации известных результатов асимптотической теории нелинейных дифференциальных уравнений, допускающих периодические решения. Основным объектом рассмотрения является уравнение Дюффинга, описывающее регулярно возмущенные нелинейные колебания. В работе предлагается компьютерная программа, осуществляющая асимптотическое разложение решения уравнения Дюффинга по степеням малого параметра. Показана компьютерная реализация известного способа избавления от секулярных членов таких разложений. Проведена серия численных расчетов и результаты отражены в графиках.*

Ключевые слова: *нелинейные колебания, метод возмущений, малый параметр, секулярный член, метод Линдштедта-Пуанкаре.*

Введение

УДК   517.928.1, 517.928.7

Рассмотрим начальную задачу для уравнения Дюффинга (см. [4,5])

$$\frac{d^2 x(t)}{dt^2} + x(t) + \varepsilon x^3(t) = 0, \qquad (1)$$

$$x(0) = a, \ \frac{dx(0)}{dt} = 0. \qquad (2)$$

где ε -малый положительный параметр. Поставленная задача относится к классу регулярно-возмущенных задач. Методы изучения уравнения Дуффинга более сложного вида (уравнение неоднородно и в него входит и первая производная неизвестной функции) можно найти в работе [6].

Очевидно, что при $\varepsilon = 0$ мы имеем уравнение гармонических колебаний $\dfrac{d^2 x(t)}{dt^2} + x(t) = 0$, имеющее решение известное решение $x_0(t) = a\cos(t)$.

Исследование вопроса о близости решения $x(t, \varepsilon)$ уравнения (1) к $x_0(t) = a\cos(t)$ при $\varepsilon \to 0$ составляет суть асимптотической теории дифференциальных уравнений и проведено в многочисленных работах. Обзор по этому направлению можно найти, например, в известном источнике [10]. Здесь мы не будем останавливаться на теоретических положениях, а сразу приступим к реализации на Maple асимптотического разложения решения (1) по степеням малого параметра и компьютерной интерпретации известных теоретических положений. В частности, покажем способ устранения отрицательного влияния секулярных

членов асимптотического разложения на точность приближений.

Один из известных способов заключается в формальном представлении решения (1) в виде ряда

$$x(t, \varepsilon) = x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t) + \dots . \qquad (3)$$

Такой метод известен под названием SEM-метода (straightforward expansion method).

Согласно SEM-методу далее подставляют (3) в (1). После приведения подобных приравнивают члены при одинаковых степенях малого параметра и получают рекуррентную систему линейных дифференциальных уравнений относительно членов разложения. Для осуществления этих выкладок удобно и эффективно использовать системы аналитических вычислений типа Maple [3]. Отметим, что в [1,2] подобный подход был осуществлен применительно к сингулярно-возмущенным дифференциальным уравнениям. Здесь мы будем использовать некоторые из этих наших наработок.

Основные результаты. Итак покажем команды Maple, выполняющие соответствующие выкладки для решения поставленной здесь задачи. Ограничимся в (3) первыми тремя слагаемыми, то есть положим $N = 2$:

> $N := 2;$

$$N := 2$$

> $dequ := \dfrac{d^2}{dt^2} X(t) + X(t) + \varepsilon \cdot X(t)^3; \ init := X(0) = a, \mathrm{D}(X)(0) = 0$

> $s := add\left(\varepsilon^i \cdot v_i(t), i = 0 .. N\right)$

$$s := v_0(t) + \varepsilon v_1(t) + \varepsilon^2 v_2(t)$$

> $ex1 := expand(subs(X(t) = s, dequ)) : ex := collect(ex1, \varepsilon) :$
> **for** i **from** 0 **to** N **do** $deq_i := coeff(ex, \varepsilon, i) = 0$ **end do**

$$deq_0 := \frac{d^2}{dt^2} v_0(t) + v_0(t) = 0$$

$$deq_1 := v_0(t)^3 + \frac{d^2}{dt^2} v_1(t) + v_1(t) = 0$$

$$deq_2 := 3 v_0(t)^2 v_1(t) + \frac{d^2}{dt^2} v_2(t) + v_2(t) = 0$$

В программе мы ограничились частной суммой $s_N(t, \varepsilon) = x_0(t) + \varepsilon x_1(t) + \dots + \varepsilon^N x_N(t)$ формального ряда (3) при $N = 2$ и получили рекуррентную систему

$$\frac{d^2 x_0(t)}{dt^2} + x_0(t) = 0, \qquad (4)$$

$$\frac{d^2 x_1(t)}{dt^2} + x_1(t) = -x_0^3(t), \qquad (5)$$

$$\frac{d^2 x_2(t)}{dt^2} + x_2(t) = -3x_0^2(t)x_1(t) . \qquad (6)$$

Естественно, при задании большего значения N, программа может выводить уравнения для последующих членов асимптотического разложения. Например, при $N = 4$, получили бы еще два уравнения

$$deq_3 := 3\, v_0(t)^2\, v_2(t) + 3\, v_0(t)\, v_1(t)^2 + v_3(t) + \frac{d^2}{dt^2}\, v_3(t) = 0$$

$$deq_4 := 3\, v_0(t)^2\, v_3(t) + 6\, v_0(t)\, v_1(t)\, v_2(t) + v_1(t)^3 + v_4(t) + \frac{d^2}{dt^2}\, v_4(t) = 0$$

Очевидно, что подставляя (3) в начальные условия (2), получаем следующее

$$x_0(0) + \varepsilon x_1(0) + \varepsilon^2 x_2(0) + ... =$$
$$a + \varepsilon \cdot 0 + \varepsilon^2 \cdot 0 + ... ,$$

$$x_0'(0) + \varepsilon x_1'(0) + \varepsilon^2 x_2'(0) + ...$$
$$= 0 + \varepsilon \cdot 0 + \varepsilon^2 \cdot 0 + ...$$

Отсюда

$$x_0(0) = a,\ x_0'(0) = 0,$$
$$x_1(0) = 0,\ x_1'(0) = 0,$$
....

Из уравнения (4) и начальных условий $x_0(0) = a$, $x_0'(0) = 0$ находим $x_0(t) = a\cos(t)$:

> $ini_0 := v_0(0) = a, \mathrm{D}(v_0)(0) = 0$

$$ini_0 := v_0(0) = a, \mathrm{D}(v_0)(0) = 0$$

> $l := rhs(dsolve(\{deq_0, ini_0\})) : v_0(t) := l : x_0 := v_0(t)$

$$x_0 := a\cos(t)$$

Подставляя найденное решение $x_0(t)$ в уравнение (5) и учитывая его начальные условия $x_1(0) = 0$, $x_1'(0) = 0$, мы можем найти второе слагаемое $x_1(t)$ в разложении (3). Нахождение решения $x_2(t)$ уравнения (6) и последующих членов разложения проводится аналогично. Покажем соответствующие команды Maple:

> **for** i **from** 1 **to** N **do**
> $l := rhs(dsolve(\{deq_i, v_i(0) = 0, \mathrm{D}(v_i)(0) = 0\})) :$
> $v_i(t) := l : x_i := v_i(t)$
> **end do**:

> **for** i **from** 1 **to** N **do** $x_i := collect(x[i], t, simplify)$ **end do**

$$x_1 := -\frac{3}{8}\, a^3 \sin(t)\, t - \frac{1}{8}\, a^3 \sin(t)^2 \cos(t)$$

$$x_2 := -\frac{243}{16384}\cos(t)\, a^9 t^4 + \frac{27}{16384}\, a^9 \sin(t)\left(12\cos(t)^2 + 17\right) t^3$$
$$- \frac{27}{131072}\, a^9 \cos(t)\left(32\cos(t)^4 - 328\cos(t)^2 - 9\right) t^2 - \frac{9}{524288}\, a^9 \sin(t)\left(64\cos(t)^6\right.$$
$$\left. - 496\cos(t)^4 + 4680\cos(t)^2 + 1703\right) t - \frac{3}{2621440}\sin(t)^2 \cos(t)\, a^9\left(64\cos(t)^6\right.$$
$$\left. - 440\cos(t)^4 + 2418\cos(t)^2 - 36407\right)$$

> $S := add\left(\varepsilon^{i} \cdot simplify\left(x_i\right), i = 0..N\right)$

Мы описали здесь вычислительные аспекты приближенного поиска решения $x(t, \varepsilon)$ возмущенного уравнения (1). Ограничились в (3) тремя слагаемыми и нашли приближенное решение при бесконечно малых ε :

$$x(t, \varepsilon) \approx x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t).$$

Теория регулярных возмущений гарантирует равномерную сходимость $x(t, \varepsilon)$ к $x_0(t)$ при $\varepsilon \to 0$ для значений t на любом замкнутом и ограниченном интервале.

Однако на этом пути есть одна преграда, вызываемая так называемыми секулярными членами асимптотического разложения. Дело в том, что мы замечаем наличие членов вида $t \sin t$ и $t^4 \cos t$ в выражениях для $x_1(t)$ и $x_2(t)$, найденных выше. Они называются секулярными членами разложения. С ростом значения $|t|$ секулярные члены могут принимать большие значения. Поэтому значения слагаемых $\varepsilon x_1(t)$ и $\varepsilon^2 x_2(t)$ могут и не быть близкими к нулю при достаточно малых, но фиксированных значениях малого параметра $\varepsilon > 0$. В нашем случае $\varepsilon x_1(t)$ характеризуется выражением $\frac{3}{8} a^2 t \sin t \cdot \varepsilon$, а слагаемое $\varepsilon^2 x_2(t)$ выражением

$\frac{243}{16384} a^9 t^4 \cos t \cdot \varepsilon^2$. Как видим, при больших значениях аргумента t и параметра a эти слагаемые могут представлять собой большие числа. Поэтому для обеспечения близости $x(t, \varepsilon) \approx x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ для всех t, взятых из большого интервала, мы будем вынуждены ε брать соответственно бесконечно малым.

В таких условиях увеличение количества слагаемых в сумме $s_N(t, \varepsilon) = x_0(t) + \varepsilon x_1(t) + ... + \varepsilon^N x_N(t)$ может привести не к увеличению точности приближения $x(t, \varepsilon) \approx s_N(t, \varepsilon)$, а к противоположному эффекту, поскольку начинают расти степени t^m. В этой связи отметим, что сумма $s_1(t, \varepsilon) = x_0(t) + \varepsilon x_1(t)$, содержащая t, может обеспечивать даже лучшее приближение, чем $s_2(t, \varepsilon) = x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$, содержащая в своих секулярных членах уже t^4.

Проведем теперь несколько численных экспериментов. Для определенности пусть всюду в дальнейшем $a = 2$. Приведем графические результаты приближения решения $x(t, \varepsilon)$ задачи (1),(2) суммой $x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ при различных значениях ε :
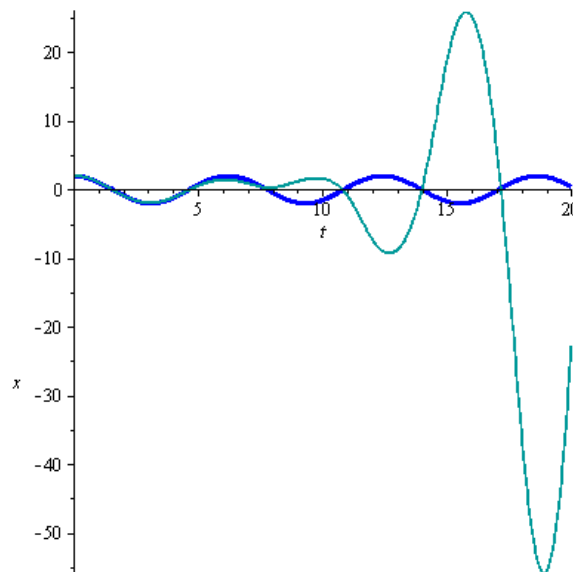

Рисунок 1- Графики решения задачи (1),(2) (синий цвет) и его приближения
$x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/128.$
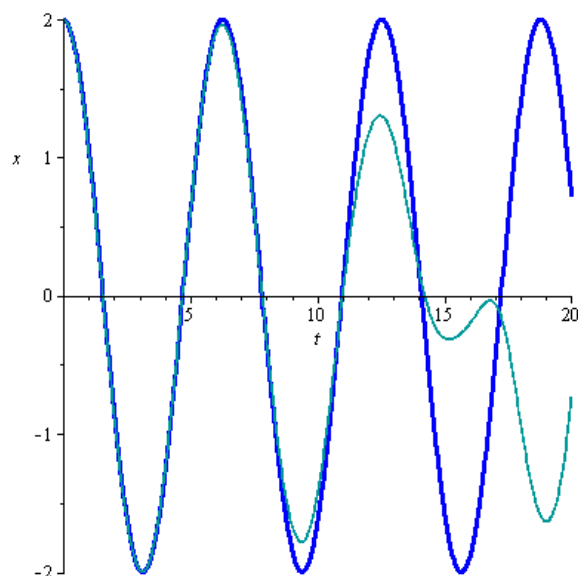
Рисунок 2- Графики решения задачи (1),(2) (синий цвет) и его приближения
$x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/512.$
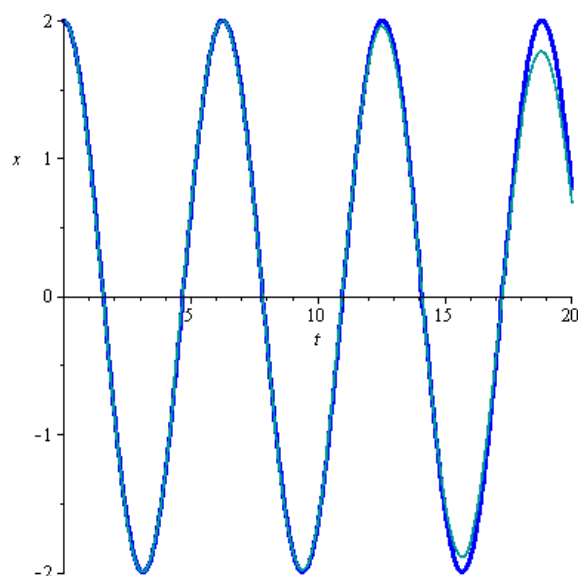

Рисунок 3- Графики решения задачи (1),(2) (синий цвет) и его приближения
$x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/2048.$

Наши теоретические наблюдения подтверждаются на численных экспериментах. Как видно из рис. 1-3, секулярные члены действительно препятствует стремлению $x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ к $x(t, \varepsilon)$. Особенно это заметно при больших значениях t. Чтобы гасить их влияние мы вынуждены уменьшать значения ε, и только при $\varepsilon \le 1/2048 \approx 5 \cdot 10^{-4}$ мы начинаем получать более или менее удовлетворительную картину. Подтверждаются также выводы о том, что при больших t сумма $x_0(t) + \varepsilon x_1(t)$ может обеспечить более точное приближение. Результат соответствующих расчетов видим на рис. 4.
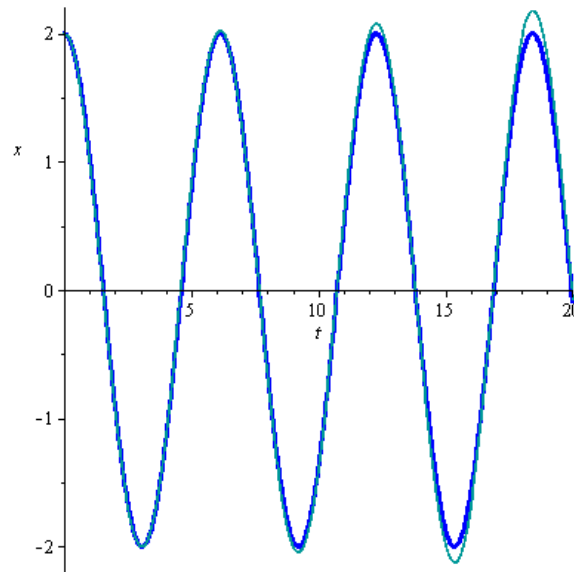
Рисунок 4- Графики решения задачи (1),(2) (синий цвет) и его приближения
$x_0(t) + \varepsilon x_1(t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/64$.

Так что при наличии секулярных членов увеличение слагаемых в сумме $s_N(t,\varepsilon)$ может привести к более точному приближению только при небольших значениях t. Следовательно, секулярные члены- наша основная проблема. Для борьбы с ними в свое время был предложен следующий метод, который называется методом Линдштедта-Пуанкаре [5,9].   Делаем замену независимого переменного $\tau = \omega t$ и получаем некую новую функцию $y(\tau)$ определяемую из тождества $x(t) = x(t(\tau)) = y(\tau)$. Отсюда

$$\frac{dx}{dt} = \frac{dy}{d\tau}\frac{d\tau}{dt} = \omega\frac{dy}{d\tau},$$
$$\frac{d^2x}{dt^2} = \omega\frac{d}{d\tau}\left(\frac{dy}{d\tau}\right)\frac{d\tau}{dt} = \omega^2\frac{d^2y}{d\tau^2}.$$

Задача Коши (1),(2) в новых переменных запишется как

$$\omega^2\frac{d^2y(\tau)}{d\tau^2} + y(\tau) + \varepsilon y^3(\tau) = 0, \qquad (7)$$

$$y(0) = a, \quad \frac{y(0)}{d\tau} = 0.$$

Теперь у нас появляется возможность избавления от секулярных членов. Для этого разлагаем $y(\tau,\varepsilon)$ и ω представляем в виде суммы по степеням малого параметра

$$y(\tau,\varepsilon) = y_0(\tau) + \varepsilon y_1(\tau) + \varepsilon^2 y_2(\tau) + ...,$$

$$\omega = 1 + \varepsilon\omega_1 + \varepsilon^2\omega_2 + ...$$

Подставляя их в (7), получаем следующее равенство

$$(1 + \varepsilon\omega_1 + ...)^2\frac{d^2}{d\tau^2}(y_0 + \varepsilon y_1 + ...)$$
$$+ (y_0 + \varepsilon y_1 + ...) + \varepsilon^3(y_0 + \varepsilon y_1 + ...)^3 = 0.$$

Приравнивая члены при одинаковых степенях малого параметра, отсюда снова получаем рекуррентную систему линейных дифференциальных уравнений. Как показывают вычисления

> $\omega := 1 + \varepsilon\cdot\omega_1 + \varepsilon^2\cdot\omega_2$

$$\omega := \varepsilon^2\,\omega_2 + \varepsilon\,\omega_1 + 1$$

> $deqq := \omega^2\cdot\frac{d^2}{d\tau^2}y(\tau) + y(\tau) + \varepsilon\cdot y(\tau)^3;$

$$deqq := \left(\varepsilon^2\, \omega_2 + \varepsilon\, \omega_1 + 1 \right)^2 \left(\frac{d^2}{d\tau^2}\, y(\tau) \right) + y(\tau) + \varepsilon\, y(\tau)^3$$

> $s := add\left(\varepsilon^i \cdot w_i(\tau),\, i = 0\,..\,N \right)$

$$s := w_0(\tau) + \varepsilon\, w_1(\tau) + \varepsilon^2\, w_2(\tau)$$

> $ex1 := expand\left(subs\left(y(\tau) = s,\, deqq \right) \right) : ex := collect(ex1, \varepsilon) :$

> **for** i **from** 0 **to** N **do** $deq_i := coeff(ex, \varepsilon, i) = 0$ **end do**

$$deq_0 := \frac{d^2}{d\tau^2}\, w_0(\tau) + w_0(\tau) = 0$$

$$deq_1 := w_0(\tau)^3 + 2\left(\frac{d^2}{d\tau^2}\, w_0(\tau) \right) \omega_1 + \frac{d^2}{d\tau^2}\, w_1(\tau) + w_1(\tau) = 0$$

$$deq_2 := \left(\frac{d^2}{d\tau^2}\, w_0(\tau) \right) \omega_1^2 + 3\, w_0(\tau)^2\, w_1(\tau) + 2\left(\frac{d^2}{d\tau^2}\, w_0(\tau) \right) \omega_2 + 2\left(\frac{d^2}{d\tau^2}\, w_1(\tau) \right) \omega_1$$
$$+ \frac{d^2}{d\tau^2}\, w_2(\tau) + w_2(\tau) = 0$$

Разрешая эту рекуррентную систему дифференциальных уравнений, мы получаем

> $l := rhs\left(dsolve\left(\{deq_0,\, w_0(0) = a,\, D(w_0)(0) = 0\} \right) \right) : w_0(t) := l : y_0 := w_0(t)$

$$y_0 := a \cos(\tau)$$

> **for** i **from** 1 **to** N **do**
> $m := rhs\left(dsolve\left(\{deq_i,\, w_i(0) = 0,\, D(w_i)(0) = 0\} \right) \right) :$
> $w_i(t) := m : y_i := w_i(t)$
> **end do**:

> $y_1 := collect(y_1, \tau, simplify);$

$$y_1 := -\frac{1}{8}\, a \sin(\tau)\left(3\, a^2 - 8\, \omega_1 \right) \tau - \frac{1}{8}\, \sin(\tau)^2 \cos(\tau)\, a^3$$

> $y_2 := collect(y_2, \tau, simplify);$

$$y_2 := -\frac{1}{128}\, a\left(9\, a^4 - 48\, a^2\, \omega_1 + 64\, \omega_1^2 \right) \cos(\tau)\, \tau^2 - \frac{1}{256}\, a \sin(\tau)\left(36\, a^4 \cos(\tau)^2 \right.$$
$$\left. - 96\, a^2 \cos(\tau)^2\, \omega_1 - 33\, a^4 - 64\, a^2\, \omega_1 + 256\, \omega_1^2 - 256\, \omega_2 \right) \tau$$
$$- \frac{1}{256}\, \sin(\tau)^2 \cos(\tau)\, a^5 \left(4 \cos(\tau)^2 - 25 \right)$$

Заметим теперь, что в $y_1(\tau)$ секулярный член $\tau \sin \tau$ может быть уничтожен выбором $\omega_1 = \frac{3a^2}{8}$:

> $\omega_1 := \frac{3 \cdot a^2}{8};$

$$\omega_1 := \frac{3}{8}\, a^2$$

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> $y_1 := simplify(y_1)$;

$$y_1 := -\frac{1}{8}\sin(\tau)^2\cos(\tau)\,a^3$$

> $y_2 := collect(y_2, \tau, simplify)$

$$y_2 := \frac{1}{256}\,a\sin(\tau)\left(21\,a^4 + 256\,\omega_2\right)\tau - \frac{1}{256}\sin(\tau)^2\cos(\tau)\,a^5\left(4\cos(\tau)^2 - 25\right)$$

Теперь можно избавиться от секулярного члена в $y_2(\tau)$, положив $\omega_2 = -\dfrac{21a^4}{256}$. Действительно,

> $\omega_2 := -\dfrac{21\cdot a^4}{256}$;

$$\omega_2 := -\frac{21}{256}\,a^4$$

> $y_2 := simplify(y_2)$

$$y_2 := -\frac{1}{256}\sin(\tau)^2\cos(\tau)\,a^5\left(4\cos(\tau)^2 - 25\right)$$

Итак в новых переменных мы получили приближение
$y(\tau,\varepsilon) \approx y_0(\tau) + \varepsilon y_1(\tau) + \varepsilon^2 y_2(\tau)$ к решению

> $S := add\left(\varepsilon^i \cdot y_i, i = 0..N\right)$

$$S := a\cos(\tau) - \frac{1}{8}\varepsilon\sin(\tau)^2\cos(\tau)\,a^3 - \frac{1}{256}\varepsilon^2\sin(\tau)^2\cos(\tau)\,a^5\left(4\cos(\tau)^2 - 25\right)$$

Вернемся теперь к старым переменным. Тогда

$$x(t,\varepsilon) = y(\tau,\varepsilon) = y(\omega t,\varepsilon)$$
$$\approx y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t).$$

уравнения (7), не содержащее секулярных членов. Соответствующие вычисления:

В правую часть полученного приближенного равенства подставляем $\omega = 1 + \varepsilon\omega_1 + \varepsilon^2\omega_2$ со значениями $\omega_1 = \dfrac{3a^2}{8}$ и $\omega_2 = -\dfrac{21a^4}{256}$.

Вычисляем $y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t)$:

> $S := add\left(\varepsilon^i \cdot subs(\tau = \omega \cdot t, y_i), i = 0..N\right)$

$$S := a\cos\left(\left(-\frac{21}{256}\varepsilon^2 a^4 + \frac{3}{8}\varepsilon a^2 + 1\right)t\right) - \frac{1}{8}\varepsilon\sin\left(\left(-\frac{21}{256}\varepsilon^2 a^4 + \frac{3}{8}\varepsilon a^2\right.\right.$$
$$\left.\left.+ 1\right)t\right)^2\cos\left(\left(-\frac{21}{256}\varepsilon^2 a^4 + \frac{3}{8}\varepsilon a^2 + 1\right)t\right)a^3 - \frac{1}{256}\varepsilon^2\sin\left(\left(-\frac{21}{256}\varepsilon^2 a^4\right.\right.$$
$$\left.\left.+ \frac{3}{8}\varepsilon a^2 + 1\right)t\right)^2\cos\left(\left(-\frac{21}{256}\varepsilon^2 a^4 + \frac{3}{8}\varepsilon a^2 + 1\right)t\right)a^5\left(4\cos\left(\left(-\frac{21}{256}\varepsilon^2 a^4\right.\right.\right.$$
$$\left.\left.\left.+ \frac{3}{8}\varepsilon a^2 + 1\right)t\right)^2 - 25\right)$$

Итак мы построили приближение $y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t)$ к решению $x(t,\varepsilon)$ уравнения (1), свободное от секулярных

членов, где $\omega = 1 + \dfrac{3a^2}{8}\varepsilon - \dfrac{21a^4}{256}\varepsilon^2$.

