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Issue **Article**

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EFFECTIVENESS OF AUTOMATIC JUDGING SYSTEMS IN SWIMMING

Abstract: *This article examines the effectiveness of automated judging systems in swimming compared to the traditional manual method. It analyzes the main principles of this process, including accuracy, objectivity, and ensuring equal conditions for participants. The advantages and disadvantages of both approaches are explored, as well as their impact on judging at international competitions. Special attention is given to the adaptation of digital technologies to the conditions of tournaments and the challenges that arise. Examples of international competitions are provided, where automated systems helped resolve controversial situations and improved the fairness of decisions.*

Key words: *digital judging, manual judging, automation of refereeing, swimming, international tournaments.*
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Introduction

Modern sports competitions require accurate recording of results. For swimming, which is a sport where speed counts especially, manual methods of timekeeping have been employed traditionally. However, as technology advances, international competitions are slowly converting to automated judging systems, which have the effect of minimizing the impact of human elements and maximizing objectivity of measurement.

Despite the clear advantages of digital technologies, there are ongoing discussions about potential inaccuracies in electronic systems and their impact on the sports process. The issue is not only about the accuracy of measurements but also about their speed, reliability, and adaptation to various competition conditions.

The goal of this study is to provide a comparative analysis of the effectiveness of manual and digital judging in swimming using examples from international tournaments. The paper discusses the technologies used in both approaches, analyzes cases of disputed decisions, and examines the impact of automated systems on the development of swimming.

Main part. Theoretical foundations of judging in swimming

Swimming judging is governed by rigorous international regulations to ensure a guarantee of the sport's fairness. Unlike sports where subjective consideration plays a large role, swimming is predicated upon firm, measurable standards. One of the main principles of judging is the objectivity and sacredness of the result. That is, all decisions are made solely on the basis of the rules, with no room for any sort of bias or external influence. Another principle is equal conditions for all participants. It applies both to the use of standardized equipment and to the necessity of observing prescribed procedures at every stage of the competition. Violation of the rules, however, cannot assuredly bring about any benefit to the athlete, but it can also lead to penalties, including disqualification [1].

Hence, the bases of swimming judging are rigorous adherence to regulations, accurate measurement of outcomes, and minimizing subjectivity. However, in spite of utmost objectivity intentions, the method of recording results in swimming has changed significantly with technological progress or advancements. Manual

timing was the predominate method of measuring time for decades, wherein direct human participation of judges was in taking down the swimmers' times. Although human input could never be absolutely eliminated, the possibility of subjective inaccuracy seeped in the level of results. The introduction of digital judging systems, on the one hand, addressed the challenges at hand, but, on the other hand, raised new issues related to the reliability of electronic systems, potential technical failures, and the need for regular calibration. In this regard, a comparative analysis of manual and digital judging methods becomes relevant.

Traditional judging method in swimming

Manual judging in swimming remained the primary method of time recording for a long time. The main tool used for measurement was the **stopwatch**, which was started and stopped manually by judges at the start and finish. This method, despite its apparent reliability, inevitably involved delays in reaction time, varying within a few hundredths of a second. To improve the accuracy of recording the finish moment, a **visual control system** was used. Judges positioned at the finish line recorded the moment when the athlete crossed the line.

Photo-finish became an important addition to the manual judging system, allowing for more fair recording of results. High-speed cameras captured the moment of completing the distance, which allowed for analyzing frames in case of disputed situations [2]. However, the interpretation of the photo images still remained the task of the judges, meaning there was still a possibility of subjective influence on the final decision.

The major problem with the traditional approach was the **volatility of human reaction**. A fraction of a second delay on the part