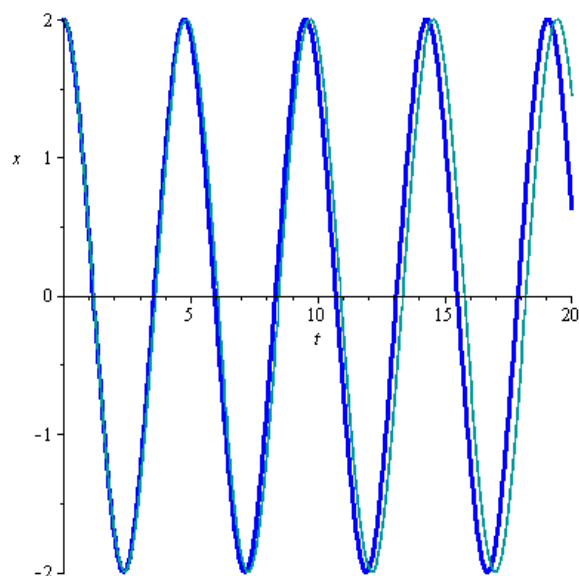Продемонстрируем точность такого приближения:

Рисунок 5- Графики решения задачи (1),(2) (синий цвет) и его приближения
$$y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t) \text{ (темно-зеленый цвет) при } \varepsilon = 1/4.$$
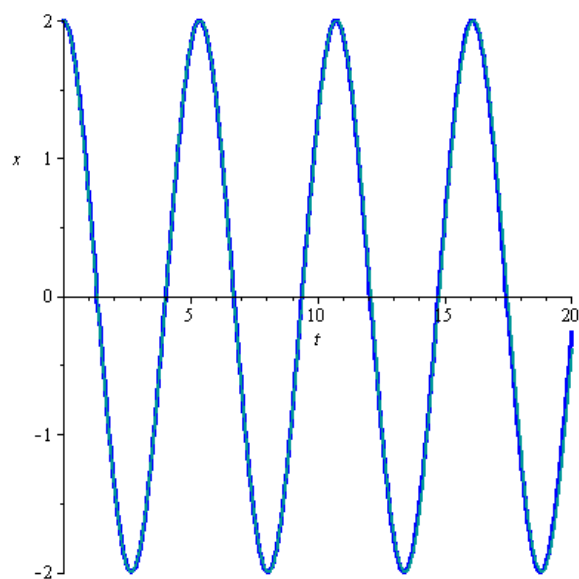

Рисунок 6- Графики решения задачи (1),(2) (синий цвет) и его приближения
$$y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t) \text{ (темно-зеленый цвет) при } \varepsilon = 1/8.$$

Как видим из рис. 5 и 6, сумма $y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t)$ достаточно хорошо приближает решение $x(t,\varepsilon)$ задачи (1),(2) при всех t даже при значениях ε, не сильно малых. При $\varepsilon = 1/8$ они почти совпадают. Для сравнения напомним, что сумма $x_0(t) + \varepsilon x_1(t) + \varepsilon^2 x_2(t)$ не могла обеспечивать

такую точность приближения даже при $\varepsilon = 1/2048$ (см. рис. 3).

Отметим также, что в случае разложений, свободных от секулярных членов, сумма $y_0(\omega t) + \varepsilon y_1(\omega t) + \varepsilon^2 y_2(\omega t)$, содержащая больше слагаемых, предпочтительнее, чем сумма $y_0(\omega t) + \varepsilon y_1(\omega t)$ с меньшим количеством слагаемых. Это видно из рис. 7 и 8.

Рисунок 7- Графики решения задачи (1),(2) (синий цвет) и его приближения
$y_0(\omega t) + \varepsilon y_1(\omega t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/4$.
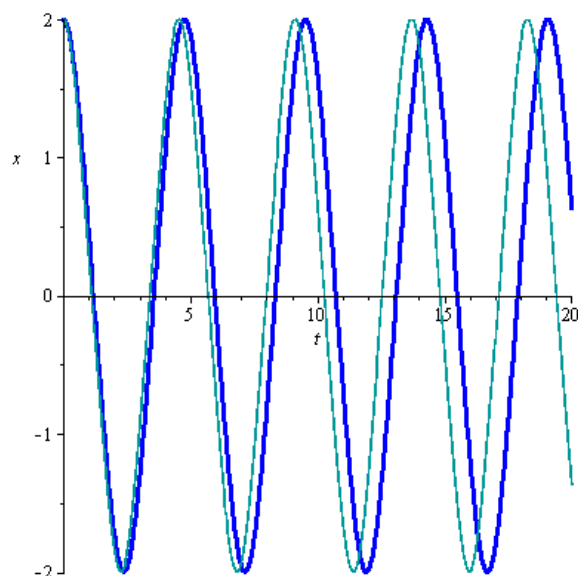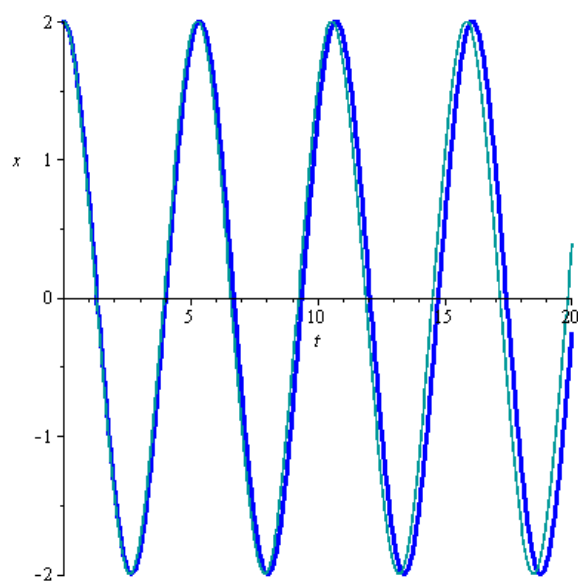

Рисунок 8- Графики решения задачи (1),(2) (синий цвет) и его приближения
$y_0(\omega t) + \varepsilon y_1(\omega t)$ **(темно-зеленый цвет) при** $\varepsilon = 1/8$.

Заключение.

Мы показали широкие возможности компьютерных технологий и предложили программу на Maple, которая реализует на компьютере метод возмущений и метод Линдштедта-Пуанкаре устранения секулярных членов. Как видно из многочисленных численных экспериментов и графических представлений их результатов, разложения Линдштедта-Пуанкаре имеют очевидные преимущества в плане точности перед SME-методом. Тем не менее, известны сравнительно новые результаты работ [7,8], в которых предложены модификации SME-метода, имеющие достаточно высокую точность.

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EQUILIBRIUM OF LIQUID IN MOVING VESSELS

Abstract: *The article discusses the mathematical modeling of pressure on the plunger during the operation of oil wells with sucker rod pumps. The problem of determining the total pressure on the plunger during its upward movement in the riser during the operation of oil wells with a plunger lift is considered. For mathematical modeling of the process, generally accepted assumptions are made regarding the movement of liquid (oil) in the annular space between two cylindrical pipes, one of which moves relative to the other. A theoretical method is proposed for determining the total pressure on the plunger, taking into account the viscoelastic properties of the produced oil. Numerical experiments have studied the effect of the viscoelastic properties of oil on the change in the total pressure on the plunger.*

Key words: *vector, soskd, force, free, geometric, differential, pressure, fluid, closed, mass, field, surface, rectilinear, distribution, level, concentric, cylinders.*

Language: *Russian*

МОДЕЛИРОВАНИЕ ДАВЛЕНИЯ НА ПЛУНЖЕР ПРИ ЭКСПЛУАТАЦИИ СКВАЖИН, ДОБЫВАЮЩИХ НЕНЬЮТОНОВСКИЕ НЕФТИ

Аннотация: *При равновесии в движущемся сосуде жидкость, заполняющая сосуд, движется вместе с ним как твердое тело. Давление в жидкости меняется по всем направлениям, кроме тех, которые нормальны к вектору единичной массовой силы; поверхности уровня (поверхности равного давления) в каждой своей точке нормальны направлению вектора единичной массовой силы, действующей в этой точке. Силы давления жидкости на стенки в рассматриваемом случае равновесия благодаря однородности поля массовых сил определяются зависимостями, аналогичными зависимостям для случая равновесия жидкости в неподвижном сосуде.*

Ключевые слова: *вектор, сосуд, сила, свободной, геометрические, дифференциал, давления, жидкость, замкнутых, масса, поля, поверхность, прямолинейно, распределения, уровень, концентрические, цилиндры.*

Введение

При равновесии в движущемся сосуде жидкость, заполняющая сосуд, движется вместе с ним как твердое тело. Закон распределения давления в жидкости выражается дифференциальным уравнением:
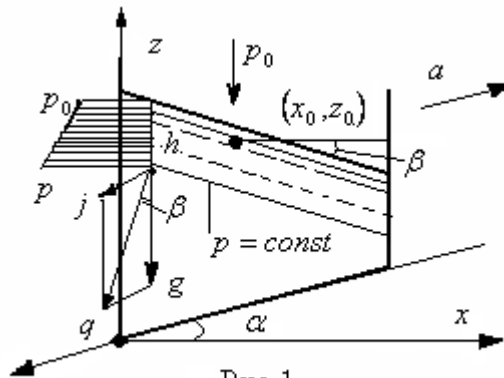
Рис.1.

$$dp = \rho(Xdx + Ydy + Zdz) \qquad (1)$$

где x, y, z - координаты точек жидкости в системеотсчета, связанной с сосудом;

$p = f(x, y, z)$ -давление в жидкости;

ρ - плотность жидкости;

X, Y, Z -проекции единичной массовой силы $\bar{q}$ (силы, отнесенной к единице массы) на координатные оси.

Вектор единичной массовой силы $\bar{q}$ в каждой точке жидкости представляет собой сумму единичной силы веса $\bar{g}$ и единичной силы инерции $\bar{j}$ переносного движения:

$$\bar{q} = \bar{g} + \bar{j}, \bar{j} = -\bar{a} \qquad (2)$$

где $\bar{a}$ -переносное ускорение в данной точке жидкости. Давление в жидкости меняется по всем направлениям, кроме тех, которые нормальны к вектору единичной массовой силы; поверхности уровня (поверхности равного давления) в каждой своей точке нормальны направлению вектора единичной массовой силы, действующей в этой точке. Дифференциальное уравнение поверхностей уровня (в частности, свободной поверхности жидкости и поверхности раздела несмешивающихся жидкостей) имеет вид:

$$Xdx + Ydy + Zdz = 0 . \qquad (3)$$

Постановка задачи.

В случае равновесия жидкости в сосуде, движущемся прямолинейно с постоянным ускорением $\bar{a}$, поле массовой силы представляет собой семейство одинаковых по величине и направлению векторов $\bar{q}$ (рис.1).

В системе прямоугольных осей координат x, y, z,связанной с сосудом (ось y перпендикулярна плоскости движения), уравнение поверхности уровня (в частности, свободной поверхности), проходящей через точку (x_0, z_0), имеет вид:

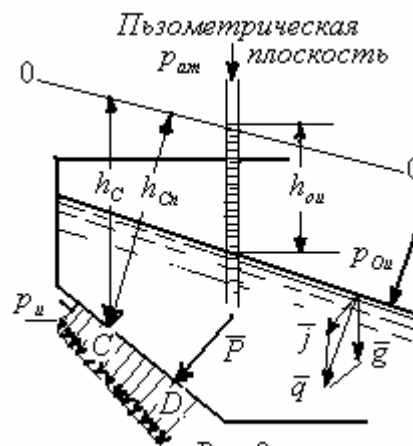$$z - z_0 = -\frac{a\cos\alpha}{g + a\sin\alpha}(x - x_0) \qquad (4)$$

Рис.2.

где x, z - координаты произвольной точки поверхности уровня; α - угол наклона к горизонту вектора ускорения $\bar{a}$,

Поверхности уровня - семейство параллельных плоскостей, нормальных к плоскости движения и наклоненных к горизонту под углом β , для которого

$$tg\beta = -\frac{a\cos\alpha}{g + a\sin\alpha} \qquad (5)$$

Закон распределения давления выражается уравнением

$$p = p_0 - [a\cos\alpha(x - x_0) + \\ + (g + a\sin\alpha)(z - z_0)] \qquad (6)$$

где p_0 - давление в точке с координатами (x_0, z_0) и p -давление в произвольной точке жидкости с координатами (x, z).

Если точка (x_0, z_0) расположена на свободной поверхности жидкости в сосуде, открытом в атмосферу, то $p_0 = p_{am}$ (атмосферное давление).

Из уравнения (6) следует линейность закона изменения давления в жидкости по любому направлению. В частности, давление в точках, находящихся на глубине h под поверхностью уровни с давлением p_0 равно:

$$p = p_0 + \rho(g + a\sin\alpha)h = \\ = p_0 + \gamma\left(1 + \frac{a}{g}\sin\alpha\right)h \qquad (7)$$

Для жидкости, заполняющей сосуд, открытый в атмосферу, избыточное давление на глубине h под свободной поверхностью равно:

$$p_u = \gamma\left(1 + \frac{a}{g}\sin\alpha\right)h \qquad (8)$$

Последняя формула применима и в случаях замкнутых сосудов с избыточным давлением или вакуумом над жидкостью, если отсчитывать глубины h от пьезометрической плоскости (поверхности уровня, давление в точках которой равно атмосферному).

Можно пользоваться также выражением

$$p_u = \rho q h_n \qquad (9)$$

где h_n - расстояние по нормали от точки до пьезометрической плоскости (рис.2).

Из приведенных уравнений выводятся уравнения равновесия жидкости в горизонтально движущемся сосуде ($\alpha = 0$), в сосуде, движущемся вертикально вверх ($\alpha = \frac{\pi}{2}$), и сосуде, движущемся вертикально вниз ($\alpha = \frac{3\pi}{2}$).

Силы давления жидкости на стенки в рассматриваемом случае равновесия благодаря однородности поля массовых сил определяются зависимостями, аналогичными зависимостям для случая равновесия жидкости в неподвижном сосуде.

Величина силы давления, воспринимаемой плоской стенкой, на несмоченной стороне которой давление равно атмосферному (рис.2), вычисляется по формуле:

$$P = p_{Cu}F \qquad (10)$$

где F - площадь стенки;

p_{Cu} - избыточное давление в центре тяжести стенки, определяемое по формулам (8) или (9) через расстояние h_C или h_{C_n} от центра тяжести стенки до пьезометрической плоскости.

Расстояние между свободной поверхностью и пьезометрической плоскостью определяется величиной p_{0u} избыточного давления на свободной поверхности.
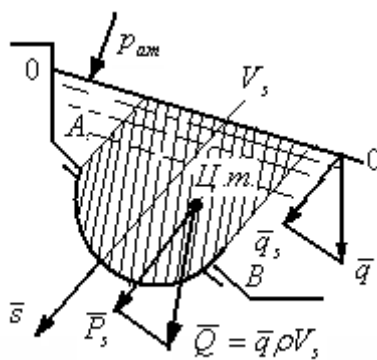

Рис.3,а.

Сила P нормальна к стенке и проходит через центр давления D, положение которого для данной стенки зависит от величины и направления вектора $\bar{a}$ переносного ускорения.

Сила давления жидкости на криволинейную стенку вычисляется суммированием составляющих по координатным осям. Составляющая силы давления по заданному направлению s равна (рис. 3,а):
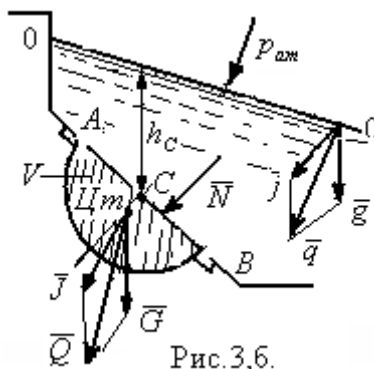
$$P_s = \rho q_s V_s \qquad (11)$$

где q_s - проекция вектора единичной массовой силы на направление s;

V_s - объем тела давления, построенного параллельно направлению s между поверхностью стенки и пьезометрической плоскостью.

Линия действия силы P_s проходит через центр тяжести объема V_s.

Рис.3,б.

Силу давления P жидкости на криволинейную стенку можно определить также из условий относительного равновесия объема V жидкости, заключенного между криволинейной стенкой и плоским сечением, проведенным через граничный контур стенки (рис.3,б):

$$\overline{P} = \overline{N} + \overline{G} + \overline{J} = \overline{N} + \overline{Q} \qquad (12)$$

где $\overline{N}$ - сила давления на плоское сечение ACB, проведенное через граничный контур стенки, вычисляемая по формуле (10);

$\overline{G}$ - вес объёма V жидкости ($G = \rho g V$);

$\overline{J}$ - сила инерции жидкости, заключенной а объеме V ($J = \rho a V$);

$\overline{Q} = \overline{G} + \overline{J}$ -суммарная массовая сила, равная

$$\overline{Q} = \overline{G} + \overline{J} \quad (Q = \rho q V)$$

Сила давления жидкости на погруженное в нее твердое тело (рис.4) складывается из вертикальной архимедовой силы $P_B = \gamma W$, обусловленной весомостью жидкости, и силы $P_u = \rho a V$ обусловленной инертностью жидкости и направленной вдоль вектора $\bar{a}$ переносного ускорения.

Результирующая сила $\overline{P} = \overline{P}_B + \overline{P}_u$ проходит через центр тяжести вытесненного телом объема V жидкости и направлена в

сторону, противоположную вектору $\bar{q}$ единичной массовой силы.

Решение задачи.

В случае равновесия жидкости в сосуде, равномерно вращающемся относительно вертикальной оси, поле массовых сил $\bar{q}$ неоднородно. Вектор массовой силы $\bar{q}$ - сумма вектора $\bar{g}$ и вектора единичной центробежной силы инерции $\bar{j} = \omega^2 r$, где ω - угловая скорость вращения сосуда. Поверхности уровня представляют собой конгруэнтные[1] параболоиды вращения, ось которых совпадает с осью вращения сосуда (рис.5).

Уравнение поверхности уровня (в частности, свободной поверхности жидкости) во вращающихся вместе с сосудом цилиндрических координатах (r, z) имеет вид:

$$\left(z - z_0\right) = \frac{\omega^2 r^2}{2g} \qquad (13)$$

Две геометрические фигуры называются конгруэнтными, если одну из них можно совместить с другой, изменив только ее положение в пространстве.

где z_0 - вертикальная координата вершины параболоида поверхности уровня;

r, z - координаты любой точки поверхности уровня.

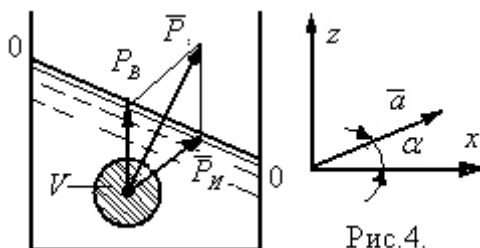Высота параболоида $H = \dfrac{\omega^2 R^2}{2g}$, где R - радиус сосуда.

Рис.4.

Закон распределения давления в жидкости выражается уравнением

$$p = p_0 + \rho\frac{\omega^2 r^2}{2} - \gamma(z - z_0) \qquad (14)$$

где p_0 - давление в точках параболоида поверхности уровня, вертикальная координата вершины которого равна z_0; p - давление в произвольной точке жидкости с координатами r и z.

Из уравнения (14) следует линейность закона распределения давления в жидкости по вертикальному направлению (рис.5). В частности, давление в любой точке на глубине h под поверхностью уровня с давлением p_0 равно:
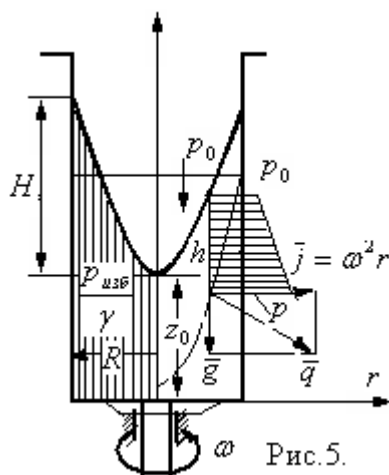
Рис.5.

$$p = p_0 + \gamma h \qquad (15)$$

Избыточное давление в точках на глубине h под параболоидом пьезометрической поверхности (в открытом сосуде- под параболоидом свободной поверхности) равно;

$$p_u = \gamma h \qquad (16)$$

Из того же уравнения (14) следует параболический закон распределения давления по радиусу (см. рис.5. где на левой стороне изображено распределение избыточного давления в точках дна).

Положение свободной поверхности жидкости в сосуде (координата z_0 вершины параболоида) при заданной угловой скорости вращения сосуда определяется объемом находящейся в нем жидкости. При этом используются следующие соотношения:

а) объем параболоида вращения равен половине произведения площади его основания на высоту (рис.5):

$$W_{параболоид} = \frac{1}{2}\pi R^2 H \qquad (17)$$

б) объем жидкости во вращающемся цилиндрическом сосуде в случае, когда свободная поверхность жидкости пересекает дно сосуда, равен (рис.6):

Рис.6.

Рис.7.

Рис.8.

Рис.9.

$$W = \pi\left(R^2 - R\right)\frac{b}{2} = \frac{\pi g}{\omega^2}b^2 \qquad (18)$$

В случае, когда свободная поверхность отсутствует, положение пьезометрической поверхности определяется из условия, что она проходит через точку жидкости, давление в которой равно атмосферному.

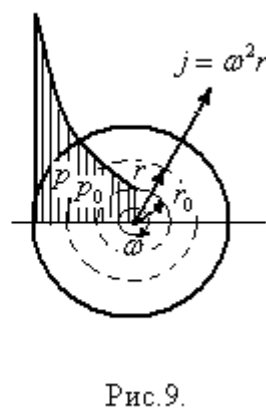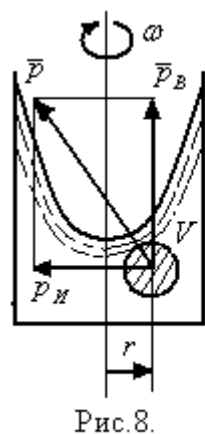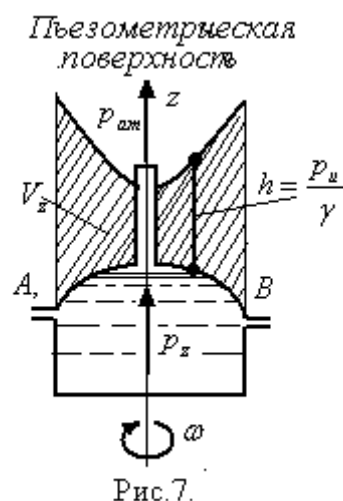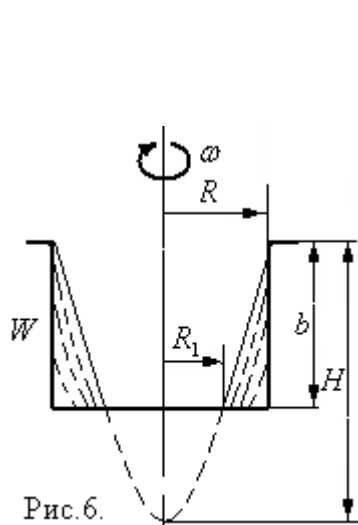Общим методом определения сил давления жидкости на стенки в рассматриваемом случае равновесия жидкости является получение функции, выражающей закон распределения сил давления по заданной поверхности и, далее, интегрирование этой функции по площади стенки. Использование такого аналитического способа расчета иллюстрируется примером 2.

Решение упрощается при определении составляющей силы давления, действующей на стенку вдоль оси вращения сосуда, поскольку инерционные массовые силы не проектируются на это направление. Осевая сила давления жидкости на стенку (рис.7) может быть определена по формуле

$$P_z = \gamma W_z \qquad (19)$$

где V_z - объем тела давления, построенного параллельно направлению z между стенкой и пьезометрической поверхностью. Сила давления жидкости на погруженное в нее твердое тело (рис.8) складывается из вертикальной архимедовой силы $P_B = \gamma W$ и центростремительной силы $P_И = \rho V \omega^2 r$, где r - расстояние от оси вращения до центра тяжести вытесненного телом объема V жидкости; результирующая сила равна $\overline{P} = \overline{P}_B + \overline{P}_И$.

Результаты расчетов и выводы

В случае вращения сосуда вокруг горизонтальной оси поле массовых сил неоднородно и несимметрично относительно оси вращения. При вращении сосуда с большой угловой скоростью единичные центробежные силы инерции $j = \omega^2 r$ велики по сравнению с единичной силой веса g и последней можно в расчетах пренебречь.

При указанном условии поверхности уровня представляют собой концентрические цилиндры с

осями, совпадающими с осью вращения сосуда (рис.9). Закон распределения давления для этого случая выражается уравнением

$$p = p_0 + \rho \frac{\omega^2 \left(r^2 - r_0^2 \right)}{2} \qquad (20)$$

где p_0 - давление в точках цилиндрической поверхности радиуса r_0; p - давление в точках цилиндрической поверхности произвольного радиуса r.

Как видно из уравнения (20), закон распределения давления по радиусу является параболическим.

Такие приближенные решения могут применяться в соответствующих случаях при любом расположении оси вращения сосуда.

Пример 1 (рис. 10.а). Сосуд с квадратным основанием $l \times l$, имеющий собственный вес G, наполнен водой до высоты h и скользит по горизонтальной плоскости под действием груза Q. Найти:

1) высоту H сосуда, необходимую для сохранения в нем всей жидкости во время движения, если задан коэффициент трения f сосуда о плоскость скольжения;

2) величины сил давления воды на переднюю и заднюю стенки сосуда.

Решение. Предварительно определим ускорение a сосуда; из уравнения движения системы сосуд — груз (трением в ролике пренебрегаем)
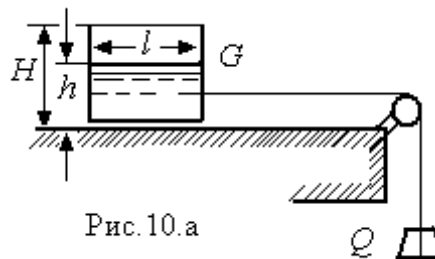
Рис.10.а

$$\left(\frac{G}{g} + \frac{\gamma l^2 h}{g} + \frac{Q}{g} \right) a = Q - \left(G + \gamma \cdot l^2 h \right) f \ ;$$

$$a = g \cdot \frac{Q - \left(G + \gamma \cdot l^2 h \right) f}{Q + G + \gamma \cdot l^2 h} \ .$$
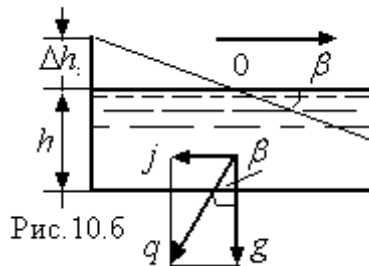
Рис.10.б

При горизонтальном движении сосуда с ускорением a свободная поверхность жидкости наклонится к горизонту под углом β, определяемым из условия, что свободная поверхность нормальна к вектору единичной массовой силы; в данном случае можно непосредственно получить (см. рис.10.б):

$$tg\beta = -\frac{a}{g}$$

Тот же результат получим, используя общее уравнение (5) при $\alpha = 0$.

Для решения первого вопроса задачи вычислим высоту Δh, на которую поднимается жидкость у задней стенки сосуда.

Из условия неизменности объема воды в сосуде следует, что свободная поверхность должна повернуться вокруг оси O, расположенной на середине длины сосуда и нормальной к плоскости движения. Таким образом:

$$\Delta h = -\frac{1}{2} tg\beta = \frac{l}{2} \cdot \frac{a}{g}$$

и требуемая высота сосуда

$$H = h + \Delta h = h + \frac{l}{2} \cdot \frac{a}{g}$$

Сила давления воды на заднюю стенку сосуда [см. формулу (10)] равна:

$$P_1 = \gamma \frac{h + \Delta h}{2} l(h + \Delta h) = \gamma \frac{l}{2}(h + \Delta h)^2 =$$
$$= \gamma \frac{l}{2}\left(h + \frac{l}{2}\frac{a}{g}\right)^2$$

Аналогичным образом сила давления воды на переднюю стенку сосуда

$$P_2 = \gamma \frac{h - \Delta h}{2} l(h - \Delta h) = \gamma \frac{l}{2}(h - \Delta h)^2 =$$
$$= \gamma \frac{l}{2}\left(h - \frac{l}{2}\frac{a}{g}\right)^2$$

Нетрудно видеть, что разность сил P_1 и P_2 равна силе инерции жидкости в сосуде.

Ответ: $P_1 - P_2 = \gamma h \dfrac{al^2}{g}$
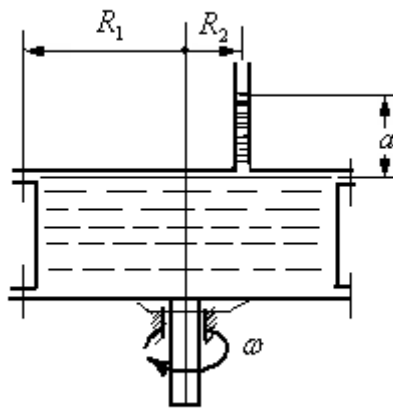
Рис.11.а

Пример 2. Цилиндрический сосуд радиуса R_1 наполнен жидкостью удельного веса γ до уровня a открытой трубке малого диаметра, установленной на крышке сосуда на расстоянии R_2 от центра, и приведен равномерное вращение относительно центральной вертикальной оси (рис.11.а).

1) Определить наибольшую угловую скорость вращения сосуда, до которой сохранится относительное равновесие жидкости.

2) Установить зависимость величины силы давления жидкости на крышку от угловой скорости вращения сосуда.

Решение. Прежде всего, найдем закон распределения избыточного давления в жидкости, заполняющей сосуд. Для этого используем уравнение(14), положив в нем $p_0 = p_{am}$ Тогда

$$p_И = \rho \frac{\omega^2 r^2}{2} - \gamma(z - z_0)$$

Неизвестную высоту z_0 вершины параболоида с атмосферным давлением найдем, используя заданное граничное условие, которое при выборе начала координат в центре крышки имеет вид:

$$p_И = 0 \text{ при } r = R_2 \text{ и } z = a.$$

Подстановка этого условия в последнее уравнение дает:

$$\rho \frac{\omega^2 R_2^2}{2} - \gamma(a - z_0) = 0$$

Откуда

$$z_0 = a - \frac{\omega^2 R_2^2}{2g}$$

и искомый закон распределения давления

$$p_И = \rho \frac{\omega^2}{2}(r^2 - R_2^2) + \gamma(a - z)$$

Impact Factor:

ISRA (India)	= **6.317**	**SIS** (USA)	= **0.912**	**ICV** (Poland)	= **6.630**
ISI (Dubai, UAE)	= **1.582**	**РИНЦ** (Russia)	= **0.126**	**PIF** (India)	= **1.940**
GIF (Australia)	= **0.564**	**ESJI** (KZ)	= **9.035**	**IBI** (India)	= **4.260**
JIF	= **1.500**	**SJIF** (Morocco)	= **7.184**	**OAJI** (USA)	= **0.350**
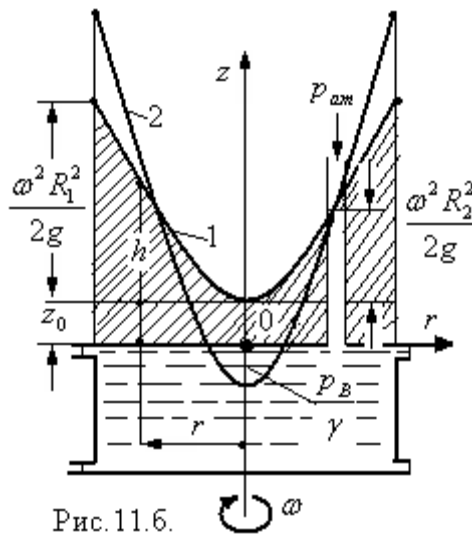
Рис.11.6.

Для точек на поверхности крышки $z = 0$ и распределение избыточного давления

$$p_И = \rho \frac{\omega^2}{2}\left(r^2 - R_2^2\right) + \gamma a$$

Из рис.11.6 видно, что это выражение приводится к виду:

$$p_И = \gamma h$$

где h - глубина точки под пьезометрической поверхностью (параболоид 1).

При возрастании угловой скорости вращения сосуда давление $p_И$, оставаясь постоянным в точках $r = R_2$ ($p_И = \gamma a$), уменьшается в центральной части крышки и увеличивается на ее краях. При достаточно большой величине ω пьезометрическая поверхность пересекает крышку сосуда (параболоид 2) и в ее центральной части возникает вакуум, имеющий максимум в точке *О*. Когда абсолютное давление в точке *О* упадет до давления насыщенных паров жидкости $p_{н.п.}$, произойдет разрыв ее оплошности и жидкость начнет выбрасываться из сосуда. Величину угловой скорости, соответствующей описанному явлению, найдем, используя условие образования разрыва в жидкости:

$$p_И = -\left(p_{ат} - p_{н.п.}\right) \text{при } r = 0$$

Подставляя это значение $p_И$ в уравнение распределение давления на крышке, получим искомую угловую скорость:

$$\omega_{макс} = \frac{1}{R_2}\sqrt{2g\,\frac{p_{ат} - p_{н.п.}}{\gamma} + a}$$
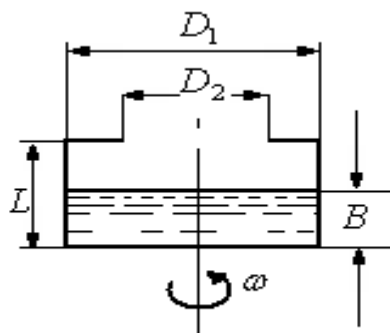
Рис.12.а.

Силу давления на крышку получим аналитическим способом, суммируя элементарные силы избыточного давления.

Разбивая поверхность крышки на элементарные кольцевые площадки и используя формулу для избыточного давления на крышке, получим для любой угловой скорости

$$\omega \prec \omega_{макс}:$$

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$$P = \int_0^{R_1} p_{\text{И}} \cdot 2\pi r dr =$$

$$= \int_0^{R_1} \left[\rho \frac{\omega^2}{2} \left(r^2 - R_2^2 \right) + \gamma a \right] 2\pi r dr =$$

$$= \pi R_1^2 a \gamma + \frac{\pi R_1^2 \gamma}{2g} \left(\frac{R_1^2}{2} - R_2^2 \right) \omega^2$$

Силу P можно найти и геометрическим способом, вычисляя вес тела давления V_z, построенного вдоль оси вращения между смоченной поверхностью крышки сосуда и пьезометрической поверхностью (объем тела давления заштрихован на рис.11.б); используя формулу (17), получим:

$$V_z = \pi R_1^2 z_0 + \frac{1}{2} \pi \frac{\omega^2 R_1^2}{2g} =$$

$$= \pi R_1^2 \left(a - \frac{\omega^2 R_2^2}{2g} \right) + \frac{1}{2} \pi R_1^2 \frac{\omega^2 R_1^2}{2g}$$

Сила давления $P = \gamma \cdot V_z$.

Ответ:

$$P = \pi R_1^2 a \gamma + \frac{\pi R_1^2 \gamma}{2g} \left(\frac{R_1^2}{2} - R_2^2 \right) \omega^2$$

Из полученной зависимости P от ω можно видеть, что если радиус расположения трубки равен $R_2^* = \dfrac{R_1}{\sqrt{2}}$, то сила давления жидкости на крышку сосудане зависит от скорости вращения и равна:

$$P^* = \pi R_1^2 a \gamma$$

Если $R_2 \succ R_2^*$,,то с ростом ω сила P уменьшается, если $R_2 \prec R_2^*$, то с ростом ω сила P увеличивается.

Пример 3. (Рис.12). Цилиндрический сосуд диаметра D_1,и высоты L, имеющий в верхней крышке центральное отверстие D_2, заполнен до высоты B жидкостью удельного веса γ .

Определить:

1) Угловую скорость вращения, при которой жидкость начнет выливаться из сосуда.

2) Силу давления на верхнюю закраину при этой угловой скорости.

Решение. Жидкость начнет выливаться из сосуда, когда ее свободная поверхность по мере увеличения угловой скорости достигнет кромки закраины (точка A на рис.12.б). При этом вершина параболоида свободной поверхности в зависимости от объема жидкости в сосуде может расположиться ниже или выше дна сосуда (параболоиды 1 и 2).

Найдем прежде всего, какому объему жидкости отвечает параболоид 3, вершина которого касается дна; пользуя формулу (17), получим:

$$W^* = \frac{1}{4} \left(D_1^2 - D_2^2 \right) L + \frac{1}{2} \frac{\pi D_2^2}{4} L =$$

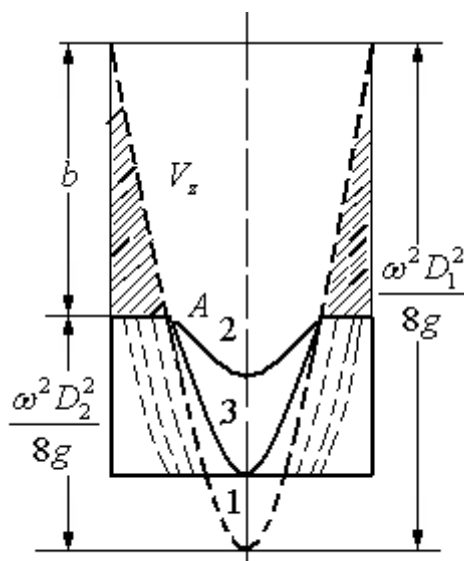$$= \frac{\pi}{4} \left(D_1^2 - \frac{1}{2} D_2^2 \right) L$$

Рис.12.б.

Соответствующая высота заполнения сосуда:

$$B^* = \frac{W^*}{\frac{\pi D_1^2}{4}} = \left(1 - \frac{1}{2}\frac{D_2^2}{D_1^2}\right)L.$$

Если заданная в задаче высота $B \prec B^*$, имеем случай 1. Искомую угловую скорость определим из условия неизменности объема жидкости в сосуде, используя формулу (18):

$$\frac{\pi D_1^2}{4}B = \frac{\pi}{4}\left(D_1^2 - D_2^2\right)L + \frac{\pi \cdot g}{\omega_1^2}L^2$$

$$\omega_1 = \frac{2L}{D_1}\sqrt{\frac{g}{B - \left(1 - \frac{D_2^2}{D_1^2}\right)L}}$$

Если $B \succ B^*$, имеем случай 2; из условия сохранения объема жидкости в сосуде получим с помощью формулы (17):

$$\frac{\pi D_1^2}{4}B = \frac{\pi D_1^2}{4}L - \frac{1}{2}\frac{\pi D_2^2}{4}\frac{\omega_2^2 D_2^2}{8g}$$

$$\omega_2 = \frac{4D_1}{D_2^2}\sqrt{g(L-B)}$$

Выражения для ω_1 и ω_2 совпадают при

$$B = B^*.$$

$$\omega_2 = \frac{2}{D_2}\sqrt{2gL}$$

Сила давления жидкости на закраину вычисляется по формуле (19), в которой объем тела давления:

$$V_z = \frac{\pi g}{\omega^2}b^2 = \frac{\pi g}{\omega^2}\left[\frac{\omega^2 D_1^2}{8g} - \frac{\omega^2 D_2^2}{8g}\right]^2$$

Ответ: Сила давления жидкости на закраину:

$$P_z = \frac{\pi g}{\omega^2}b^2\gamma = \frac{\pi}{2\sqrt{2}\omega}\gamma\left(D_1^2 - D_2^2\right)^2$$

Пример 4. Для измерения ускорения горизонтально движущегося тела может быть использована закрепленная на нем $\bigcup$-образная трубка малого диаметра, наполненная жидкостью. (Рис.13.).
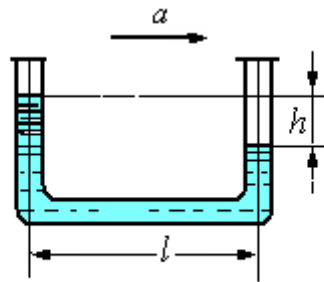
Рис.13

С каким ускорением движется тело, если при движении установилась разность уровней жидкости в ветвях трубки, равна $h = 5 см$ при расстоянии между ними $l = 30 см$?

Решение. При горизонтальном движении сосуда с ускорением a свободная поверхность жидкости наклонится к горизонту под углом β, определяемым из условия, что свободная поверхность нормальна к вектору единичной массовой силы; в данном случае можно непосредственно получить (рис.13.):

Тот же результат получим, используя общее уравнение (5) при $\alpha = 0$.

$$tg\beta = -\frac{a}{g}$$

Находим угол наклона по рис.1.
$tg\beta = -\frac{a}{g} = -\frac{h}{l} = -\frac{5 см}{30 см} = -0,166.$ Отсюда находим

$$a = 0,166 \cdot 9,81\frac{м}{сек^2} = 1,635\frac{м}{сек^2}$$

Ответ: $a = 1,635\frac{м}{сек^2}$.

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OPTIMIZING YOLOv3 DETECTION MODEL USING TERAHERTZ ACTIVE SECURITY SCANNED LOW-RESOLUTION IMAGES

Abstract: Terahertz technology is nonionizing radiation consequently posing less human risk. However, its spectroscopy-scanned images are characterized by low-resolution images thereby posing significant challenges when object detection is to be performed in such images. Recently, deep learning-based detection has shown much prospects owing to their highly based computer vision approach for its superior efficiency and easy network parameter optimization. In this paper, we perform a comprehensive analysis of prominent object detection models based on terahertz images regarding concealed dangerous and prohibited objects in bags, books, wood etc. as often witnessed in airports, subway stations etc. By way of boosting the performance coupled with detection accuracy of the models, we expand our initial terahertz images via image augmentation. Experimental results reveal that one-way detection method for hidden weapons and non-weapons is far better than two-way detection methods. Moreover, we achieved a 2% increased accuracy and an increased rate of 2.5 due to the optimization fromYOLOv3.

Key words: Terahertz image, object detection, deep learning, hidden weapon.
Language: English
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Scopus ASCC: 1700.

Introduction

To mitigate the increased danger of terrorism activities, illicit items in luggage and personal safety at checkpoints in airports, bus terminal and industry entry gates, etc., the use of diverse detection technologies turn to be highly important [1]. Detection systems such as weapon detectors for travelling passengers and X-ray systems [2] for scanning hand-carried gadgets are effective but additionally have their own shortcomings. X-ray imaging systems can penetrate materials such as paper box, leather bag, clothing, wooden boxes as well as the human body. The hazards of X-ray system are that their radiation is very high and they are very detrimental to the human body. The operators staffing these check points who are performing their lawful businesses turn to be in danger as well as the passengers or the clients being attended to at various checkpoints since these X-rays signals reflect, absorb and transmit contrary to terahertz rays. [3–6]

The terahertz (THz) portion of the electromagnetic spectrum, shown in figure 1, extends from approximately 100 GHz to 10 THz (where 1 THz = 1012 Hz corresponding to 4.14 meV). It lies between the microwave and infrared band; the wavelength in this range is 3 mm to 30 μm. THz waves can penetrate numerous non-metallic materials that may be opaque in the range of visible and infrared light. Moreover, as nonionizing radiation, THz waves present minimal known health risks [7].

Terahertz system can also be referred to as the millimeter wave or submillimeter/far-infrared waves (sometimes also called T-rays). THz waves have attracted increased interest due to their capability to non-destructively penetrate strong objects, including, those made of cloth, paper, wood, plastic, and ceramics, and to produce images of the hidden objects. Sub-THz body safety scanners are also encouraged at airports because of their non-ionization effects.

Higher frequency represents shorter wavelength (1–10 mm) [7], which yields higher resolution terahertz images. Weapon detectors can solely identify similar weapon targets, such as metal handguns, knives, blade, screwdrivers as against non-weapon gadgets such as mobile phone, water bottle, board marker, wireless mouse etc.

This paper focuses on terahertz active imaging for security applications and intends to realize high-speed and high-accuracy detection of weapon and non-weapon objects of terahertz scanned images. Deep learning models have great effects on optical images as well terahertz images.

Optical images basic classification and feature extraction strategies brings boundary path histogram [8], Fourier transform, window Fourier transform [9], wavelet transform [10–12], least squares [13],etc. Additionally, it includes histogram of oriented gradient (HOG) [14] and invariant feature transform (SIFT) [15], the most widely used object-detection-and-recognition model is the deformable parts model (DPM) [16], which uses a support vector machine (SVM) [17] to train an object model and retain the best performance unlike the hand-made features, which lack the self-training processing and visual processing. Today artificial neural network (ANN) and convolutional neural network (CNN) LeCun et al [18] depicts from support virtual Machine (SVM) notwithstanding has gradually attracted peoples' interest [19, 20].
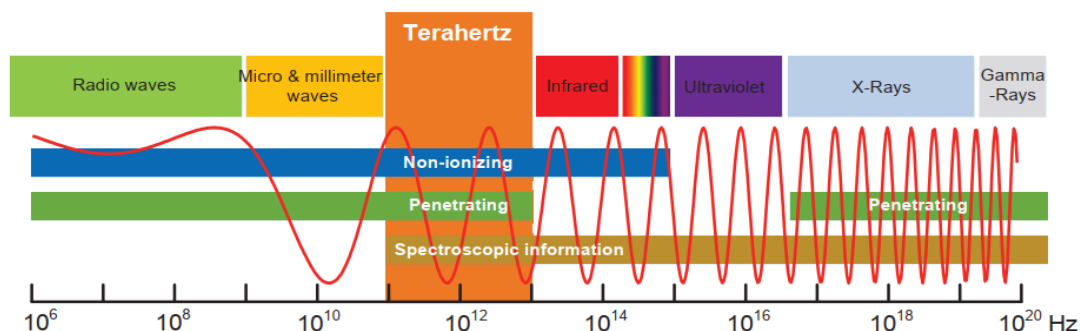
Figure 1 - Terahertz Spectrum region

CNN aims to mimic human perception for intelligent classification, recognition and segmentation. CNNs architectural structure (e.g., AlexNet [21]), the deep structure (e.g., VGG [22], GoogleNet [23], the residual unit embedded structure like ResNet [24], ResNeXt [25], DenseNet [26], DarkNet [27], and the lightweight structure MobileNet [28]. Krizhevsky et al. (2012) with understanding of SVM trained a large, deep CNN (Alexnet) [29]. The activation functions that Rectified linear devices (ReLUs) and others utilized improved nonlinear mapping capacity of this network and lost gradient. Large and improved networks in Alexnet [30, 31] due to more studies in Alexnet [32] Pan et al., (2009). Donahue et al. studied a semi-supervised deep convolution method for multitask mastering of transfer learning. This growing knowledge in CNN turns to caffe best features. Today, caffe is a widely

used open-source framework for deep learning with incredible GPU speed. R-CNN (Fast R-CNN) proposed by using Girshick et al. [33] is a one-stage detection algorithm that improves object proposals and refines their locations and their real-time detection. SNIP [34] discovered the domain-sift and corrects the multi-scale training problem. To solve the problem of multi-scale object detection, STDN [35] introduced a scale-transfer layer into DenseNet without increasing computational complexity. To further boost the detection efficiency, RefineDet [36] combined the RPN and FPN with the fast SSD [37] approach. Fast R-CNN [30], Faster R-CNN [38], R-FCN [39], and YOLO [27] use their numerous features within CNN to predict objects at different scales, as well as SSD [25] and MS-CNN [26]. Combining RPN and Fast R-CNN into a single network, called the Faster R-CNN, the framework of Faster R-CNN and other advanced models, such as the Mask R-CNN [32, 40], adds pixel-level segmentation. PANet [41] was thereafter proposed and has achieved even better segmentation results. The (SPPnet)[42] reduces the training and speed. Spatial pyramid pooling networks had been proposed to speed up R-CNN by way of sharing computation and convolutional features. To solve the micro target detection problem, [23, 29] revised the ResNet by integrating the idea of feature pyramid. PASCALVOC 2007 [43], MS COCO [44] from optical images, x-ray image and terahertz images are slightly different with distinctive imaging mechanisms. Their similarities in frequency spectrum are nearer. As a result, terahertz images of detection have inspection geometry features to optical images and x-ray images, because reflection, absorption, scattering of electromagnetic rays exhibits similar traits like angle, target structure and material penetration factors. In this paper, we attempt to transfer these classification strategies and detection strategies in terahertz images.

In order to detect objects of different scales, a basic strategy is to use **featurized** image pyramids [23] to obtain features at different scales.Yolov3 backbone is also known as Darknet-53 [27] .In this paper, we also adopt this training framework to instruct an effective model network on terahertz weapon and non-weapon security scanned image.

This paper is arranged as follows. In Section 2, the introduction of Terahertz scanned images and augmented dataset arrangements. In Section 3, the methodology of object detection grouped into one-stage, two- stages detector models, and their concealed diagrams are explained. In Section 4, we present the experimental outcomes and corresponding evaluation of the model. Section 5 discusses the optimized best results based on analyzed models and Section 6 concludes this paper.

Dataset Description

In this section, we introduce the acquisition steps of terahertz image and the expansion methods for the image data set, including rotation, translation, affine transformation, transmission transformation and so on. Finally, the corresponding statistical analysis of the expanded data set is carried out.

Data Acquisition

Due to acquisition rate up to 5000 lines per second teraFAST-256 device can accommodate scan speed up to 15 m/s. The sensor has single sensitivity band at 100±10GHz but experimental power source is between 100GHz. The conveyer belt speed of 10.1m/s is for image capture.

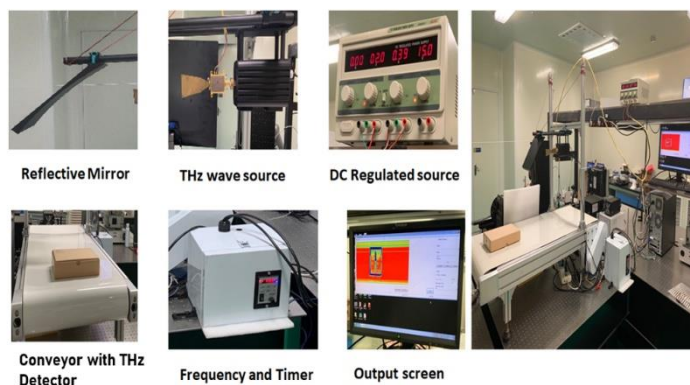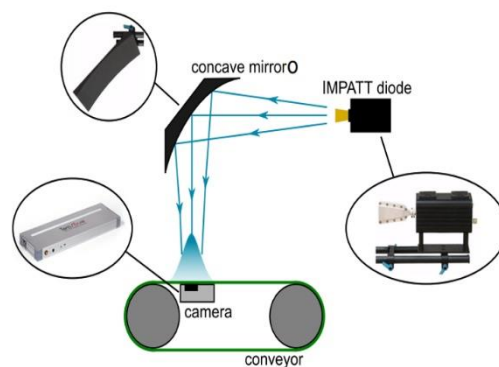**Figure 2 - Terahertz image acquisition**

The size of the image data collected by the device is 512px*256px. For our research, we collected a total of 8 kinds of terahertz images of objects, including 4 types of weapon images and 4 types of non-weapon images (in total, 369 images, because there might be more than one instance of a single image).

The raw data information is shown in table 1 and Figure 3.

Table 1. Original terahertz image data

Class	Screwdriver	Blade	Knife	Scissors	Board marker	Mobile phone	Wireless mouse	Water bottle
Number of images	65	19	66	59	40	40	40	40
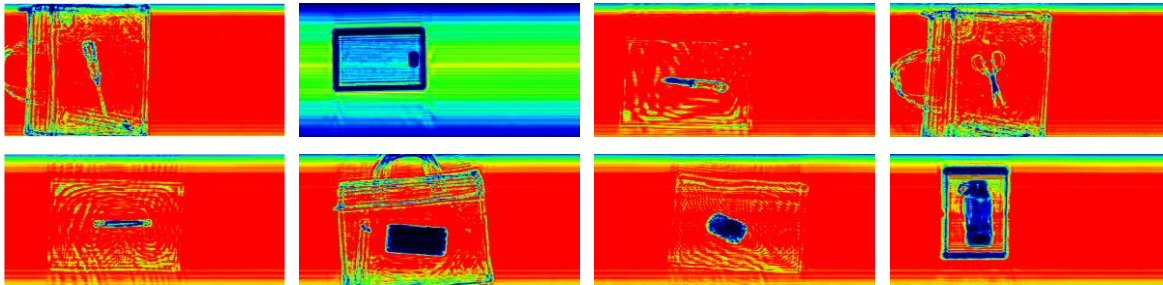
Figure 3 - Scanned THz images

Data Augmentation

It is indisputable fact that terahertz technology is fairly new hence associated images are scanty. It is therefore not bizarre that from the previous steps the number of terahertz data sets collected was too small.

Consequently, the target detection algorithm may be under-fitted in the case of so little data since terahertz image database is uncommon, and the performance of the model cannot meet the actual detection accuracy requirements. For this reason, it is necessary to expand the original image data. The methods of data argumentation used in this study are shown in figure 4.

These image augmentation methods can be used alone or combined with a variety of transformations, that solves the problem of little training data to a certain extent. After augmentation, we get a total of 1884 images, and mark the location of the object. The next section will make a statistical analysis of the augmented data set.
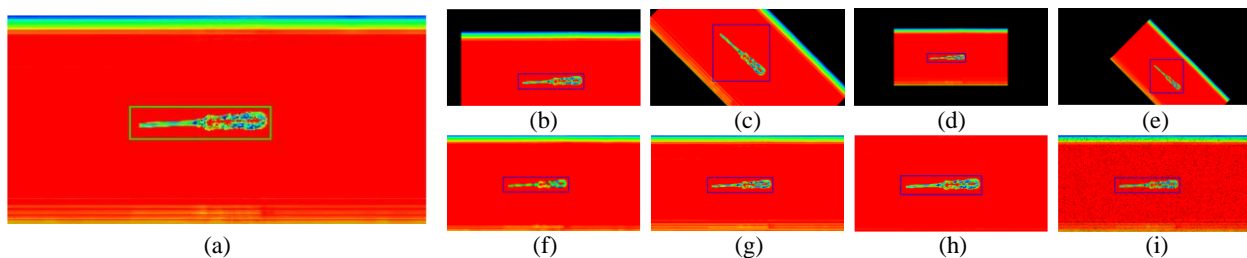
Figure 4 - Methods for augmenting terahertz images. (a) Original image. (b) Translation. (c) Rotation. (d) Scaling. (e) Affine. (f) Blurring. (g) Sharpen. (h) Cropping. (i) Dropout.

Statistical Information of Dataset

The statistical analysis of the data set is helpful for us to understand the characteristics of the data and to optimize the subsequent model. First, we make statistics on the number of instances and the average bounding box size of eight (8) categories, and get the following results:

Table 2. Dataset Statistics Analysis

Class	Number of instances	Average bounding box size
Screw drive	390	108px*84px
Blade	200	36px*35px
Knife	396	89px*75px
Scissors	354	104px*91px
Board marker	240	78px*68px
Mobile phone	240	110px*87px
Wireless mouse	240	70px*75px
Water bottle	240	118px*91px

As can be seen from table 2, the number of blade categories is the fewest, and the average bounding box is also the smallest. Screwdriver and knife are the largest in number and, bounding box is relatively large. In addition, we also counted the ratio of all bounding box areas to the whole picture, and obtained the histogram shown in figure 5.

From the results of figure 5, we can see that most of the bbox area ratio is about 3% to 10%. A small part is concentrated in the 1% area ratio, and the maximum proportion is no more than 25%. Further, we can analyze the size distribution of different types of bbox, as shown in figure 6.

It can be seen from figure 6 that the bbox size of the blade category is relatively small, which may also cause the target detection algorithm to become worse under this category. The sizes of other categories are widely distributed and evenly distributed.

Methodology

In this section, we introduce five target detection algorithms for terahertz images, namely, YOLOv3 and SSD, (one-stage detection) and Faster RCNN as well as Cascade RCNN (two-stage detection). These algorithms will be used to detect weapon class objects and non-weapon class objects in terahertz images.

One-stage detector

The single-stage detector realizes a series of end-to-end processes such as image input, feature extraction, regression location and object classification, and no other processes are introduced as shown in figure 6. This kind of target detection algorithm ensures a certain accuracy under high detection speed, and is also widely used in industrial detection.
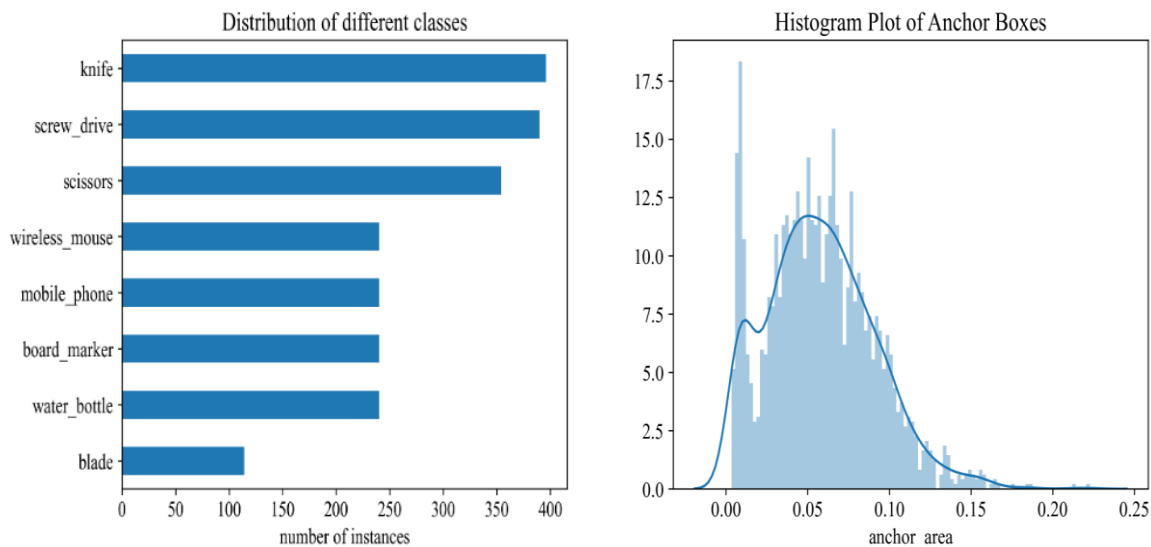
Figure 5 - Graph of Classes distribution & Histogram of Bounding boxes
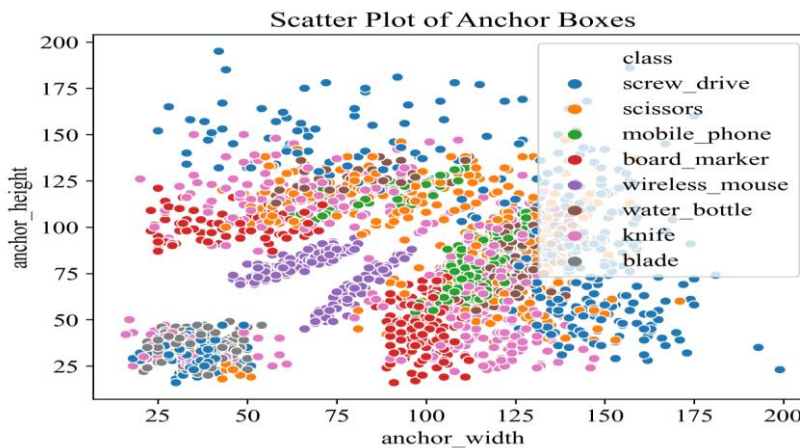
Figure 6 - Scatter diagram of bounding boxes

Figure 7 - One-stage detector Architecture

YOLOv3

YOLOv3 is the improved algorithm for YOLOv2 [27] and uses the darknet-53 network as the feature extraction network and the residual module (residual block).

In order to better detect objects of different scales, YOLOv3 draws lessons from feature pyramid network[45].We refer readers to [45–47] for further information on YOLOv3 regarding the ideas of outputting the three feature graph maps of different sizes. The overall structure of YOLOv3 as shown in figure 8.
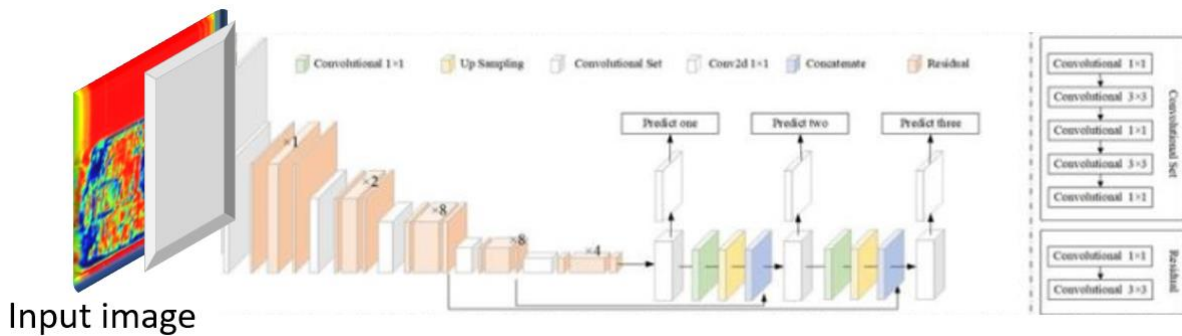
Figure 8 - YOLOv3 Model Structure [48]

The loss function of YOLOv3 is composed of the loss sum of three output characteristic graphs. The loss of each feature graph is composed of bounding box loss, object confidence loss and non-object confidence loss (non-object confidence). The expression is as follows:

$$
\begin{aligned}
loss = &\ \lambda_{box} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbf{1}_{i,j}^{obj} \left[(t_x - t_x)^2 + (t_x - t_x)^2 + (t_x - t_x)^2 + (t_x - t_x)^2 \right] \\
&+ \lambda_{box} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbf{1}_{i,j}^{obj} \left[-\log(p_c) + \sum_{c \in classes} BCE(\hat{c}_i, c_i) \right] \qquad (1) \\
&+ \lambda_{noobj} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbf{1}_{i,j}^{obj} \left[-\log(1 - p_c) \right]
\end{aligned}
$$

In the above formula, the weight control parameter, *tx*, *ty*, *tw*, *th* is the offset, $\mathbf{1}_i^{obj}$ denotes if object appears in cell *i* and $\mathbf{1}_{ij}^{obj}$ denotes that the *j*-th bounding box predictor in cell *i* is "responsible" for that prediction that needs to be learned.

Single Shot MultiBox Detector (SSD)

The Single Shot Detector (SSD) [48] is one of the first attempts to use the pyramidal characteristic hierarchy of the convolutional neural network to detect items of different sizes effectively.
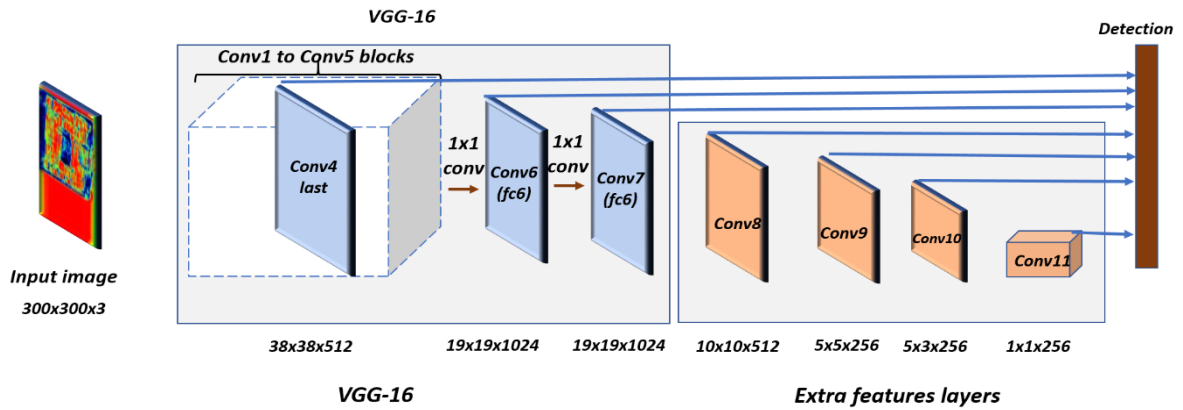
Figure 9 - SDD Model Structure

SDD loss function is the sum of a localization loss and a classification loss.

$$L = \frac{1}{N}(L_{cls} + \alpha L_{loc}) \qquad (2)$$

Where N is the number of bounding boxes matched and where α balances the weights between two losses, chosen by cross validation. The loss of localization is a smooth loss of L1 between the expected correction of the bounding box and the true values. The transformation of the correction of coordinates is the same as what R-CNN does in the regression of bounding boxes.

Where 1_{ij}^{match} indicates whether the i-th bounding box with coordinates $(p_x^i, p_y^i, p_w^i, p_h^i)$ is matched to the j-th ground truth box with coordinates $(g_x^i, g_y^i, g_w^i, g_h^i)$ for any object $d_m^i, m \in \{x, y, w, h\}$.

$$\mathcal{L}_{cls} = -\sum_{i \in pos} 1_{ij}^k \log(\hat{c}_i^k) - \sum_{i \in neg} \log(\hat{c}_i^0), \text{ where } \hat{c}_i^k = \text{softmax}(c_i^k) \qquad (3)$$
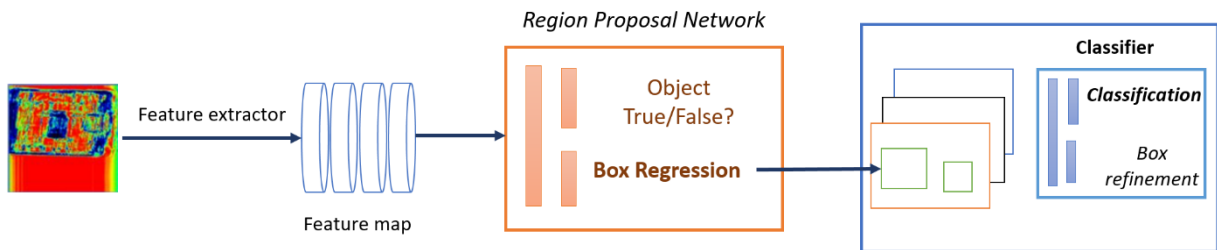
Figure 10 - Two-Stage detector architecture

Where 1_{ij}^k indicates whether the *i-th* bounding box and the *j-th* ground truth box are matched for an object in class k [48].

The R-CNN clusters of models are all regional focused from figure 8. The detection takes place in two stages: (1) first, by selecting search or regional proposal network the model proposes a collection of regions of interest. The regions proposal network are sparse as possible candidates for the bounding box may be infinite. (2) Secondly, only the region candidates are processed by a classifiers [49].

Faster R-CNN

To incorporate the area proposal algorithm into the CNN model, an intuitive speed-up solution is Faster R-CNN [50] which does exactly this: create a single, unified model consisting of RPN (region proposal network) and fast R-CNN with shared convolution layers.
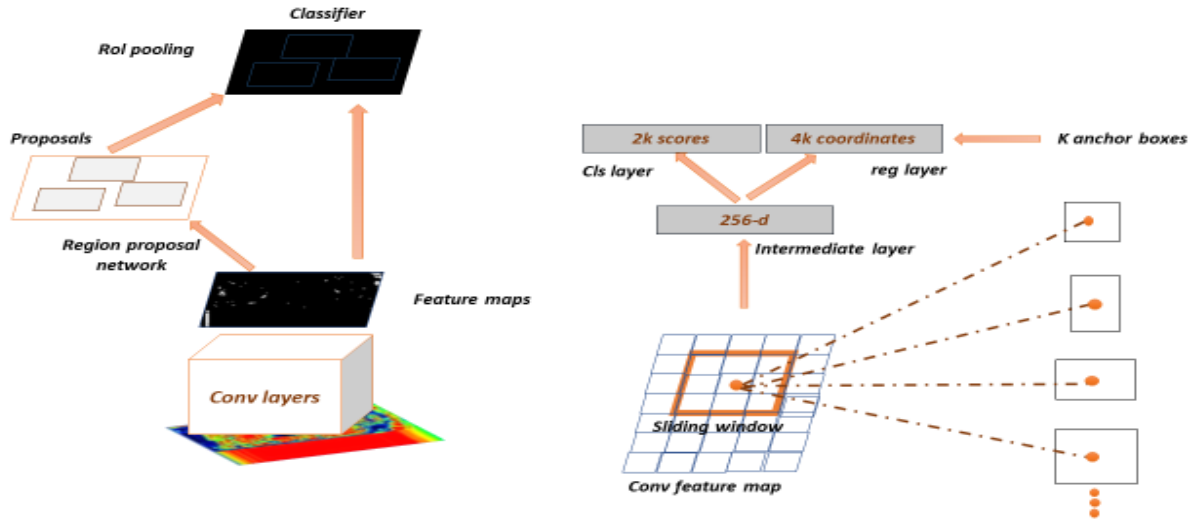
Figure 10 - Faster R-CNN Model Structure

Faster R-CNN is optimized for a multi-task loss function [49]

Symbol   Explanation

p_i Predicted probability of anchor i being an object.

p_i^* Ground truth label (binary) of whether anchor i is an object.

t_i Predicted four parameterized coordinates.

t_i^* Ground truth coordinates.

N_{cls} Normalization term, set to be mini-batch size (~256) in the paper.

N_{box} Normalization term, set to the number of anchor locations (~2400) in the paper

λ A balancing parameter, set to be ~10 in the paper (so that both L_{cls} and L_{box} term are roughly equally weighted.

The multi-task loss function combines the losses of classification and bounding box regression:

$$\mathcal{L} = \mathcal{L}_{\mathrm{cls}} + \mathcal{L}_{\mathrm{box}}$$

$$\mathcal{L}(\{p_i\},\{t_i\}) = \frac{1}{N_{\mathrm{cls}}}\sum_i \mathcal{L}_{\mathrm{cls}}(p_i, p_i^*) + \frac{\lambda}{N_{\mathrm{box}}}\sum_i p_i^* \cdot L_1^{\mathrm{smooth}}(t_i - t_i^*)$$

(4)

Where L_{cls} is the log loss function over two classes, as we can easily translate a multi-class classification into a binary classification by predicting a sample as being a target object otherwise L_1^{smooth} is the smooth L_1 loss.

$$\mathcal{L}_{\mathrm{cls}}(p_i, p_i^*) = -p_i^*\log p_i - (1 - p_i^*)\log(1 - p_i)$$ (5)

Mask/Cascade R-CNN

Mask R-CNN [32] extends Faster R-CNN to segmentation of images at pixel level. The key point is to decouple prediction activities from the classification and the pixel-level mask.

It introduced a third branch, based on the Faster R-CNN architecture, to predict an object mask in parallel with existing branches for classification and localization. The mask branch is a small completely linked network added to each RoI predicting a pixel-to - pixel segmentation mask.

Since segmentation at the pixel level involves much more fine-grained alignment than bounding boxes, the R-CNN mask enhances the RoI pooling layer (named " PsRoI Pooling layer") so that RoI can be better and more accurately mapped to the regions of the original image. The PsRoI Pooling layer is designed to fix the location misalignment caused by quantization in the RoI pooling. Bilinear interpolation is used to measure the input values of floating-point positions [51].
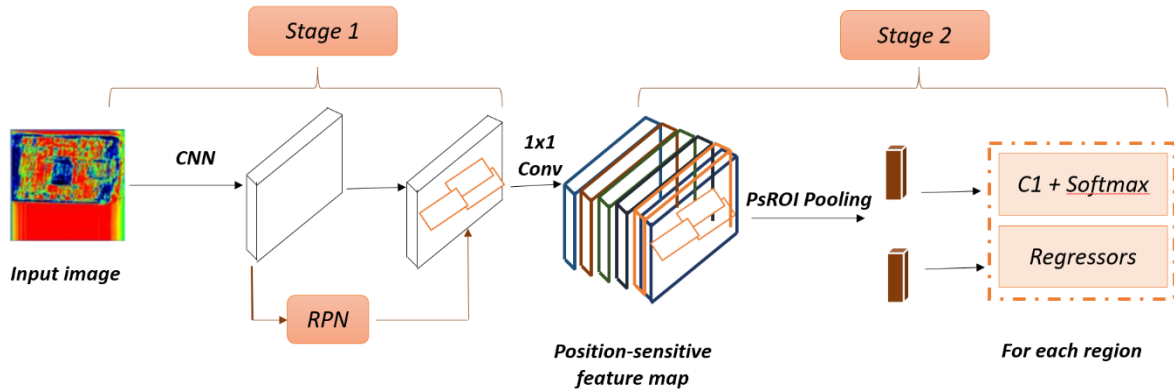
Figure 11 - Mask R-CNN Model Structure

The multi-task loss function of Mask R-CNN combines the loss of classification; localization and segmentation mask $\mathcal{L} = \mathcal{L}_{cls} + \mathcal{L}_{box} + \mathcal{L}_{mask}$ where $\mathcal{L}_{cls}$ and $\mathcal{L}_{box}$ are same as in Faster R-CNN. The mask branch generates a mask of dimension m x m for each RoI and each class; K classes in total. Thus, the total output is of size $K*m^2$.

$\mathcal{L}_{mask}$ is defined as the average binary cross-entropy loss, only including k-th mask if the region is associated with the ground truth class k.

$$L_{mask} = -\frac{1}{m^2} \sum_{1 \leq i,j \leq m} [y_{ij}\log\hat{y}_{ij}^k + (1 - y_{ij})\log(1 - \hat{y}_{ij}^k)] \qquad (6)$$

where y_{ij} is the label of a cell (*i, j*) in the true mask for the region of size m x m; $\hat{y}_{ij}^k$ is the predicted value of the same cell in the mask learned for the ground-truth class k [49].

Experimental Results and Discussion

In this section, we first introduce the indicators used to evaluate the accuracy of the detection model.

Secondly, we compare and analyze the detection results of the five detection models mentioned above under the terahertz image data set, and discuss the differences between them.

Finally, we select a model with the best detection speed and accuracy as our final detection algorithm for security detection of terahertz images. The hardware and software configuration of experiments is shown in Table 11.

Table 3. Hardware and software configuration of experiment

Hardware/Software	Parameters
Operating System	Ubuntu18.04 LTS 64bit (Linux 4.15)
Central Processing Unit	Intel(R) Core (TM) i7-7800X CPU @ 3.50GHz
Graphical Processing Unit	NVIDIA RTX 2080(8G)
RAM	DDR4 32G
CUDA	CUDA 10.1
cuDNN	cuDNN 7.6.1
Deep Learning Framework	PyTorch 1.4

Evaluation for Metric Detection

In this paper, we adopted the detection metrics introduced in [22] applied to table 5, which includes average precision (AP) over multiple Intersection over Union (IoU) values. The IoU can be calculated in equation 7.

$$IoU(Box_{pred}, Box_{gt}) = \frac{Box_{pred} \cap Box_{gt}}{Box_{pred} \cup Box_{gt}} \qquad (7)$$

The calculations of precision and recall are shown in Figure 12. Traditionally, The average precision (AP) is a detection measure which combines the classification accuracy and location accuracy for each object. *mAP* is the mean AP for all objects. (likewise AR and mAR).

Unless otherwise specified, AP and mAP used in this paper. The detection metrics are listed in Table 4.
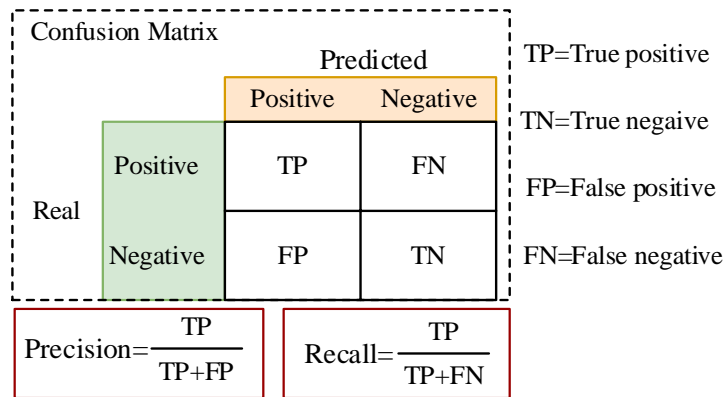
Figure 12 - Calculation of precision and recall.

Datasets and Training Configuration

The target detection task not only needs to determine which object it belongs to, but also needs to determine the location of the object. This paper uses the evaluation indicators used in the COCO data set and the labelImg software tool. We included the average precision (AP) and average recall (AR) indicators, with results further subdivided into: under small (area smaller than 32px*32px), medium (area between 32px*32px and 96px*96px) and large (area larger than 96px*96px) detection areas. Finally, the augmented data total of 1884 images, and divide the training, and test sets at the proportion of 4:1:1. Finally, we randomly divided the data samples get 1205 training sets, 302 validation sets and 377 images of the test set. In order to ensure the rationality of the

algorithm comparison, we uniformly use the parameters shown in table 5 during the model-training phase.

AP (averaged across all 10 IoU thresholds and all categories) should be considered the most important metric when considering model performance in our research. For metric AR, the larger the value the lesser the false negative rate which is important for defect inspection along the overhead transmission line. Finally, in order to measure the image detection speed of different models, we also use the detection speed index: frame per second (FPS).

To train the defect detection model introduced in previous section 2, it is essential to setup the training configurations properly. In our research, we use the configurations listed in Table 5.

Table 4. Dataset information for training and testing

Metric	Meaning
AP	Average precision for [IoU = 0.50:0.95 | area = all | maxDets = 100]
$AP^{@0.5}$	Average precision for [IoU = 0.50 | area = all | maxDets = 100]
$AP^{@0.75}$	Average precision for [IoU = 0.75 | area = all | maxDets = 100]
AP^{small}	Average precision for [IoU = 0.50:0.95 | area = small | maxDets = 100]
AP^{medium}	Average precision for [IoU = 0.50:0.95 | area = medium | maxDets = 100]
AP^{large}	Average precision for [IoU = 0.50:0.95 | area = large | maxDets = 100]
AR^{1}	Average recall for [IoU = 0.50:0.95 | area = all | maxDets = 1]
AR^{10}	Average recall for [IoU = 0.50:0.95 | area = all | maxDets = 10]
AR^{100}	Average recall for [IoU = 0.50:0.95 | area = all | maxDets = 100]
AR^{small}	Average recall for [IoU = 0.50:0.95 | area = samll | maxDets = 100]
AR^{medium}	Average recall for [IoU = 0.50:0.95 | area = medium | maxDets = 100]
AR^{large}	Average recall for [IoU = 0.50:0.95 | area = large | maxDets = 100]

Table 5. Models Training Parameters

Parameter	Value
Training epochs	50f
Optimizer	Adam
Learning rate	1e-4
Batch size	8

Evaluation results

After completing the model training, we evaluate the performance of the five models on the test set.

Since there are eight categories to be detected, we first present the overall results in table 6.

As can be seen from table 6, the yolov3 model has the best results in evaluating the overall performance of the dataset.

Table 6. Models Evaluation Performance

Metric	yolov3	SSD300	SSD512	Faster RCNN	Cascade RCNN
AP	0.739	0.713	0.716	0.562	0.632
$AP^{0.5}$	0.992	0.963	0.981	0.884	0.878
$AP^{0.75}$	0.854	0.774	0.828	0.596	0.669
AP^{small}	0.51	0.339	0.345	0.26	0.221
AP^{medium}	0.705	0.681	0.695	0.524	0.599
AP^{large}	0.816	0.781	0.776	0.643	0.682
AR^{1}	0.763	0.747	0.744	0.624	0.678
AR^{10}	0.791	0.759	0.756	0.652	0.697
AR^{100}	0.791	0.759	0.756	0.652	0.697
AR^{small}	0.699	0.366	0.472	0.358	0.282
AR^{medium}	0.761	0.727	0.733	0.617	0.658
AR^{large}	0.85	0.823	0.808	0.709	0.74

The higher the AP, the higher the true positive rate, the average recall, and the smaller the false negative rate, which is very important in the field of security. To ensure high recognition accuracy, it is also necessary to ensure a lower missed detection rate.
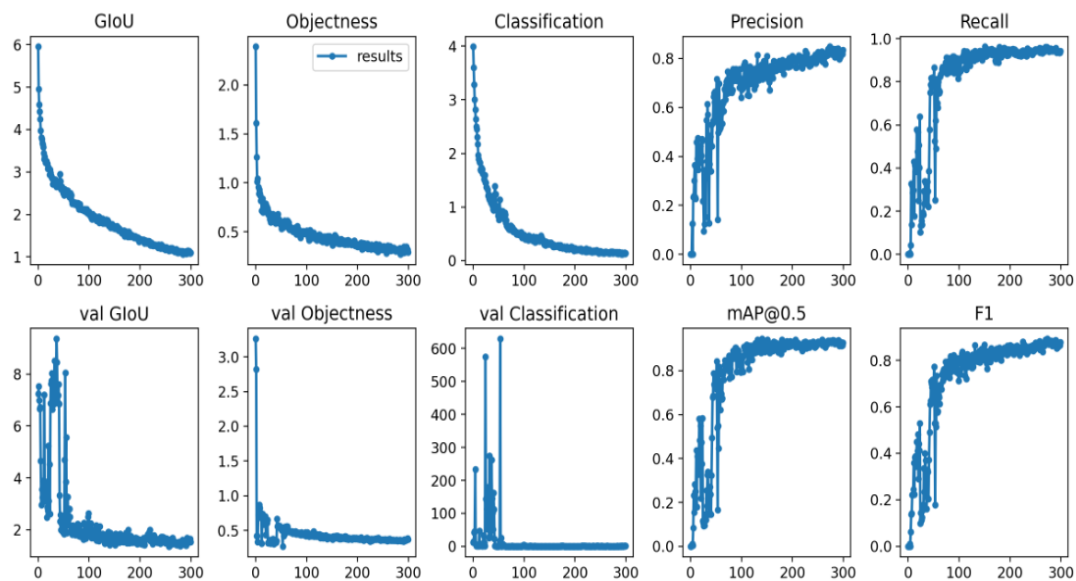
Figure 13 - Yolov3 training Model

The more surprising result is that the performance of two-stage detector Faster RCNN and Cascade RCNN on terahertz data is not satisfactory, and its AP index decreases by 23.9% and 14.5% respectively compared with yolov3. The detection effect of the model is the worst. For SSD300 and SSD512 models, there is little difference in AP indicators, but in AP0.5 and AP0.75 indicators, SSD512 model is 1.9% and 6.5% higher than SSD300 respectively. The reason is that SSD300 zooms to 300px*300px size during image input, while the original image is 512px256px. A lot of feature information is lost after image compression, resulting in a decline in SSD300 performance. However, compared with the yolov3 model, the SSD500 model still decreased by 3.1% under the AP index. The calculations of precision and recall are shown in Figure 6.

In table 7, we analyze the recognition effect of six (6) categories and select AP as the analysis index, which is stricter to the detection accuracy.

Table 7. Model Detection Accuracy for hiding weapons & non-weapons

Category	yolov3	SSD300	SSD512	Faster RCNN	Cascade RCNN
Screw drive	0.659	0.642	0.63	0.409	0.449
blade	0.539	0.479	0.557	0.26	0.385
knife	0.642	0.563	0.594	0.326	0.33
scissors	0.695	0.605	0.608	0.433	0.455
Board marker	0.78	0.803	0.771	0.663	0.773
Mobile phone	0.899	0.878	0.875	0.837	0.886
Wireless mouse	0.832	0.868	0.826	0.748	0.907
Water bottle	0.87	0.866	0.865	0.816	0.872
mAP	0.740	0.713	0.716	0.562	0.632

Combined with the detection accuracy results obtained above, we use AP as abscissa and AR as ordinate to draw figure 13 to show the results, in which the circle size represents the speed of model reasoning.

Table 8. Inference Models with time

Model	yolov3	SSD300	SSD512	Faster RCNN	Cascade RCNN
Inference time (ms per image)	21.2	50.4	61	79.6	61
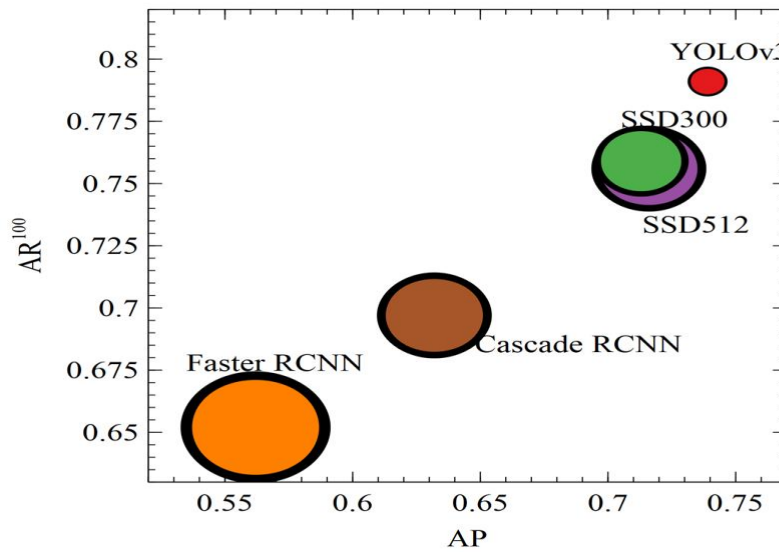
Figure 14 - Comparison of models' detection performance

From figure 14, we can see that while ensuring the detection performance, yolov3 also ensures the detection speed. Compared with other models, yolov3 is more superior. Figure 15 shows the recognition results of yolov3 in different categories.
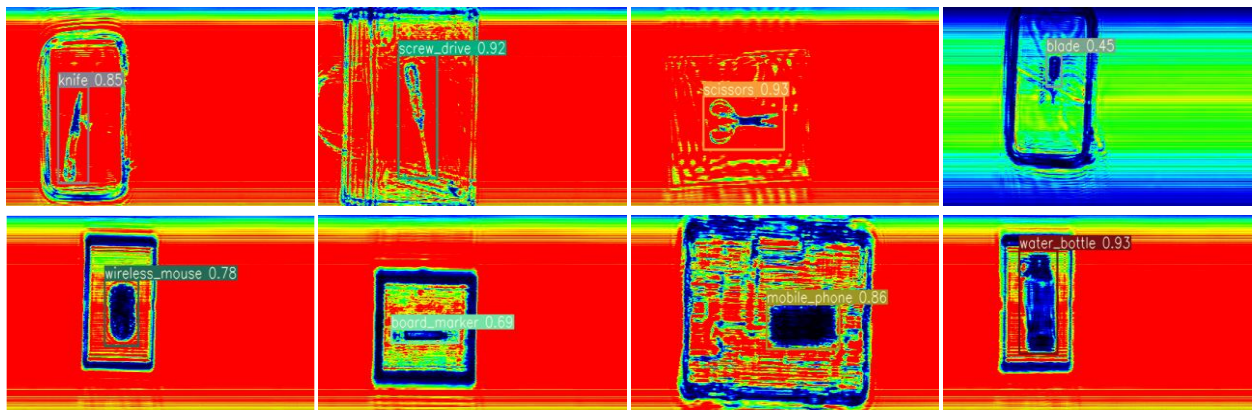
Figure 15 - True-Recognition of hidden weapons and non- weapons

It can be seen that it is good to identify the type and the specific location of objects. However, when we check the model test results, we also find that the probability of false recognition of category blade is relatively high, and it is easy to be wrongly identified as scissors, knife, and screen drive as shown in figure 15.

It is necessary to further improve the recognition effect of this category.

Optimizing YOLOv3

From the previous experimental results, we can see that among the single-stage and two-stage algorithms proposed in this paper, the YOLOv3 algorithm is currently the best in terms of detection accuracy and speed, and the detection speed can achieve 21.2ms image, which is close to the acquisition speed of terahertz images.
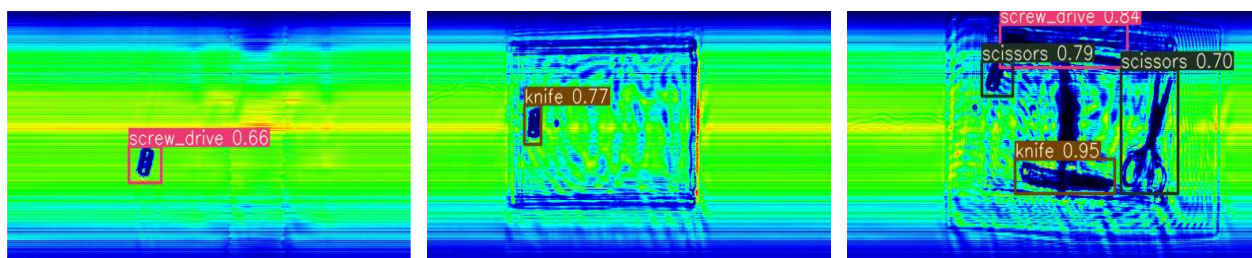
Figure 15 - Falsehood –Recognition of hidden weapons

In order to further improve the detection speed and ensure sufficient accuracy, we will improve the backbone and neck parts of YOLOv3 in this section.

Optimizing Backbone

The overall structure of YOLOv3 includes data input, backbone, neck and head, for detection. The schematic diagram of the structure is shown in figure 16.

In the previous experiment, the backbone of the YOLOv3 detection model is the darknet53 network proposed by [27] which draws lessons from the resnet network, so there are more convolution layers to extract image features.

Here we draw lessons from the cross stage partial structure proposed in the [27] to transform the darknet53, and its structure is shown in figure 16.
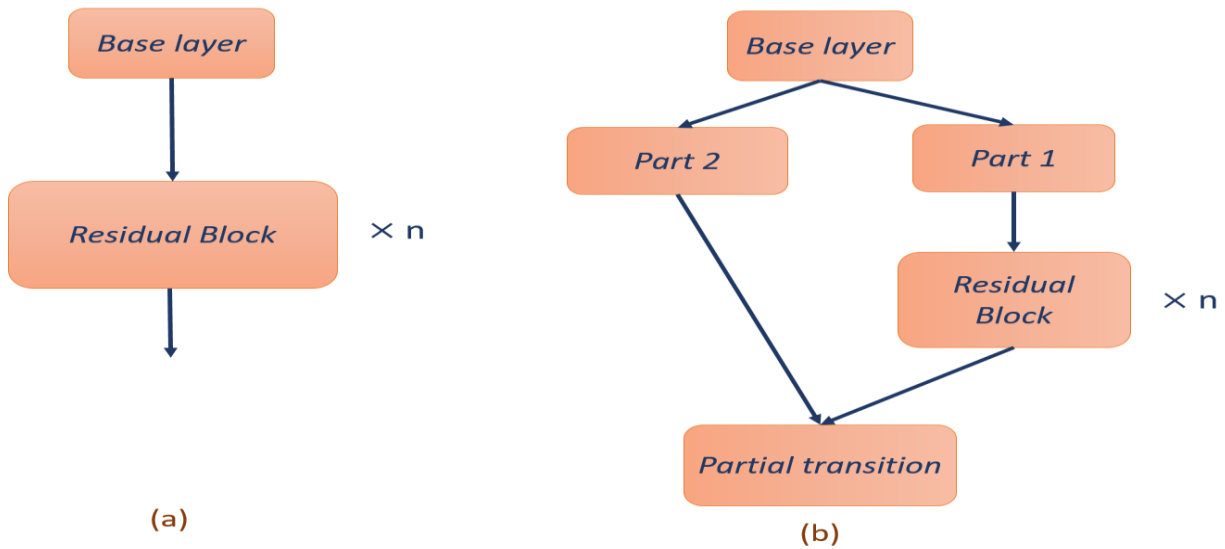
Figure 16 - Our model structure

The graph (a) is the original darknet structure, and the graph (b) is the improved structure where Partial transition represents the convolution operation and pooling operation. Using this structure can not only ensure accuracy, but also effectively reduce the calculation of the model, so as to obtain faster reasoning speed.

Optimizing Neck

In the neck section, our improvement is to add PANet and SPP structures. The structure of PANet is as shown in figure 17.

The function of adding bottom-up path augmentation network to the FPN network is to make full use of the object position information in the shallow features, which will help to improve the target position detection accuracy of the network.
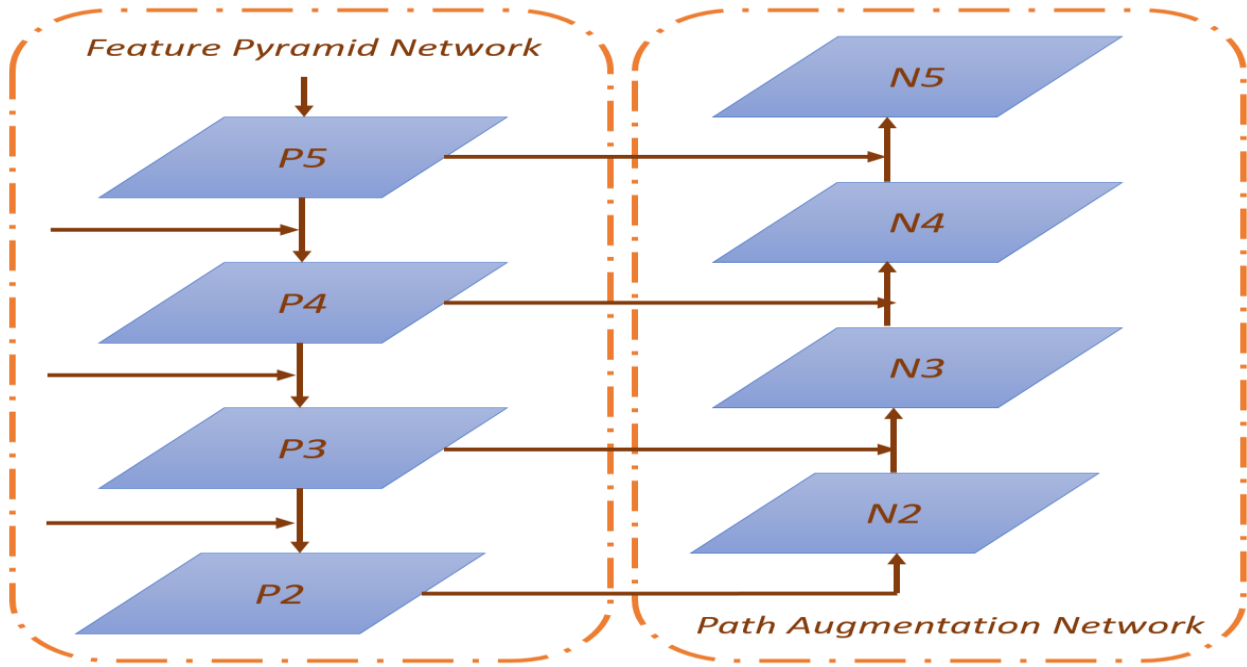
Figure 17 - The structure of PANet

SPP network solves the problem of fusion of different size features, and can ensure that images of different sizes are input during training and testing.

Experimental Results and Discussion

After improving the structure of YOLOv3, we use the previous experimental conditions and data sets to retrain, and evaluate the results of the improved model on the test set. The training graph and results are shown in figure 18.
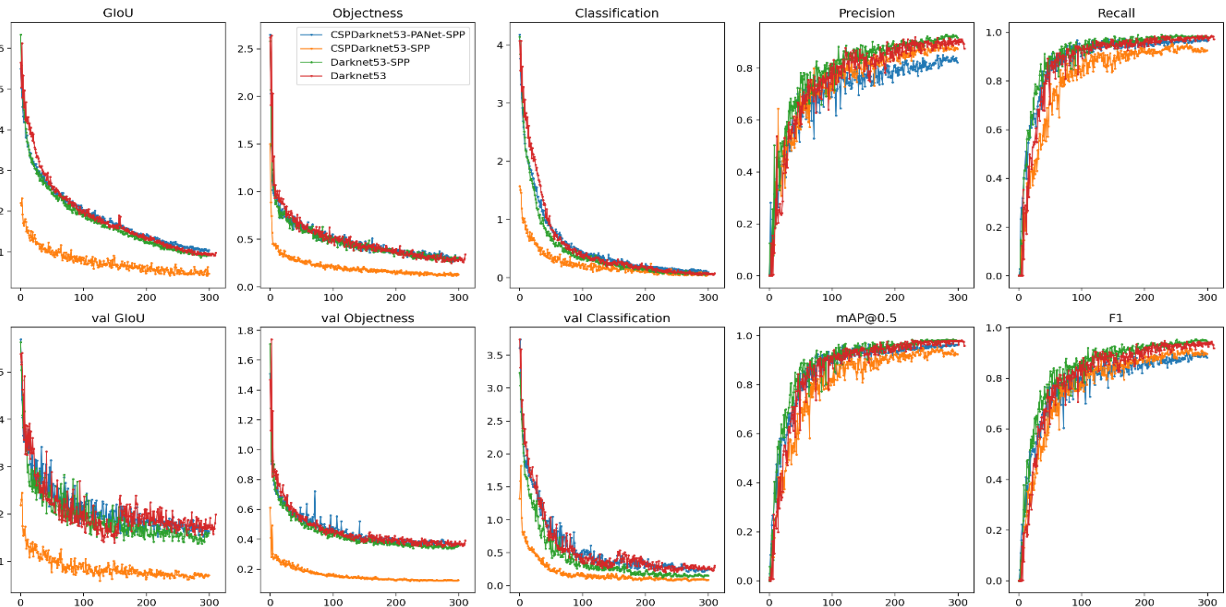
Figure 17 - Our Optimization Training Model

Table 8. Optimized model

Model	AP	AP0.5	AP0.75	AP_{small}	AP_{medium}	AP_{large}	Inference time(ms)
Darknet53	0.739	0.992	0.854	0.51	0.705	0.816	21.2
Darknet53-SPP	0.735	0.991	0.855	0.591	0.703	0.8	21.5
CSPDarknet53-SPP	0.733	0.986	0.864	0.534	0.716	0.788	6.9
CSPDarknet53-PANet-SPP	0.748	0.99	0.873	0.585	0.725	0.804	8.4
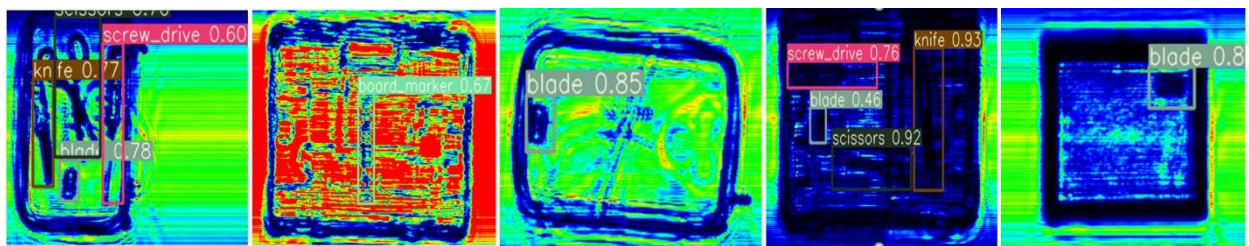
Figure 18 – Improved Yolov3 model correctly identifies blade
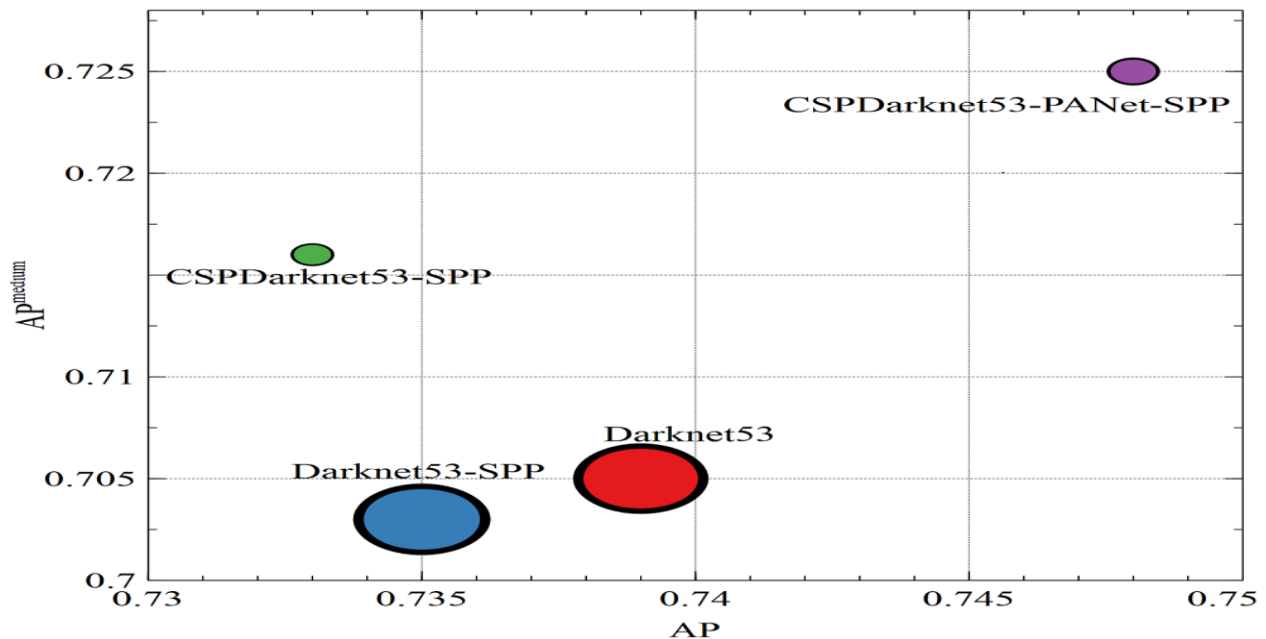
Figure 17 - Comparison of different optimized models

After the backbone structure of YOLOv3 blade detection has been signiificantly improved better than the former at Figure 18.

From the comparison results of the above table, it can be seen that the detection speed of the modified backbone model CSPDarknet53-SPP and CSPDarknet53-PANet-SPP is 3.1 and 2.5 times faster than that of the yolov3 model with Darknet as backbone, respectively.

Among them, the reasoning speed of CSPDarknet53-PAN-SPP model is 17% slower than that of CSPDarknet53-SPP without PAN (path aggregation network), and the increased time loss mainly occurs in the process of characteristic information propagation in PANet.

However, the adoption of the PANet structure also brings a 2% performance improvement to the AP index of the model.

From the optimization results of yolov3, the reasoning speed of the model is greatly improved by using the new CSPDarknet53 network, but the improvement in prediction accuracy is not very

obvious. Considering the detection speed and accuracy, CSPDarknet53-PANet-SPP network will be the best choice for detecting terahertz images.

Conclusions

In this paper, we perform a comprehensive comparative study of five deep learning detection algorithms for detecting terahertz hidden weapons and non-weapons objects. We also performed data argumentation to increase the database. In other terms, the greater the Dataset, the greater the improved detection method efficiency achieved.

On the successful distribution of hidden weapons and non-weapons in terahertz image, we implement large average recall and average precision of intersection of union (IOU) parameters. In addition, we pooled this approach and Yolov3 into a uniform terahertz detection system and it performed the best as compared to other deep learning models proving that one-way detection method for hidden weapons and non-weapons is far better than two-way detection methods.

It can also be deduced from experimental results that after optimization of *Yolov3*, the detection speed and accuracy of our new model out performs five elected existing models with respect to the detection of hidden weapons and non-weapons in terahertz images.

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MODERN ASPECTS OF DIAGNOSIS AND TREATMENT OF ACUTE CALCULUS CHOLECYSTITIS IN PATIENTS WITH INCREASED OPERATIONAL RISK (Literature review)

Abstract: The authors conclude that for each surgical intervention there are separate indications, mainly as a justification of contraindications for video laparoscopic cholecystectomy, most of the contraindications are due to destruction of the gallbladder, its infiltrate, and pathology of the extrahepatic biliary tract. According to the authors, laparoscopic cholecystectomy overcomes contrain-dications to traditional cholecystectomy, and is feasible in patients with high operational risk. As a result of a long-term study, the authors showed all the positive aspects of laparoscopic cholecystectomy compared with laparotomy.

Key words: gallstone disease, acute cholecystitis, surgery, elderly and senile age.

Language: English

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Introduction

Acute cholecystitis is quite widespread in urgent abdominal surgery and is currently still relevant. In most cases, the cause of the disease is gallstone disease. [1,2,18]. Gallstones are the cause of acute cholecystitis (AC) in 80-95% of patients with varying degrees of severity of pathomorphological changes in the wall of the gallbladder (GB) [3,6].

In developed countries, 10-15% of the adult population suffer from cholelithiasis. The prevalence directly depends on the age and gender of the patients. According to different authors, in the general structure of AC morbidity, patients aged 60-71 account for 32 to 52.6%, 51-60 years - 26%, 41-50 years -14%. The incidence of AC in the age groups 21-30 years old and 31-40 years old averages 7-8%. [18,12,7,4]. Despite

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the fact that the diagnostic criteria are constantly being improved, and the methods of treatment have undergone significant changes due to the advent of minimally invasive technologies, there is no unequivocal proposal for the diagnosis, treatment and prevention of the development of all kinds of complications in this age group. In particular, men suffer from this disease two times less often than women, respectively. Every fifth of women aged 40 and over is faced with cholelithiasis, while men of the same age are faced with it in every tenth case. According to the Third National Health and Nutrition Examination Survey, 6.3 million men and 14.2 million women aged 20 to 74 in the United States had gallbladder disease [45,47,49,51]. In Europe, the Italian Multicenter Study for Gallstone Disease examined nearly 33,000 subjects between the ages of 30 and 69 in 18 cohorts from 10 regions in Italy. The overall incidence of gallstone disease was 18.8% for women and 9.5% for men [34]. However, the prevalence of gallstone disease (GSD) varies significantly depending on ethnicity, for example, the lowest incidence is noted in Ireland (5%), and the highest in Sweden (32%) [38]. The indigenous population of Africa almost does not suffer from gallstones, the frequency of the latter is 1% [9,46], African-American women - three times less often than Indo-American women. In Chile, cholelithiasis is found in 55% of women and 30% of men. Among Pima Indians, gallstone disease is observed in 45% of men and 75% of women, and in women after 70 years - in 90%, which is due to a genetic decrease in the pool of bile acids [50]. In Russia, the annual appealability for gallstones is on average 5-6 people per 1000 population [12]. In Kazakhstan, 22.4% of calls to an ambulance are for gallstones, acute and chronic cholecystitis, [8,17]. More than 750,000 cholecystectomies are performed annually in the United States and the cost of treating these patients is approaching $ 10 billion [48,51,52]. Uzbekistan also belongs to the regions with an increased tendency of patients with calculous cholecystitis, detected by the appeal of the population for medical care, and is 5.82 per 100 thousand, and the number of operations carried out in the republic for complicated forms of calculous cholecystitis ranges from 1 to 1.5 thousand a year. The steady increase in the number of patients with cholelithiasis leads to an increase in its complications from 17 to 83%, often requiring urgent surgical intervention. At the same time, postoperative complications and mortality after emergency operations remain several times higher than with planned surgical interventions [15,25,26], and among males, this figure can reach 27%. The gender of patients should also be considered as an additional factor in the increased risk of morbidity, mortality and possible intraoperative complications. At the same time, according to various authors and according to our data in men, clinical manifestations of acute calculous cholecystitis are by no means always expressed clinical manifestations, which sometimes leads to severe changes in the gallbladder and complicates the operation technique with inevitable conversion [14,16,26].

As for purulent complications in acute calculous cholecystitis (ACC), the leading place is occupied by perivesical infiltrate (15.0%) and empyema of the gallbladder (12.4-16.1%), then subhepatic abscess (2.3-3.6 %), dropsy of the gallbladder (4.7-7.2%), local peritonitis (0.4-1.3%) and diffuse peritonitis (1.4-2.3%) [15]. To conduct a systematic search of scientific information and to achieve this goal, an analysis of the recommendations of the World Society for Emergency Surgery 2016 (Israel) and Tokyo Recommendations 2007 and 2013 (Japan), as well as scientific publications in evidence-based medicine databases (PubMed) was carried out, with using specialized search engines (Google Scholar) and in electronic scientific libraries (CyberLeninka, e-library) from 1990 to 2018 [29].

In the last decade, in order to improve the diagnosis and treatment of ACC, a number of targeted scientific studies have been carried out in the world, including screening for the early detection of patients and the provision of timely therapeutic and preventive care, the development of various methods of operations, including tactical aspects of performing endosurgical interventions.

The Tokyo Clinical Guidelines (TG07) for the treatment of acute cholecystitis were first published in 2007. The main goal of the TG07 was to achieve a consensus among specialists in this field worldwide [29]. Later, in clinical practice, the low diagnostic sensitivity of TG07 in relation to AC and the relationship between the assessment of the severity of the condition and the clinical characteristics of the disease was proved [29,54].

To date, some of the TG13 recommendations are outdated, the OC scoring system has not been tested and proven reliable. Finally, the conclusions are unclear, as all different therapeutic options are available for the same "level of cholecystitis severity", there is ongoing debate about the diagnostic value of uniform ultrasound signs and laboratory tests. Other major controversies regarding AC are the choice of the best method for diagnosing the biliary tract, treatment options, type of surgery, identification and treatment of patients at high surgical risk. There is still controversy regarding the surgical treatment of ACC regarding the timing of the operation. The need for surgical treatment compared with conservative management of patients has been less studied [28].

The most important issue requiring study and in-depth analysis is the issue of timely diagnosis and adequate treatment tactics for different clinical forms of acute cholecystitis in patients with a low pain threshold [6,9,10].

For these reasons, the World Society of Emergency Surgery (WSES) decided in 2016 to convene a Consensus Conference (CC) to examine these controversies and to establish guidelines for the diagnosis and treatment of ACC [29,32,54]. Its main provisions were published in June 2016 in the "International Journal of Emergency Surgery" ("World Journal of Emergency Surgery").

In July 2016 (Ireland, Donegal), a consensus conference "Means of Optimization for Emergency Surgery" was held, where protocols for the diagnosis and treatment of acute surgical diseases based on the best practice and from the standpoint of evidence-based medicine were introduced. Criteria were presented for assessing the quality of emergency surgical care for patients with AC, which took into account such indicators as the duration of treatment, analysis of each death, severe complications and emergency conditions [29].

Diagnosis requires a detailed study of the history, physical examination, and clinical laboratory tests. For patients at risk (over 60 years of age) there is no single clinical or laboratory study with sufficient diagnostic accuracy to establish or exclude AC [9,31,52].

Ultrasonography of the gallbladder continues to be the gold standard for diagnosing ACC. Wide availability, lack of invasiveness, lack of exposure to ionizing radiation, and a short study period are characteristics that make ultrasound the first choice of imaging for diagnosing ACC [44,45]. Meta-analysis by Shi et al. support these data [51].

Another meta-analysis by Kieiwiet et al. Investigated the diagnostic value of computed tomography (CT) and magnetic resonance imaging (MRI) in addition to ultrasound in the diagnosis of AC [58]. According to it, no significant advantages of CT have been identified, in addition, the problem lies in the ionizing radiation to which patients are exposed. As for MRI, its effectiveness is equal to abdominal ultrasound. It is recommended to combine clinical, laboratory and imaging research methods to improve the quality of research and clarify the diagnosis, although the best combination is not yet known [42,44].

Surgical tactics for acute calculous cholecystitis. Today, there are three main technologies in the treatment of various forms of GSD [16, 22]:

- traditional cholecystectomy from a median or oblique laparotomic approach;

- laparoscopic cholecystectomy (LCE), which requires special equipment and sufficient qualifications of the surgeon (accompanied by fewer complications, shorter rehabilitation period and lower cost);

- cholecystectomy from a mini-access, the technique of which is closer to the traditional one;

The most common method of surgery is now LCE [40,59]. According to TG13, video laparoscopic cholecystectomy is now considered a safe surgical technique when performed by emergency surgeons for acute calculous cholecystitis [29,54].

Early LCE is indicated for patients with class I (mild) ACC. This group includes somatically healthy patients without concomitant diseases with moderate inflammatory changes in the gallbladder walls. In the presence of one of such signs in patients as, the duration of the acute period is more than 72 hours, the presence of a palpable gallbladder or infiltrate in the right hypochondrium, leukocytosis more than 18x109 / l, a destructive form of acute cholecystitis, are classified as class II (moderate) ACC. For patients with severe local complications such as biliary peritonitis, emphysematous cholecystitis, gangrenous cholecystitis, and purulent cholecystitis, urgent surgery is performed along with the usual supportive measures. Class III (severe) ACC includes patients with multiple organ failure, hypotension, impaired consciousness, high plasma creatinine levels, and thrombocytopenia in blood coagulation. In this case, TG13 suggests gallbladder drainage and delayed cholecystectomy after improvement in general clinical conditions [55]. But a recently published meta-analysis by Coccolini F. et al. (2015) showed that LCE for ACC is the preferred approach with lower mortality and morbidity, significantly shorter postoperative hospital stays, and reduced incidence of pneumonia and wound infections compared to the open method [41].

According to C. Kum et al. (1996) after LCE in chronic cholecystitis in 0.2% of cases, hepaticoholedochus damage is noted, and in acute cholecystitis - in 5.5% of cases. Similar data are given by other authors [45,48,51,52]. At the same time, the transition to laparotomy is not the optimal way to solve the problem of treating acute cholecystitis complicated by infiltration. B.A.Korolev, D.L. Pikovsky, (1990), H. Burhenne, (1989) believe that carrying out "open" cholecystectomy in acute cholecystitis is accompanied by a significantly higher frequency of deaths, ranging from 1.0% to 10 , 6%. While after LCE performed for acute cholecystitis, deaths are observed much less often - from 0.2% to 0.5% of cases [11,14,34]. Considering that paravesical infiltration is observed in 8.0–40.7% of patients with acute destructive cholecystitis [48,51,52], it is of great practical interest to develop atypical LCE methods that allow avoiding the transition to laparotomy and reducing the frequency of hepaticocholedochus injuries.

As for the timing of interventions, early LCE should be performed as soon as possible, but can be performed up to 10 days after the onset of the first symptoms of AC. However, it should be noted that earlier surgery is associated with shorter hospital stays and fewer complications. One randomized controlled

trial compared early LCE with LCE after symptom resolution but within 5 days of admission in patients with ACC [39]. At the same time, one of the main limitations that still exists today is the time from the moment of the disease. So, according to a number of authors [1,2,6,7,30,35], the optimal time for laparoscopic cholecystectomy is the first 48 hours from the onset of the disease. All these factors determine the indications for an emergency operation or for a staged method of treatment.

Provided by Zafar S.N. et al. (2015) results from a large database review of approximately 95,000 patients with ACC showed that patients who had surgery within 2 days of admission had fewer complications than those who underwent surgery 2 to 5 days after admission. receipts [39, 56]. Finally, several studies have shown that cholecystectomy performed as soon as possible is cost effective [37,50,56].

In the case of severe local inflammation, the presence of adhesions, bleeding in the Kahlo triangle, or suspicion of damage to the bile ducts, then it is necessary to switch to the "open" method of surgical treatment - Tang et al. (2006) in their systematic review, identified the main risk factors for conversion in LCE. These are male sex, deep old age, obesity, cirrhosis, a history of abdominal surgical interventions, severe acute and chronic cholecystitis. Another reason for intraoperative tactical errors and postoperative complications in typical cholecystectomy and LCE is the complex anatomical and surgical conditions of the intervention zone - pronounced variability of the topography of the gallbladder, anatomical forms of the cystic duct and variants of branching and location of the cystic artery, the variability of their relationship with the vascular and ductal structures of the subhepatic space. In this regard, it is obvious that it is necessary to evaluate the techniques used in endosurgery of the biliary tract in terms of effectiveness and acceptability in LCE in various clinical situations, as well as to develop an individualized approach to surgical technique based on the principles of typical variability [38, 46, 53].

According to Eldar et al. (1998), the incidence of complications in ACC is generally associated with a duration of complaints of more than 48 hours, gangrenous cholecystitis, male sex, age> 60 years, other comorbidities, large gallstones, and elevated serum bilirubin levels. As a rule, LCE is safe for catarrhal and phlegmonous ACC and is accompanied by a small number of conversions and complications [46], except for gangrenous cholecystitis, where the conversion rate ranges from 4 to 40% [44.65]. As for patients at risk with AC, some authors prefer multistage treatment, while other authors [30] practically abandoned two-stage treatment due to the good tolerance of LCE, conversion to the traditional method of surgery in this group is 1.7%, mortality is 0. fifteen%.

Traditional cholecystectomy is a safe technique in the presence of perivesical infiltrate, inflammatory and cicatricial changes in the subhepatic region and hepatoduodenal ligament. But due to its shortcomings, such as significant trauma to the structures of the anterior abdominal wall, intestinal paresis, impaired respiratory function, a large number of early and late complications, cosmetic defect, long-term postoperative recovery, make this technique a losing one in comparison with LCE and mini-access [10]. According to the author Dolgov OA (2008), the number of complications in open surgery is 20.4%, and the mortality rate is 3.7% [14].

Complications of acute calculous cholecystitis. About 20% of patients, especially males, seek surgical help after 3-4 days from the moment of illness, due to the paucity of clinical manifestations due to the low pain threshold. As a rule, the operation is performed at this time in conditions of perivesical infiltration. With peri-vesical infiltration, in addition to the presence of changes in the wall of the gallbladder, the surrounding tissues are also involved in the inflammatory process. So in the work of Temirbulatov V.M. et al. (2008) during ultrasound diagnostics of the gallbladder out of 403 patients, 324 (80.4) patients were found to have pericholecystitis, and in 73 cases the presence of perivesical infiltrate, mainly in the area of the gallbladder neck and hepato-duodenal ligament [27]. In the early stages of inflammation, ultrasound visualizes hyperechoic fields without clear boundaries. Subsequently, the inflammatory process is delimited with the formation of an infiltrate in the perivesical region, which is found in the form of a hyperechoic formation with clear contours.

Differentiation of "loose" infiltrate from "dense" infiltrate is necessary, as it dictates different surgical tactics. In the presence of the first option, it is possible to perform surgical intervention; in the case of the second, cholecystectomy may be inappropriate, since it is most often accompanied by intraoperative complications: bleeding and damage to the extrahepatic biliary tract [26,27,32]. So the incidence of complications in the form of the risk of damage to the bile ducts during surgery accounts for 36 to 47 injuries per 10,000 patients during laparoscopic surgery and from 19 to 29 cases of injuries per 10,000 patients during minilaparotomic surgery [4,7]. The experience of the authors of the Russian recommendations speaks in favor of conservative treatment in the presence of a dense infiltrate, and later on performing cholecystectomy from a mini-access [4,15,26]. However, if within half an hour the surgeon fails to verify the cystic duct and the cystic artery in conditions of a strong inflammatory process in the gallbladder neck and hepatoduodenal ligament, then it is recommended to perform a timely conversion from the minilaparotomic approach to an open operation before complications develop.

Discussion.

Analysis of literature data allows us to judge that AC and AC is a fairly widespread pathology. The main goal of the TG07 was to achieve a common vision among specialists in the field of diagnosis and treatment of AC around the world. However, in clinical practice, the low diagnostic sensitivity of TG07 in relation to AC has been proven. In this regard, the TG13 revised diagnostic criteria and criteria for assessing the severity of the patient's condition, as well as the role of surgery. For this purpose, Grade systems for determining the level of evidence and the grade of recommendation were used. However, TG13 did not give an exhaustive answer regarding the determination of the scope of surgical tactics in elderly and senile patients, therefore the WSES 2016 highlighted patients from high-risk groups, where it was noted that the age of patients over 80 years old with AC should be considered as an additional factor of increased risk of intraoperative complications , morbidity and mortality. In the presence of a perivesical infiltrate, which technically complicates the performance of LCE, it is recommended to switch to open surgery. In this case, according to the opinion of the Russian authors A.G. Beburishvili, M.I. Prudkov. the choice of cholecystectomy from the mini-access as a conversion method is more preferable [7].

The criteria for assessing the quality of care for patients with AC and ACC according to the Consensus Conference "Means of Optimizing Emergency Surgery" (Ireland, Donegal, July 2016) are: 80% of patients with AC who are admitted before 16:00 should undergo an ultrasound examination on the day of admission. The 30-day mortality should not be >5%. More than 80% of cholecystectomies should begin laparoscopically and >65% laparoscopically and complete. More than 90% of patients should be operated on in the first 6 days. hospitalization. 80% of patients should be seen by the responsible surgeon within the first 12 hours after admission. 60% of patients with ACC should be operated on at the first hospitalization and in 80% during an acute episode. 95% of patients should have a blood test for amylase / lipase levels. In 100% of cases, patients who underwent cholecystectomy should be entered in the register of the institution for the presence of bile leakage, bleeding and damage to the bile ducts [29].

To date, there is no single protocol for the diagnosis and treatment of acute destructive forms of calculous cholecystitis. And the existing algorithms determine the activities of clinics of regional subordination. We were interested in the question of the possibility of implementing the proposed numerous algorithms for the treatment of acute calculous cholecystitis. In particular, in 2007 adopted (revised in 2016) "Recommended protocols for the provision of emergency surgical care to the population." These protocols do not contradict the regulations adopted by the Ministry of Health and the Republic of Uzbekistan, they are a recommendation for the implementation and examination of diagnostics and treatment of the most common urgent surgical diseases in medical institutions. In the available literature, there are no works reflecting the implementation of the proposed algorithms for the treatment of acute destructive forms of calculous cholecystitis both in clinical hospitals and in level 3 hospitals (central city hospitals and central district hospitals (CRH, CGH). The bulk of medical institutions providing emergency surgical care the population, both on the territory of the Republic of Uzbekistan and in the Andijan region, correspond to levels III and IV (CRH and CGB) - They do not have the equipment and technical equipment to perform high-tech operations, which are operations in acute destructive forms of calculous cholecystitis. point to conduct this study.

Conclusions.

Thus, the introduction into clinical practice of laparoscopic cholecystectomy in the treatment of acute calculous cholecystitis significantly improves the immediate and long-term results. Over the past decades, the increase in patients with cholelithiasis has led to the search for the most sparing, low-traumatic methods of surgery. Today, the modern method of treating acute cholecystitis is laparoscopic cholecystectomy and it is feasible in patients of all age groups, but much depends on the skills and experience of the surgeon. According to the 2016 WHO recommendations, further study and development of intraoperative assessment is required in the choice of the method of completion of the operation in conditions of increased operational risk and destructive changes in the gallbladder, since the study of this issue is still open.

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QR – Issue   **QR – Article**

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PREPARING PRIMARY SCHOOL PUPILS FOR INTERNATIONAL ASSESSMENT RESEARCH

Abstract: *This article deals with the issues of international assessment systems that affect the process of primary school education and the quality of education. The structure of the exercise book in solving problems is described. Examples of tests in the field of PISA and TIMSS are given.*
Key words: *international program, society, development, school, family, teacher, discussion, relationship.*
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Introduction

It is known that in our rapidly developing country, as in any other field, a number of innovations and research are being carried out in the field of education. New changes are also being made to the system of assessment of pupils' knowledge, skills and abilities, which has been in place for decades. In particular, since such a process is an important factor in determining the development of education, the Ministry of Public Education has taken the first steps to implement an international program to assess the knowledge of secondary school pupils. It is planned to widely use assessment programs such as PISA (Program for International Pupil Assessment), TIMSS (Trends in Mathematics and Science Study) in order to bring pupils' knowledge in line with international requirements. to assess the effectiveness of the world education system in the literacy of pupils in 3 areas (reading, mathematics and science), their creative and critical thinking, the ability to apply their knowledge in life and In short, it is about increasing the intellectual potential of the country's youth. So, of course, recognize this program as a key criterion for the further development of our country. sh is also possible. This begs the legitimate question: So, what is PISA and TIMSS?

The main part

PISA is a program that assesses the literacy of 15-year-old pupils in different countries (reading, mathematics, science) and the ability to apply their knowledge in practice. This program is held once every 3 years. To date, a total of 7 times (2000,2003, 2006.2009,2012,2015,2018) tests were conducted under the PISA program, and the next tests are scheduled for 2021. Our country is also preparing to join this program from 2021.

TIMSS is an international monitoring of the quality of teaching mathematics and science in schools, organized by the International Association for the Assessment of Educational Achievement. This study covers the knowledge of 4th and 8th grade pupils in mathematics and science in different countries. The survey is conducted every four years with the participation of the Secretariats of many research centers and organizations around the world. Advisory committees consisting of experts from different countries are also established. The first step towards international monitoring is the gradual introduction of TIMSS international monitoring in our country. Various studies are being tested as experiments, test questions are being developed. Test materials are being summarized and analyzed in cooperation with UNICEF.

Approved by the Resolution of the Cabinet of Ministers No. 187 of April 6, 2017, the STS, curriculum and study programs are reviewed by international experts, conclusions and recommendations are obtained. In particular, the preparation for international research should be carried out from primary school. expedient.

This exercise book is designed to test and reinforce the knowledge of 4th grade pupils in mathematics and to help them prepare for PISA and TIMSS international research. TIMSS (Trends in mathematics and science study)) used open sources of research.

The exercise book is divided into sections, each theme with different tasks:

-Examples on the theme of natural numbers (4 tasks)

-Examples on the theme of simple fractions (3 tasks)

-Examples of numerical expressions and equations (2 tasks)

-Problems on the representation of shapes in the plane (4 tasks)

-Problems on points, intersections and angles (2 tasks)

-Reading and data interpretation issues (3 assignments)

and at the end the assignments were answered.

The 18 assignments in the notebook are easy, medium, and difficultis a logical question, test, diagram, and table. Tasks are answered numerically, verbally, and by selecting test answers. For example:

Task 1 asks a logical question: Aziza has 1,8,6,3,2, numeric cards. Which of the following cards can she use to show the smallest three-digit number? She can use each card only once. Answer: 123. The child remembers three-digit numbers when completing this task and memorizes the order in which the numbers grow when generating three-digit numbers from the required numbers and thinks logically about the exact answer.

Task 16 shows a diagram for 4th grade. Question: Ahmad conducts a survey among 4th grade pupils about their favorite colors. In which grade did pupils choose blue the least? Pupil reads the question, understands the content and pays attention to the 3 different colors in the diagram, understands the increase or decrease of the colors in the diagram by lines and determines the correct answer. Answer: The least chosen in 2nd grade.

This exercise book allows you to work with each pupil individually during math lessons.

As a logical continuation of Exercise 1, Exercises 2 and 3 were also developed and presented to pupils to assess their mathematical knowledge. The difference between Exercise 2 and Exercise 1 is that the tasks in Exercise 2 are the same. (Exercise 22) In Exercise 3, on the other hand, although the tasks are

few in number (10), each task is expressed in the form of a visual weapon, picture, diagram, diagram. given

The State Inspectorate for Quality Control in Education under the Cabinet of Ministers of the Republic of Uzbekistan and the National Center for International Research for Quality Assessment of Education have organized the 1st, 2nd , Exercise 3 "can be a great help in developing pupils' logical thinking and thinking skills.

Based on the above examples and issues, I would also like to recommend the following assignments as an appendix.

Task 1: There are 96 seats for the audience in the Puppet Theater, which are arranged in 8 out of 12 rows. Karimjon received a ticket to enter the Puppet Theater. His place is 32 seats. How many rows does it have to go up from the bottom to find its place?

A) Row 2 B) Row 4 C) Row 3 D) Row 5 Answer (Row 3)

Task 2: Fatima and Zuhra are playing an antique game. Fatima is 10 steps ahead of Zuhra. According to the rules of the game, if Fatima takes one step, Zuhra must take two steps. ?

A) Step 5 B) Never equal C) Step 6 D) Step 10 Answer: (step 10)

Task 3: There were 14 butterflies in the first flower garden and 4 butterflies in the second flower garden. How many butterflies fly from the first flower garden to the second flower garden and the number of butterflies in both flowers is equal?

A) 4 B) 5 C) 10 D) Not equal Answer; 5

Task 4: Today is February 10, 2020. Bobur was walking in the store. Did he know which product in the store could not be purchased after the shelf life?

A) cheese (March 20, 2020) B) juice (February 8, 2021) C) yogurt (January 23, 2020) D) chocolate (May 27, 2020) Answer: Yogurt

Task 5: Using the numbers 2,7,1,0, how many different numbers greater than 10 and less than 30 consisting of two different numbers can you make?

A) 5 B) 6 C) 7 D) 8 Answer: 5

Conclusion

In conclusion, such logical questions and tables serve to further increase the intellectual potential of pupils. Every pupil is very interested in solving such problems. In my opinion, such logical, mind-boggling examples and problems that incorporate questions from the PISA and TIMSS assessment programs can only be addressed in our daily math classes.

It would be better to give it not only in 4th grade, but even in 1-2-3th grades, depending on age and thinking ability.

Timely and high-quality implementation of the above task will ensure the integration of the education system of our country into the international educational process, to identify gaps in the field and to identify new tasks. we will bring up representatives

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of a higher generation of appropriate independent thinking.

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MENTAL ARITHMETICS

Abstract: This article discusses the importance of mental arithmetic in the intellectual development of preschool children. The essence of mental arithmetic and educational results are illustrated on the basis of examples.
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Introduction

The country's global success depends in many ways on its ability to create innovative technologies, develop resources wisely, and formulate long-term strategies for economic development. Achieving such characteristics is directly related to the level of mathematics in general and the mathematical literacy of society in particular. The most effective and convenient way to develop the mind in this way is to teach mathematics.

At the present stage, the problem of intellectual development of preschool children is determined, firstly, by the contradictions of the existing curricula of preschool education, which does not always contribute to the disclosure of the intellectual potential of the child. Insufficient development of pedagogical techniques of teaching mental arithmetic to develop thinking processes and operations in preschool children. Therefore, the development of effective teaching methods and programs aimed at maximizing the opportunities for the intellectual, creative and personal development of children, depending on their age, is of particular importance.

The main part

Mental Arithmetic is an additional general development program designed for a group of children who want to improve their logical thinking and are interested in specific sciences.

Mental arithmetic is the only way to develop mental and creative abilities harmoniously, which helps to fully reveal the intellectual and creative potential of the student.

It is known that learning new knowledge stimulates the brain. The more we use our brain, the more active the neural connections between the right and left hemispheres. Then things that seem difficult or even impossible become simple and clear. In addition, teaching in an additional general development program helps the student to develop logical skills, as well as the ability to think outside the box without being tied to any template, which allows them to solve various professional and life tasks in a unique way.

The Mental Arithmetic program aims to solve the following main tasks.

1. Develop students' logical thinking practical skills through the joint work of the left and right hemispheres of the brain.

2. Improving visual (auditory) and auditory memory.

3. Increase the ability to concentrate and attract attention.

4. Develop the creative potential of the student based on his / her natural abilities (for example, developing the ability to learn foreign languages).

5. Increase the student's general intellectual level, including interest in specific subjects, such as arithmetic and mathematics.

The program is designed for children ages 4 to 12, but can also be mastered at an older age. For more than 20 years, mental arithmetic has been successfully

used in educating children in 56 countries around the world, especially in China, Canada, the United States, the United Kingdom, Austria, Spain, Australia, and the Middle East. Among the CIS countries, the teaching of mental arithmetic is widespread in Kazakhstan. This program is described as an ancient Chinese way to harmonize the brain and develop the body. This program is called " Mental Arithmetic ". The mental arithmetic program is positioned as an effective program for developing children's mental abilities. This system of teaching oral counting is based on the use of an ancient abacus count that has existed for more than a thousand years, so the time and practice of many generations have been tested.

The abacus is used in the early stages of mental arithmetic. The students then perform calculations in their minds and create a fantastic image of the abacus. The abacus is a Chinese invention called the first wooden computer. This tool was used to add, subtract, multiply and divide, calculate fractions and square roots.Even though it was invented in China, it found the largest application in Japan. For example, there is an exercise in abacus or a lesson called soroban is mandatory for students in grades 3-4. Abacus is a rectangular shaped wooden abacus-vertical speaker divided by a longitudinal rod. Each row of knitting needles contains bones that allow the child to visualize the basics.4 From the age of 4, the child becomes familiar with the numbers from 1 to 10 years old and begins to use the abacus. In the process of performing arithmetic operations for simple arithmetic exercises, the child moves the wooden bones simultaneously with the thumbs of both hands, which contributes to the harmonious development of both hemispheres of the brain. In this case, the child learns to express numbers and mathematical movements in the form of a certain position of the bones in the knitting needles. Over time, the child's attachment to the abacus gradually subsides and his imagination awakens, as a result of which he is able to perform the simplest calculations in his brain after a few sessions, just by imagining the abacus in front of him. , makes mental movements with his bones. The child can perform mental arithmetic operations only after learning to replace the physical abacus with his own image. The child can perform mental arithmetic operations only after learning to replace the physical abacus with his own image. programs teach children to perform arithmetic operations at the level of physical perception. At the same time, they learn to reflect the numbers in their minds as a picture and begin to solve problems, adding pictures to the picture, not numbers. When working on an abacus, several types of perception at once work according to the leading analyzer.They are auditory, intuitive, visual. The abacus sharpens the edges of the bones, which allows the child to develop fine motor skills. Teachers do not recommend skipping classes as this can affect the results - the ability to calculate correctly and the speed

will decrease. The training is conducted in several stages; In the first stage of the lesson, the mechanical method of the abacus is used; then the children are taught to repeat actions on a conscious, intelligent level, using figurative thinking and imagination. Practice shows that for many children, the learning outcome improves not only the identified computational ability, but also attention concentration, memory ability, develops imaginative thinking, imagination and observation, improves the ability to analyze and generalize. At the same time, emotional and voluntary qualities are developed (independence, determination to achieve results, voluntary regulation of behavior, self-confidence).

Experts say that with the right approach to combining knowledge, preschool and primary school age children demonstrate excellent skills in performing their arithmetic operations with 2,3,4-digit numbers. An important factor in the effectiveness of the program is that the child almost always experiences a successful situation in the learning process. The preschooler becomes less dependent on the teacher, thus forming a cycle of confidence and motivation. This psychological aspect of teaching mental arithmetic cannot be ignored, as the psychological characteristics of preschool children include a high self-esteem, which means that the child is not afraid to learn the truth, they are still competent. engaging in non-profit activities and thus actively assimilating the social and objective world.

There is almost no serious scientific research in Uzbekistan on the impact of mental arithmetic on human intellectual or personal development, but there are many foreign studies. Michelle Frank, a professor at Stafford University, concluded after extensive research in India that mental calculations do not work in a linguistic, linguistic system, but are based on more visual experience, in particular the ability to group multiple objects in parallel to create visual representations. from Allows you to quickly encode objects in visual working memory. The scientist, together with his colleagues, was instructed to perform arithmetic operations, interfering with the performance of calculations in various ways (reading, reading a book aloud, etc.). As it turned out, a student of mental arithmetic schools showed the highest results in this program compared to group reading. The untrained group was more prone to verbal interventions. The walk of the abacus is not only a powerful computing tool, but also simplifies the visualization process (reflecting the image in the mind). Scientists note that children use the maximum number of brain cells during abacus movement and simultaneous counting in their minds, leading to the development of the right and left hemispheres. The left hemisphere of the brain is responsible for the development of logical, mathematical skills, language, while the right hemisphere is involved in

creativity, art, imagination, visualization, and nonverbal aspects.

Conclusion

For children of preschool and primary school age, it is more interesting and understandable that knowledge is given on the basis of objective activity rather than in an oral-theoretical form. In this case, the lesson turned into a fun game or competition that contributes to the faster and better acquisition of knowledge. can be an effective tool for developing the intellectual abilities of older preschool children.

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THE FOLK'S DISCOVERIES AND GENERATIVE LEXEMES

Abstract: This article describes the use of generonyms in the Uzbek language in folklore, the analysis of their peculiarities.
Key words: genre, folk riddles, the root meaning, generonym, language, "creation" semaphore, continuity.
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Introduction

In recent years, hundreds of studies have been published on various aspects of Uzbek linguistics. But there are problems in all areas that need to be studied in more depth. In particular, the study of the linguistic features of folklore materials, sources of different genres is one of such problems.

When studying the linguistic features of the sources of genres related to the Uzbek folklore and analyzing the sources of this genre from a linguistic point of view, their diversity is absolutely obvious. With this in mind, the study of the language of riddles is important in determining the specific features of the Uzbek language [2].

The main part

The wisdom and ingenuity of the people are reflected in the riddles, which are one of the cultural and enlightenment heritages of a particular nation. "Riddles are not only an entertaining game of the mind, a means of spiritual relaxation, which develops human perception, observation, poetic imagination, but also a key role in understanding the spiritual world and historical past of our ancestors" [4; 3].

Riddles are among the means of expressing the thinking, ingenuity, perception of a particular nation, as well as its responsiveness. Based on this notion, riddles serve as a means of enriching our speech through the expression of people's life, worldview, imagination. In Uzbek linguistics, some research has been done on riddles. In particular, in the researches

of J.Abdullaev, M.Saparniyazova, U.Kabulova the riddles are analyzed to a certain extent on a linguistic basis. In extended sense, the scientific works of J.Abdullaev and U.Kabulova are directly related to the lexical-semantic features of riddles, while in the dissertation of M.Saparniyazova the semantic-syntactic features of riddles are studied on a monographic basis [1; 3; 4; 5].

"Riddles are based on distinguishing important features of what needs to be found and events. While the names of things and events that need to be found are hidden, its essential features are reflected in the formal structure of the riddle "[5].

When generative lexemes in the Uzbek language were analyzed directly from this point of view, two different cases were observed. Firstly, to identify the units that represent the semantic object, action, process of "creation" through the riddle. Secondly, the aim is to uncover the function of generative units as a means of determining basic content.

For example, in the first case:

If it is cooked, it will be a meal,
If it is not cooked, it will become a bird (Egg) [4]

In the given riddle, two different situations specific to the egg lexeme are understood, one is the process of turning an egg into food by boiling and frying, and the other is the process of turning a chicken into an egg by opening the egg. Here, the focus is on the food when the process of cooking turns into a meal, and if the end is taken into account, not cooking,

it means the beginning of life that is, breaking the egg into a bird by pressing.

We have discussed above the anti-semitic relationship between generative units. Such an attitude is also reflected in the text of the riddles. The following puzzles aimed at finding the name of a fish used generative units related to birth and death:

Born in water, died on earth (Fish).

This discovery gives a special case to the lifestyle of fish, which assumes that the process of reproduction (birth) is associated with water, and can not live on land. It should be noted that in this case the generative units retained their denotative meaning.

A similar situation is observed in the riddle of the butterfly insect:

There are wings, there is no blood,
There is no number of eggs laid (Butterfly).

The most important semantics in the meanings of the butterfly lexeme, namely "winged", "anemic", "egg-laying", "butterfly" semantics, used to determine the answer to the riddle. Here, too, the combination of "laying eggs", which is a generative unit, save its own meaning.

Lexemes, which represent a concept that should also be found in riddles about plants, can retain their specific semantic properties. For example:

It grows out of the ground,
Gold flows from its heart (Cotton).

This riddle indicates that the cotton is growing and the harvest is unique and valuable. The semantics of "creation" and "growth", which are characteristic of the lexical unit, have a generative character. At the same time, in this find, the expression of golden flow is given, and the descriptive expression of the cotton plant takes into account the sign corresponding to the combination of white gold.

It is well known that folk riddles usually have a "two-line semantic structure. The first line is the surface content derived from the meaning of the formal structural units, and the second line is the subtext that is expressed under the structural structural units and understood on the basis of the listener's language skills. The presence of original content in riddles makes it a metaphorical text. This shows that what is found in the semantic structure of the metaphorical text and the differential features of the event occupy a main role" [5].

It can be seen that generative units play an important role in determining basic content. In puzzles related to generative lexemes, such a situation is often overlooked. For example, let's analize a riddle specific to the cotton plant:

Fluffy mother,
Greasy child (Cotton, seeds).

By means of this riddle, the "softness" characteristic of the cotton lexeme and the "greasy" semantic characteristic of the seed lexeme are understood. Through the lexemes of mother and child

associated with generative units, it is felt that the seed (child) appears in the cotton (mother).

There are also words related to generative units such as a mother and a child in the riddle about pepper:

Like blood, no blood,
But with thousand children (Pepper).

Here the meaning of the riddle is determined by the semantics of "redness" and "plurality" of the seed. The location of the seed connects the small sign with the "child" lexeme.

A similar process is observed in the riddle about the word watermelon:

I wonder something,
He is standing on a stake,
The mother is in the womb of her child (Watermelon).

The riddle given here is the opposite of the content, that is, the seed of a watermelon is the mother, and the watermelon is the child. Usually, the appearance of the child in the mother's womb, in contrast to the watermelon, is said to be in the mother's womb, indicating an important characteristic of watermelon. In fact, such inverse puzzles can be applied to all seeded, leguminous plants. The metaphorical content of the riddles reflects the ingenuity of the people. It is also clear from this riddle that the mother, i.e. the seed, the child is the watermelon, referring to the seed inside the watermelon through the expression in the womb of the child. This process can be conditionally expressed as follows:

MOTHER (SEED) - CHILD (WATERMELON) - MOTHER (SEED).

Here, along with the semantics of "creation" and the semantics of "continuity", the role of generative units in the expression of the subtext is obvious.

In the book "Uzbek riddles", among the riddles about housing and its equipment, the following riddle related to housing construction attracted our attention:

In the mother's womb the child lies crosswise (Tosin, vassa).

In this riddle, the beam is likened to the mother, the vassal is likened to the child, and the general basis is "size," the size of the beam is given by the mother's lexeme, and the fact that the beam is smaller than it is given by the child.

Among the riddles about home furnishings, the following riddles related to beds were directly involved in generative lexemes:

Throat at night,
Nocturnal (Bed).

Apparently, the fact that the bed is used at night, that is, when a person lays it, is logically connected with the semantics of the pregnant lexical unit *"there is a child in the womb."*

In the following puzzles, which are aimed at determining the duration of life, the sequence specific to the period of life, some semantics of the childhood

lexeme, which are associated with the above, are manifested with certain features:

He walks on all fours in the morning,
He walks on two legs in the afternoon,
He walks on three legs in the evening.
Or:
A seed at four,
Bears at thirty,
Like a chicken at nineties.
(Man - childhood, youth, old age).

In these puzzles, the semantic "beginning" characteristic of the lexical unit of childhood is given in the morning, and the semantic "smallness" is given in the form of the seed, and the semantic "continuity" characteristic of the lexeme of life is given at noon (middle age), evening (old age); The semantic "growth" is reflected in the following lines.

Five sons from one father.
Or:
Two mothers for five children,
Each has a name (Hand, fingers).

The given puzzles involve father, mother, child lexemes, and these units are also associatively associated with generative lexemes. In the riddles, the father and mother lexemes are connected by the semantics of "creation" and "intimacy" with the child lexeme.

"In riddles, the hidden semantic component is involved in the expression of the unknown reality into the known reality as a result of thinking activity, that is, the information in the riddle consists of appearances of hidden content without explicit description of the speaker" [3]

In particular, Uzbek folk riddles are sometimes given in verse and sometimes in prose. The riddles given in the prose are also called fairy tales. For example, in one of these fairy tales, a proud king goes hunting, meets a boy when he is not hunting, and the conversation between them is given as follows:

"The king asks:
What are you slaughtering for us as guests?
Then the boy:
If we find one, we will kill two.
The king was astonished at the boy's answer. Then to the ministers:
There is a something tricky in this boy's words, let's try it, 'he said.
The king went with the sevants to the boy's house. The boy made the king`s people a good guest. From the king asked from the boy:
Boy, how many sheep have you slaughtered? He asked. Then the boy:
We didn't find one, so we killed two, 'he replied. The king was surprised again:
If you can't find one, where can you find two? He said.
We had a ewe lamb, but we could not find another ewe, so we slaughtered that ewe. After committing suicide, the child also died. That's what it means to kill two, 'said the boy. (Uzbek riddles, Child's answer).

Apparently, in this fairy-tale find, the gender of the sheep is indicated by lexemes such as one or two. In particular, the two words were used appropriately to describe throat soreness. Here, through the semantics of "having a child in the womb" and "something tricky", which are characteristic of the sign of pregnancy, it is hidden under the subtext that the sheep is not a ram (one) but a pregnant sheep (two).

Conclusion

In short, the puzzles distinguish important features of things and events that need to be found, and when generonyms are analyzed directly from this point of view, the problem of identifying the semantic object, action, process units and creating the function of generonyms as a means of illuminating the subtext.

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ORGANIZING LESSONS BASED ON MODERN INFORMATION TECHNOLOGIES IN ELEMENTARY SCHOOL CLASSES

Abstract: *The article is devoted to thoughts concerning the use of information technologies in an elementary school. Particularly, the study illuminates the use of Power Point program in teaching numeral in Uzbek language lessons of elementary school classes.*

Key words: *The Five Initiatives, elementary school, information and communication technologies, numeral.*
Language: *English*
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Introduction

Informatization of society counts as one of the main trends of the late 20th and the early 21st centuries. The informatization process is a prospective method of developing our country economically, politically, socially and educationally. Currently, numerous reforms aimed at stimulating the process are underway. In the meeting held on the 9th January, 2018, and devoted to development of information and communication technologies (ICT), the President of Republic of Uzbekistan Shavkat Mirziyoyev stressed the importance of implementation of these technologies in governing, economy, social and everyday life. Moreover, in the videoselector was held on the 19th March, 2019, and was devoted to paying more attention to the youth, involving them to art, physical training and sport, increasing computer literacy and propagating reading among the youth, employment of women and girls. During the videoselector the President proposed five initiatives aimed at reforming social, cultural and educational matters. Therefore, it is not surprising, that the third of the Five Initiative focuses on effective use of computer technologies among population in general and youth in particular. Information and

communication technologies can be employed in education as well. Introduction of ICT in education, particularly in elementary classes, increases quality of teaching and interest of students to a subject. We will discuss it in the example of Uzbek language lessons.

The main part

Elementary school students get the first acquaintance with the numeral as early as during learning the alphabet. For example, in order to enrich students in all lessons introductory conversations and dialogs are held. Questions, such as "What is the date today?", "How many seasons are there in our country?", "How many students are there in our class?", "How many of them is absent?", are widely used. In order to answer these questions, students naturally use numbers. Moreover, in mathematics classes, digits, numerals and operations over them are taught.

As known, the numeral as a grammatical term is not taught in the first class. Nevertheless, students are familiar with numbers and are able to add or subtract. Based on that, it can be said, that teaching the numeral in context of mathematics lesson would be much more effective. To obtain highest results different pictures
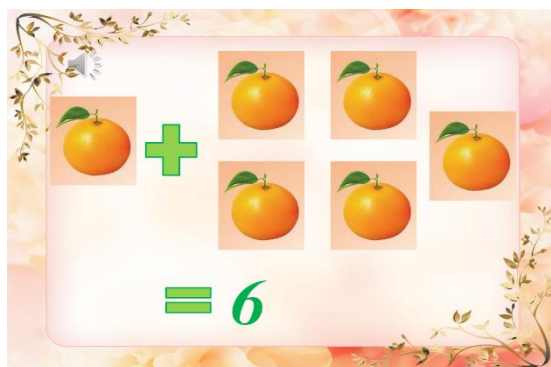
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or ICTs can be used. By asking questions, such as "You have one orange, I give you five more oranges. How many oranges do you have now? (six). Well,

what does the word "six" mean? (number of oranges)" to students, the numeral in Uzbek language can be introduced.

Pic.1

In the 1st grade, students get acquainted not only with cardinal numbers, but also with ordinal numbers. During this period first year students learn to differentiate questions such as how many? and which?, as well as how to write numbers with two adjoining consonants such as *ikki, yetti, to'qqiz* (two, seven and nine respectively).

In the second grade material learned in the first grade is reviewed and consolidated. "In this year mainly two objectives are accomplished:

1. To create elementary notion of questions how many? (by which the number of objects is clarified) and which? (by which the order of objects is clarified);

2. To increase students abilities of asking adequate questions about the numeral and comprehending the answers, appropriate usage

different types of numerals in speech (ten students vs about ten students), as well as to teach how to use dictionaries" [2,262]

In the 1st and 2nd grades the numeral is learned completely from practical point of view. Above mentioned skills and knowledge are formed while doing different exercises. Finding a missing number, asking adequate questions, differentiating cardinal and ordinal numbers are examples to such kind of exercises. During the exercises different multimedia applications can be used in order to interest students. For instance, the following Power Point presentation helps students not to confuse cardinal and ordinal numbers. While doing the exercise students should mark cardinal numbers with red and ordinal ones with black color.

Pic.2

In the 2nd grate little time is allocated for teaching the numeral. Therefore, teacher should pay particular attention to problems that students face while learning the numeral.

In the third grade students learn that words that signify amount and order of objects and people is called the numeral. Moreover, they understand theoretically, that the numeral answers question what number?, how many? and which (by order)?. While students get general understanding of ordinal numbers

in previous year, in the 3rd grade they learn, that the ordinal numbers in Uzbek language are created by adding suffix *-inchi (-nchi)* (roughly -th in English).

Additionally, student learn how to write the numeral with letters and digits, as well as the fact that while writing ordinal numbers using digits, the suffix *-inchi (-nchi)* (roughly -th in English) should be replaced by dash (-). Exercises such as transforming cardinal numbers into ordinals or letter form of the number into digital and vice versa can be used in

teaching. Students also should to learn that the numeral is a secondary part of speech, it usually bounds with a noun and is marked by wavy underline.

Students vocabulary should be enriched by homonyms, and special care should be paid so that the numerals are not confused with paronyms in speech. The fact, that numbers such *uch, qirq, yuz* (three, forty and hundred respectively in this particular context, but have additional meanings) can have meaning other than numeral, should be explained using examples. Students should also be taught not to confuse paronyms such as *to'rt-tort* (four-cake), *yetti-yetdi* (seven-arrived).

Letter form of the numeral is taught in the 4th grade completely. Learning material in this year include: When writing compound numbers using letters, each component is written separately: *yetti yuz sakson* (seven hundred eighty); While writing ordinal numbers using Arabic numerals dash is used, while using roman numerals, dash is not used; Special attention should be paid to numbers with two adjoining consonants; Ordinal numbers are often used with units of measurement (bunch, bag, kilo, etc.). Computer technologies can be effectively used in this process. Games, such as following teach students to write numbers correctly.

Pic.3

Students also learn, that the numeral binds with a noun and the numeral is not formed.

The role of the numeral in our speech is demonstrated by replacing them with adjectives (few, little, a lot).

"After learning the numeral students should have following skills and knowledge:

1. The numeral signifies number and order of objects and people;

2. The numeral answers the questions what number?, how many?, which (by order)?;

3. The numeral binds with a noun;

4. The numeral is a secondary part of speech;

5. How to write the numeral correctly;

6. Correct use of the numeral grammatically and situationally in spoken and written speech;

7. Homonyms of certain numbers;

8. How to replace the numerals with other parts of speech signifying quantity" [2, 263] .

In elementary school notional types of the numeral is not taught.

Conclusion

In conclusion, in should be stressed, that usage of ICT in education increases the effectiveness of a lesson, develops knowledge, skills and compete*nce of students, helps to retain information for longer time and to avoid difficulties in teaching abstract notions. Therefore, favorable conditions should be created for pedagogue to develop his/her computer competencies and to self-improve.

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WORKING WITH BORROWINGS GIVEN IN DICTIONARIES OF PRIMARY SCHOOL TEXTBOOKS

Abstract: This article is devoted to the development of speech of elementary school students, for this they need to know the meaning, pronunciation and spelling of certain words. Using dictionaries in reading lessons is an important part of building students' vocabulary, familiarizing them with different dictionaries, and developing the skills to use those dictionaries.

Key words: primary education, speech, vocabulary, word meaning, word interpretation, word pronunciation.
Language: English
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Introduction

Today, many positive changes are taking place in the education system of our country, in the system of primary education. At the same time, the development of speech of primary school students, equipping them with the necessary language materials for free communication with the outside world, should be one of the first requirements of the teacher. To give a speech, a student needs to know the meaning, pronunciation, and spelling of certain words [10].

The richer the vocabulary, the more meaningful and beautiful the speech, and the clearer and easier it is for the listener to understand it [1, 148].

The main part

The use of dictionaries in reading lessons is an important part of increasing students' vocabulary, introducing them to different dictionaries, and developing their skills in using these dictionaries. Students need to have the necessary knowledge and skills to use dictionaries quickly and correctly. One of the most important of these skills is a good understanding of the alphabet. A student who does not know the alphabet by heart will not be able to find the word he needs using a dictionary [3, 4, 5].

To illustrate this, glossaries are provided at the end of elementary school textbooks. The main goal is for students to be able to work with a dictionary as they search for the meaning of words they do not understand.

We know that the use of annotated dictionaries, in addition to the interpretation of words, depends on which language they are derived from, its meanings, polysemous words, figurative expressions and phrases, phraseological units, the style of the word. helps to determine. However, the glossaries in elementary school textbooks are much simpler, with only words and their explanations and meanings [6, 7, 8].

Let's look the dictionary given at the end of the 3rd grade textbook by M. Umarova, H. Hamrokulova, R.Tadjibayeva.

Clarivate Analytics indexed

Table 1. Use of assimilation words in a grade 3 reading dictionary

№	Words	The meaning of the word	From what language borrowing
1	Afv	Sorry	Uzbek
2	Ajnabiy	Foreign or belonging to foreigners	Persian - Tajik
3	Ardoqlaydi	Be careful, be sorry	Uzbek
4	Ark	A fortified part of the Khan's palace	Persian - Tajik
5	Armon	Regretful of unfulfilled dreams or untimely deeds	Persian - Tajik
6	Ayamajiz	Ayyomi ajuz; the last week of winter	Pure Turkish
7	Asrandi	An adopted child in the care of another parent	Uzbek
8	Bandi	Captive	Persian - Tajik
9	Behuda	Useless	Persian - Tajik
10	Bekvachcha	A child born to Beck; bekzoda	Uzbek
11	Bemador	Weak, no cure	Persian + Uzbek
12	Bemajol	Weak, no cure	Persian + Uzbek
13	Bigiz	A shoemaker's wooden tool	Uzbek
14	Bo'z	Cotton yarn on hand loom	Arabic
15	Donishmand	Knowledgeable, scholarly, wise	Persian
16	Doro	King of the Iranian state	Persian - Tajik
17	Ehtirom	High respect, honor	Arabic
18	E'zoz	Respect, honor	Arabic
19	Faqirona	Poor	Arabic + Persian
20	Farovon	Everything is perfect, everything is in abundance	Persian
21	Faxr	Satisfaction, pride	Arabic
22	Firqa	Group, gang	Arabic
23	Fuqaro	A permanent resident of a country	Arabic
24	Fursat	The best time to do a job	Arabic
25	Gadoyvachcha	Beggar child	Uzbek
26	Go'sha	Deserted or deserted area; dull	Persian
27	Hakim	A sharp doctor	Arabic
28	Hijron	Separation, loss	Arabic
29	Himmat	Kindness, blessing, help to someone	Arabic
30	Iltifot	Good attitude, attention	Arabic
31	Imon	Faith in the power of God	Arabic
32	Iste'mol	Use, consumption, food and drink	Arabic
33	Ittifoq	A group, society, or state working together, an association	Arabic
34	Jam	Collected	Arabic
35	Jarohat	Injured, wounded place	Arabic
36	Jiddiy	Thoughtful	Arabic
37	Jur'at	courage, determination	Arabic
38	Kayfiyat	Condition, state, state of mind of a person	Arabic
39	Kashf	To discover, to create	Arabic
40	Klaviatura	The sum of the keys in different mechanisms	German
41	Kulfat	A tormenting, painful situation	Arabic
42	Ko'hna	It's been a long time coming, ancient	Persian
43	Lavozim	Rank	Arabic
44	Manzil	A place to stop or reach on the road	Arabic

45	Matonat	Endurance, perseverance	Arabic
46	Manglay	Forehead	Mongolian
47	Mezbon	The host	Persian
48	Mijoz	Regular customer Regular customer	Arabic
49	Mirza	The person who did the writing; secretary	Arabic + Persian
50	Misli	Like	Arabic + Persian
51	Mulzam	Guilty, embarrassed	Arabic
52	Naf	The result of a work or thing, a benefit	Arabic
53	Notavon	Weak, crippled, helpless	Persian
54	Parishon	Scattered, chaotic, messy	Persian
55	Qadr	Respect, attention	Arabic
56	Qaroqchi	Robber	Uzbek
57	Qiyofa	Appearance	Arabic
58	Qulun	A one-year-old mare, a mare	Uzbek
59	Samoviy	Heavenly	Arabic
60	Sarvar	Guide	Persian
61	Sekund	Seconds	Lotincha
62	Tanob	Unit of measure	Arabic
63	Tarh	Appearance, project	Arabic
64	Tanho	Alone	Persian
65	Ulamo	Scientist, scientists	Arabic
66	Ungur	A steep hill in the mountains, a cave	Uzbek
67	Xulq	Human behavior	Persian - Tajik
68	G'arib	A lonely, alien man	Arabic
69	Zarb	Hard hit, force, intensity	Uzbek
70	Sha'n	High human quality, dignity, good name	Arabic
71	Shon	Mahsi or boot mold	Arabic
72	Chilpish	Cutting the ends of trees, branches	Uzbek

As can be seen from the table above, the dictionary in the 3rd grade textbook contains a total of 72 words, of which only 11 are Uzbek words. Most of the remaining words are in Arabic, some are from Persian-Tajik, and some are from other languages: Russian, German, Mongolian.

Conclusion

In recent years, a number of words from European languages have entered our language, along with new concepts. All this expands and enriches the lexical potential of the Uzbek language [2, 55].

We can see the proof of the above idea in the 3rd grade textbook. Indeed, in recent years, many words from European languages, such as seconds, keyboards, buttons, have entered our language and have become firmly entrenched in our language.

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QR – Issue   QR – Article

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PSYCHOSOCIAL STATE OF STUDENTS DURING THE COVID-19 PANDEMIC (literature review)

Abstract: *The article provides an overview of the literature on the study of the psychosocial state of students during the COVID-19 pandemic. The paper analyzes scientific articles published in foreign literature in 2020-2021.*
Key words: *distance learning, stress, mental health, students, COVID-19.*
Language: *Russian*
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ПСИХОСОЦИАЛЬНОЕ СОСТОЯНИЕ УЧАЩИХСЯ ВО ВРЕМЯ ПАНДЕМИИ COVID-19
(обзор литературы)

Аннотация: *В статье представлен обзор литературных данных посвященный изучению психосоциального состояния учащихся во время пандемии COVID-19. В работе анализированы научные статьи опубликованные в зарубежной литературе в 2020-2021 гг.*
Ключевые слова: *дистанционное обучение, стресс, психическое здоровье, студенты, COVID-19.*

Введение

В декабре 2019 года в городе Ухань провинции Хубэй в Китае было зарегистрировано тревожное число случаев пневмонии, что вынудило китайское правительство объявить чрезвычайное положение. Вскоре было установлено, что эти случаи были вызваны новым коронавирусом под названием Коронавирус 2 тяжелого острого респираторного синдрома (SARS-CoV-2), который стал широко известен как COVID-19 [1].

Весной 2020 года многие страны решили принять меры для сдерживания первой вспышки пандемии. Поскольку это заболевание может передаваться как от симптоматических, так и от бессимптомных случаев, наиболее широко используемой стратегией по прекращению распространения инфекции было максимальное сокращение социальных взаимодействий. Власти по всему миру распорядились о локдауне по всей стране, часто называемой «карантином», которая предусматривает разделение и ограничение граждан. Кроме того, школы, университеты, и все места, где могли собираться люди, должны были быть закрыты до дальнейшего уведомления [2].

Хотя лечение и передача COVID-19 вызвали серьезный исследовательский интерес, не следует упускать из виду психосоциальные последствия пандемии, поскольку уже есть доказательства, свидетельствующие о том, что пандемия и введение строгих мер могут поставить под угрозу психическое здоровье людей. В частности, было выявлено, что социальная изоляция и одиночество во время изоляции могут повышать риск развития депрессии и тревожных расстройств. Кроме того, сообщается, что у людей, помещенные в карантин, могут развиться негативные эмоции, такие как раздражительность, страх, разочарование, скука, замешательство, гнев, а также различные стрессовые расстройства и бессонница [3,4]. При

этом, необходимо с особой важностью подчеркнуть, что это крупномасштабное инфекционное событие в области общественного здравоохранения оказало огромное давление как на медицинских работников так и на систему образования. Эпидемия принесла не только риск смерти от вирусной инфекции, но и психологическое давление на людей во всем мире. Продолжающееся распространение эпидемии, строгие меры изоляции и задержки с поступлением в школы, колледжи и университеты по всей стране могут повлияют на психическое здоровье обучающихся [5].

Цель обзора. Целью проведения настоящего литературного обзора является анализ зарубежной литературы посвященные изучению психосоциального состояния учащихся во время пандемии коронавируса.

Методы. Были проанализированы работы опубликованные в 2020-2021 гг. в базе данных PubMed. Поиск статьей проводился по ключевым словам «дистанционное обучение», «стресс», «психическое здоровье», «студенты», «COVID-19»

Результаты литературного обзора Переход системы образования из традиционной формы в дистанционную, стал особо проблемным для обучающихся. Дети, подростки и студенты университетов испытывают стресс во время карантина, поскольку им приходится проходить длительные периоды изоляции от своих одноклассников, друзей, учителей. При этом, необходимо отметить, что дети более уязвимы к проблемам с психическим здоровьем из-за мер социального дистанцирования по сравнению со взрослыми, и уже есть сообщения о подростках, испытывающих плохое психическое состояние во время карантина COVID-19 [6]. Пандемия COVID-19 вызвала огромные изменения в повседневной жизни детей и подростков, и известно, что стрессовые события в раннем возрасте могут привести к психическому срыву. В частности, несколько расстройств психического здоровья возникают в подростковом возрасте, когда состояние психического здоровья формируется, но во время пандемии коронавируса социальное дистанцирование может обострить или усугубить психологический дисбаланс и психические заболевания у людей имеющих проблемы с психическим здоровьем. Нарушение распорядка дня и потеря контакта с группой поддержки сверстников могут вызвать чувство неуверенности, особенно у тех, у кого уже имеется дисбаланс психического здоровья [7,8]. Многие проведенные исследования изучали психическое состояние студентов, учеников старших классов, которые являются более устойчивыми к резким изменениям в обществе чем дети младшего школьного возраста. Хотя имеются сообщения о

том, что даже студенты университетов, испытывают выраженную тревожность и обеспокоенность в связи с задержкой в учебе и влиянием COVID-19 на их успеваемость [9].

В литературе указывается, что социальная изоляция может привести к депрессии, тревоге или соматическим симптомам, а также к психотическим приступам и суицидальным мыслям, причем процент таких случаев выше у молодых людей. Также могут развиваться аддиктивные расстройства и расстройства мышления. Более того, болезнь может вызвать страх смерти, беспокойство, депрессию и даже стигму у тех, кто находится на карантине. Данные показывают, что во время пандемии COVID-19 чувство страха, нервозности, печали и связанной с тревогой бессонница выше у помещенных в карантин детей и подростков по сравнению с их сверстниками, не помещенными в карантин [10].

Кризис может по-разному повлиять на социальные отношения людей. Социальные отношения - это мост социальной поддержки. Во время кризиса социальная поддержка может быть важнее, чем когда-либо. Но в то же время физическая близость и возможности для взаимодействия важны для развития и укрепления социальных связей. Поскольку личные взаимодействия и случайные встречи сведены к минимуму из-за мер социального дистанцирования, вполне вероятно, что люди сосредотачиваются на тех отношениях, которые являются пространственно близкими, наиболее значимыми или наиболее устоявшимися. Частично их можно найти за пределами студенческого сообщества, например, в семье и в круге друзей [11]. Хотя общее влияние университетской среды на образование и психическое здоровье все еще неизвестно, ожидается, что оно будет очень значительным. Учитывая высокую частоту эмоциональных расстройств у студентов университетов, можно ожидать, что текущая ситуация может оказать заметное влияние на эту популяцию. Например, в недавнем исследовании, посвященном студентам китайских медицинских колледжей, сообщается, что более высокий уровень тревожности был связан с факторами, связанными с COVID-19, такими как знакомство с пациентом с диагностированным COVID-19. Аналогичным образом, данные иностранных студентов показали рост обеспокоенности не только своим образованием, но и благополучием их семей в случае их возвращения домой из-за приостановки очных занятий [12]

Пандемия COVID-19 внесла структурные изменения в стратегии преподавания и обучения. Студенты университетов продолжили обучение во время пандемии с помощью платформ онлайн-обучения. Однако результаты онлайн-обучения

различались в разных странах. На них повлияли инфраструктуры онлайн-обучения, такие как доступность и скорость интернета, а также доступность электроники и компьютеров [13].

Поскольку многие университеты приостановили обучение в традиционном режиме и перешли на онлайн-обучение, жизнь учащихся резко изменилась. В то время как меры социального дистанцирования могут успешно замедлить распространение инфекции и облегчить работу систем общественного здравоохранения, они могут усилить социальную изоляцию учащихся и повлиять на их психологическое благополучие и психическое здоровье. Находясь под сильным давлением с целью академической успеваемости, студенты склонны к развитию проблем с психическим здоровьем. Утверждается, что социальные сети учащихся являются важным фактором смягчения стресса и повышения их эффективности. Уменьшение социальных взаимодействий, отсутствие социальной поддержки и вновь возникающие стрессоры, связанные с кризисом COVID-19, потенциально могут негативно повлиять на психическое здоровье учащихся [11]. В ходе онлайн-опроса были собраны данные о психическом состоянии населении Китая в начале вспышки COVID-19. Он показывает умеренное и тяжелое психологическое воздействие на большую часть исследуемого населения (53,8%), но также высокий уровень умеренной и тяжелой тревожности (28,8%), депрессивных симптомов (16,5%) и уровня стресса (8,1%), с более высоким процентом среди студентов, женщин и людей с плохим состоянием здоровья. Исследование, проведенное в Испании во время пандемии, показывает, что симптомы тревоги, стресса и депрессии, измеренные с помощью шкалы DASS (шкала депрессии и стресса), выше у молодых людей, страдающих хроническими заболеваниями [10].

Несмотря на то, что данные свидетельствуют о негативном влиянии гуманитарного кризиса и социальной изоляции на психическое здоровье детей и подростков, нужно осознать тот факт, что все проводимые профилактические мероприятия преследуют общую цель - уменьшить передачу коронавируса [14]. При этом, учащиеся должны получить возможность взаимодействовать и общаться в неформальной социальной обстановке. Это могло иметь большое значение для вновь поступивших студентов, у которых еще не было возможности установить социальные связи с другими. Если это невозможно из-за ограничений COVID-19, руководители и преподаватели университетов могут рассмотреть возможность разработки онлайн-мероприятий и использования онлайн-платформ для поддержки развития социальных связей между студентами. Сообщается, что дружба, социальная поддержка, учеба и взаимодействие с другими людьми влияют на благополучие и академические успехи студентов. В частности, поддержание социальных сетей помогает детям и подросткам чувствовать себя частью сообщества, более широкого, чем их семья, что может оказать им поддержку и дать им возможность получить социальную опору [11,14].

Вывод.

Таким образом, осознавая что карантинные меры направлены на уменьшение распространение коронавирусной инфекции, изоляция во время вспышки COVID-19 может неблагоприятно влиять на психосоциальное состояние обучающихся. Исходя из этого, большое значение могла бы иметь организация и проведение руководством образовательных организации онлайн мероприятий по социальной поддержке и укреплению социальных взаимодействии среди обучающихся.

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VISCERAL AND SUBCUTANEOUS ADIPOSE TISSUE AS A RISK FACTOR FOR DEVELOPING DIABETES (literature review)

Abstract: Obesity is the most common risk factor for many noncommunicable diseases. The accumulation of adipose tissue in certain areas of the body may be associated with various diabetes risks. Excessive visceral adipose tissue is positively associated with the risk of diabetes, but the association of subcutaneous adipose tissue in the abdominal or femoral region and diabetes is still a matter of controversy.

Key words: obesity, central obesity, visceral abdominal tissue, subcutaneous abdominal tissue, diabetes mellitus.

Language: Russian

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ВИСЦЕРАЛЬНАЯ И ПОДКОЖНАЯ ЖИРОВАЯ ТКАНЬ КАК ФАКТОР РИСКА РАЗВИТИЯ ДИАБЕТА (литературный обзор)

Аннотация: Ожирение является самым распространенным фактором риска развития многих неинфекционных заболеваний. Накопление жировой ткани в определенных областях тела может быть связано с различными рисками диабета. Избыточная висцеральная жировая ткань, положительно связана

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с риском развития диабета, но ассоциация подкожной жировой ткани в брюшной или бедренной области и диабета до сих пор остается предметом споров.

Ключевые слова: ожирение, центральное ожирение, висцеральная абдоминальная жировая ткань, абдоминальная подкожная жировая ткань, сахарный диабет.

Введение

Распространенность ожирения увеличилась во всем мире за последние 50 лет, достигнув уровня пандемии. Ожирение - это гетерогенное состояние с индивидуальной вариабельностью отложений жировой ткани и связанных с ними метаболических осложнений. Ожирение является основным фактором риска развития сахарного диабета 2 типа (СД 2), но этот риск неоднороден среди людей с разным видом ожирения. Независимо от общего ожирения, центральное ожирение является установленным фактором риска многих социально-значимых неинфекционных заболеваний [1,2,3].

Цель литературного обзора. Целью исследования является изучение данных литературы по ожирению, висцеральной и подкожной абдоминальной жировой ткани в качестве фактора риска развития диабета.

Методы. В данной статье проведен обзор литературы по ключевым словам «ожирение», «центральное ожирение», «висцеральная абдоминальная жировая ткань», «абдоминальная подкожная жировая ткань», «сахарный диабет» в базах данных PubMed и ScienceDirect.

Результаты литературного обзора. Контроль потребления и расхода энергии - основные механизмы, с помощью которых достигается энергетический баланс. Правильное объяснение патофизиологии ожирения включает два параллельных механизмов - одно с точки зрения баланса энергии, а другое - с точки зрения питания [4].

Хотя ожирение традиционно считалось болезнью энергетического дисбаланса, его этиология очень сложна и включает взаимодействие между генетическими, экологическими, физиологическими, поведенческими, социальными и экономическими факторами [5]. Размеры и форма тела пациента могут быть использованы для оценки избыточного веса и ожирения. Двумя наиболее доступными измерениями размера тела являются рост и вес. Как впервые сообщил в 1842 году Адольф Кетле, вес у взрослых людей варьируется в зависимости от роста. Разделив вес на рост в квадрате (кг/м^2), находится индекс массы тела (ИМТ). Возникшая пять десятилетий назад область эпидемиологии питания побудила Ансела Киза и его коллег искать простой индекс формы, сильно коррелирующий с весом, но не зависящий от роста. Исследователи изучили несколько показателей формы тела, связанных с ожирением, которые оценивались с помощью методов подводного взвешивания и антропометрии кожных складок. Наибольшая корреляция между оцененными показателями ожирения и индексом формы была для веса/роста^2, переименованного из индекса Кетле в ИМТ. Многочисленные исследования изучали взаимосвязь между ИМТ и клиническими исходами, показали, что риск заболевания и уровень смертности выше у людей с ИМТ на нижнем и верхнем квартилях популяционного распределения ИМТ. Продолжаются споры об «оптимальном» ИМТ для поддержания здоровья и долголетия, но существует почти всеобщее признание диапазонов, соответствующих критерию здоровья [4].

Точная причина ожирения неизвестна, однако, существует сложная взаимосвязь между биологическими, психосоциальными и поведенческими факторами, которые включают генетический фактор, социально-экономический статус и культурные влияния. Ожирение связано с эпигенетикой, увеличением возраста матери, паритетом родов, недостатком сна, эндокринными нарушениями, фармацевтическим ятрогенезом, а также внутриутробными и наследственными факторами. Коморбидные состояния и их лечение также могут быть фактором риска развития ожирения. В таблице 1 представлен список причин развития ожирения [6].

Таблица 1. Причины развития ожирения [6].

Первичные причины		
	Генетические факторы	
	Моногенне нарушения	Мутация меланокртин-4 рецептора
		Дефицит лептина
		Дефицит проопиомеланокортина
	Синдромы	Prade-Wili
		Bardet-Biedl
		Cohen
		Alstrom

		Froehlich
Вторичные причины		
	Неврологические	Поражение мозга
		Новообразование головного мозга
		Последствия излучения мозга
		Гипоталамическое ожирение
	Эндокринные	Гипотиреоидизм
		Синдром Кушинга
		Дефицит гормона роста
		Псевдогипопаратиреоидизм
	Психологические	Депрессия
		Нарушения поведения питания
	Лекарственно-индуцированные	Трициклические антидепрессанты
		Оральные контрацептивы
		Антипсихотические препараты
		Антиконвульсанты
		Глюкокортикоиды
		Сульфонилмочевина
		Глитазоны
		Бета-блокаты

Исследования показали, что ожирение в определенных областях тела может быть связано с различными рисками диабета. Так, например, брюшное ожирение, в частности, избыточная висцеральная жировая ткань, положительно связана с риском развития диабета, но ассоциация подкожной жировой ткани в брюшной или бедренной области и диабета до сих пор остается предметом споров [7].

Абдоминальная жировая ткань состоит из подкожной и висцеральной жировой ткани, которые выполняют разные функции в метаболизме липидов и глюкозы [8]. Диапазоны ИМТ азиатского населения в качестве риска диабета отличаются от диапазонов европейского населения. Согласно данным экспертов Всемирной организации здравоохранения, средний ИМТ в азиатских популяциях ниже, чем в неазиатских популяциях. Была выдвинута гипотеза, что у азиатов более высокая степень ожирения на единицу ИМТ по сравнению с другими этническими группами, что подвергает их повышенному риску СД 2 при более низком уровне ИМТ [7].

В последние годы исследования, охватывающие населения разных полов, возрастов, уровней ИМТ и этнических групп, показали, что висцеральная жировая ткань играет другую и более неблагоприятную метаболическую роль, чем подкожная жировая ткань [9]. В исследовании Framingham Heart Study изучалась связь между распределением жира в брюшной полости, оцененным с помощью компьютерной томографии, и различными факторами метаболического риска. Как висцеральная, так и подкожная жировая ткань была в значительной степени связана с уровнем глюкозы в плазме натощак и инсулинорезистентностью. При этом, по толщине висцеральной жировой ткани ассоциации были сильнее, чем с подкожным отложением жира. В отличие от подкожной, висцеральная жировая ткань вносила значительный вклад в вариацию факторов риска после поправки на ИМТ и окружность талии [10]. The Insulin Resistance Atherosclerosis Study (IRAS) Family study показало, что подкожная и висцеральная жировая ткань положительно связаны со случаями диабета [6]. Связь между распределением жира в брюшной полости и метаболизмом глюкозы в исследовании «Здоровье, старение и состав тела» была исследована на когорте пожилых участников. В ходе исследования был обнаружен стандартизованный бета-коэффициент значимой связи висцеральной жировой ткани, оцененный с помощью компьютерной томографии, и инсулина плазмы натощак [11,12]. Исследования сообщают, что мужчины склонны к отложению жира в брюшной полости, по сравнению с лицами женского пола [13]. В другом исследовании масса висцерального жира показала самую сильную корреляцию с HOMA-IR, за которой следовали общая масса жира, ИМТ и окружность талии. Проведенные другие исследования также сообщили о значительной корреляции между HOMA-IR и абдоминальным отложением жира. По результатам некоторых исследований, висцеральная жировая ткань оказалась лучшим предиктором инсулинорезистентности [14,15,16,17]

Хотя традиционно жировая ткань считается молчаливым органом, пассивно накапливающим избыточную энергию, теперь она считается эндокринным органом, не только участвующим в

управлении потоком энергии в организме, но также взаимодействующим с воспалительной системой и сосудистой стенкой. Несколько исследований показали, что жировая ткань активно продуцирует различные локально и системно функционирующие биоактивные молекулы, которые взаимодействуют при различных заболеваниях, связанных с ожирением, например лептин, адипонектин, фактор некроза опухоли-α (TNF-α) и ингибитор активатора плазминогена типа 1 [18,19,20,21].

Висцеральный жир напрямую связан с воспалением, дисфункцией печени и инсулинорезистентностью [22]. Многие исследования показали положительную связь между висцеральной жировой тканью и непереносимостью глюкозы [23,24,25], но есть работы, где показана положительная ассоциация для подкожной жировой ткани. Более того, в некоторых исследованиях было показано, что

подкожная жировая ткань более тесно связана с инсулинорезистентностью, чем висцеральная [26]. Таким образом, проведенный обзор литературы свидетельствует о том, что как висцеральная так и подкожная абдоминальная жировая ткань является фактором риска ризвития СД 2.

Вывод.

Несмотря на то, что во многих исследованиях сообщается о высоком риске развития СД 2 при избыточном накоплении висцеральной жировой ткани в абдоминальной области, проведенные исследования не исключают подкожную жировую ткань в качестве риска развития диабета. Существующие данные подтверждают необходимость проведения дальнейших исследований для оценки механизмов ассоциации подкожной и висцеральной жировой ткани с кардиометаболическим риском.

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THE IMPORTANCE OF INTERACTIVE METHODS IN THE DEVELOPMENT OF PRESCHOOL EDUCATION

Abstract: *The article presents effective methods of using interactive methods in organizing the pedagogical process by teachers working in preschool education as a result of observational analysis.*
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Introduction

Innovative technologies in the field of education originated at the beginning of the twentieth century on the basis of the idea of humanizing the educational process. At the same time, attention is paid to the issues of meeting the interests of children, respect and love for each child, creating all conditions for his personal development, being at the center of the child's personal educational process.

Attention to updating the content, form, means and methods of teaching in recent years is of great importance in the search for innovations in preschool education, the system of advanced training when it is introduced into the educational process, pedagogical activities of teachers. In particular, the introduction of advanced pedagogical technologies in the pedagogical process, the introduction of innovations, the use of modern methods, the equipping of teachers and educators with skills and abilities are based on the tasks set by the advanced training system [1].

In the field of pedagogy, it is necessary to solve an important question, which is that teachers organize the pedagogical process methodically correctly, having the ability to target, systematize and predict the results based on modern methods. It should be noted that interactive methods are a priority in education reform, and the ix role in solving pedagogical problems is an important factor in ensuring the effectiveness of education [2]. An important aspect of

the theory of pedagogical technology is determined by the level of abilities of a kaydogo teacher; it is such an effective use of interactive methods in the educational process with a purposeful use of learning opportunities

Today, as noted by psychologists around the world, indigo children are more sensitive to what is happening in the world than adults. Therefore, teachers today are faced with a number of urgent tasks. One of them is the use of interactive methods in the learning process. A natural question arises: What interactive methods can preschool teachers use?

President of our country Sh.Mirziyoyev "... we must openly admit that we neglected to work in this important direction. ... It is necessary to radically revise the curricula and programs with the involvement of experienced teachers and specialists" [3].

One of the important tasks of modern pedagogy today is to teach teachers to use interactive methods in a rational, purposeful and contextual way based on didactic principles.

Preschool educators apply modern methods in their activities, studying preschool education journals, scientific articles, brochures on "preschool education", best local practices [4]. Sometimes they use interactive methods without fully understanding the essence and purpose. Therefore, if in the process of professional development an interactive learning

environment is created and teachers become its direct participants, that is, if they master each interactive method directly, it will be easier and more convenient to adapt these methods to preschool education [5].

In preschool education, interactive methods can be used: "Brainstorming", "Role-play", "Work in small groups", "Discussion", "Gallery tour", "Cluster", "Boomerang", "Energetics". The educator can use brainstorming techniques at the beginning and at the end of the lesson to determine the children's understanding of the topic and reinforce their knowledge [6]. Small group work is based on the interaction of children and the exchange of ideas. In this case, the theme is developed based on the analysis and verification of the group. In role-playing games, children are given a problem situation. With this method, children recreate their (real) life situations. Debate - In the discussion method, children are given the topic of the day before. Children ask parents questions and find answers, and the answers to the questions are based on "discussion". The use of the

above interactive methods and techniques is important to achieve the quality and effectiveness of early childhood education [7].

Preschool education, which is the first stage of the lifelong education system and forms its basis, currently plays a key role in determining the quality and effectiveness of education. Therefore, it is important that preschool education is based on modern requirements [8]. Therefore, it is important to familiarize students with the methods of using the teacher's training module in the educational process in training courses. At the beginning of each lesson, the teacher asks: "What can I teach children today?" he must ask himself a question and set a clear goal. Therefore, each teacher should clearly define the approximate time required for the pedagogical situation when creating a training module.

Based on the above, we give an example of the development of a training module and a lesson by the teacher of an integrated lesson in a preparatory group using interactive methods:

Table 1. Teacher training module [9]

Direction of development: Development of the cognitive process	
Lesson topic: Talking about mountains	
Purpose of the topic: To acquaint children with the world around them, form ideas about the mountains, replenish vocabulary, form friendly relations between children. Develop independent thinking and creativity.	**Key ideas and concepts for children to learn:** • have an idea of the mountains; • explore the nature of mountains, plants and fruits; • understand the words geologist, climber and their meanings; • feel happy in the games and break into groups; • learn and collaborate in activity centers;
Technological training map: What do we know about mountains? Brainstorming session - 5 minutes. Talk about mountains. Slideshow - 15 minutes. Energizer "Mountain Fruits" - 3 minutes. Small group work. (Practical work in activity centers) - 12 minutes. Presentation - 5 minutes. Reflection - 3 minutes.	**Necessary equipment for the lesson:** yarn for the number of children, plasticine, colored paper, scissors, glue, scraps of fabric, materials for slides, staples, products for the game "Shop-shop", balls-globes.

Course:

Educator: Guys, I'm going to tell you a riddle now:

It's high-altitude places.
It is a place for arches.

Children's answers:
- Arch.
"No, it's not.
"No, it's not.
"Mountain"

Educator: Good. It was a mountain.
"Brainstorm"

Educator: Children, what do you know about mountains.

Children's answers:

Educator: Yes, you were right. The mountains will be high. Nozimahon beautifully described a hike in the mountains with his family, good.

Educator: Now let's do the Magic Mountain exercise with you. To do this, you make a mountain shape out of threads on the table. Good, you have correctly described the mountain. Now let's make the mountains high. Let's see you did everything right.

Let the mountain that the children are building now be wider.

The educator observes and encourages children's work.

Educator: Guys, did you like the exercise "Magic Mountain"?

Children's answers:

Educator: Now I want to tell you about the mountains.

The interview will be conducted using slide materials.

Guys, you know, the earth is made of earth and water, and we'll look at this globe. The globe is a miniature image of the earth [10]. On the globe, earth is shown in yellow and water is shown in blue. Children are introduced to the globes that are placed on the table for each child [11].

Educator: Pay attention to the dryness of children's globes. On land there are plains and mountains. Now I will tell you about the mountains.

The mountains will vary depending on the altitude. High mountains, medium mountains and low mountains.

The highest mountain on earth is the Himalayas. (The slide shows the mountains).

The Tien Shan and Gissar Alai mountains are located in Uzbekistan. The Nurata mountain range is located in the Navoi region. In our Kashkadarya region there are Gissar, Kungrad, Zarafshan mountains.

In spring, the nature of the mountains is very beautiful. Because tulips are the first to open in the mountains. Medicinal plants include caraway, kyikot, mint, almond, pistachio, hawthorn from fruit trees.

There are various minerals in the mountains, and those who look for them are called geologists. Those who conquer the highest peaks of the mountains are called climbers. Climbers carry food and supplies in a backpack (travel bag) because they have been walking in the mountains for a long time.

The children learned about the mountains. Now we are going to play with you a fun game called "Mountain Fruits".

Game rules: Children sit in a circle. The teacher places the sheets of fruit trees on the tray upside down and asks the children to take one. The teacher is a beginner and does not put on a chair. A group of children take pictures of a fruit named by the teacher. Then the beginner takes the place of one of them, and the child, who did not have time to sit down, continues the game.

Educator: Did you like the children's game?

Children's answer: yes or no.

Educator: Children, you will be divided into groups according to the picture of a fruit tree in your hand. The first group - the "Mountain Cherry" group, the second group - the "Hawthorns" group, the third group - the "Almond" group.

Practical work is carried out in activity centers.

Educator: Children can go and sit in the center of their choice. I give you the next task. In the art center, you make climbers out of plasticine. A climber's backpack is made at a construction site. In the Shop-Shop game in the role-playing games center, you will buy products that you need to put in the backpacks of the climbers (water, smoked meats, sugar, bread, etc.).

"Reflection" of the machine zhuftlikda ishlash ўtkaziladi. Bolalar bilimini mustaҳkamlash uchun savollar:

In each center there will be a presentation of the children about the completed tasks.

Exercise "Reflection" is performed in pairs. Questions to strengthen children's knowledge:

Q1: How much do the mountains differ in height?

Q2: Which mountain is the tallest?

Q3: What kind of fruit trees grow in the mountains?

Q4: Which flower opens first on the mountain?

Q5: What medicinal plants grow in the mountains?

Q6: Who are geologists?

Q7: Who are climbers?

At the end of the lesson, children are encouraged.

Therefore, in preschool education, teachers need to clearly define the approximate time required for the pedagogical situation, determine the sequence based on the flow chart, using interactive teaching methods [12].

In conclusion, we note that the fact that the interactive methods used by the teacher are organized in such a way as to meet the interests and needs of children is an important factor in improving the quality of preschool education. After all, a good teacher is a quality education.

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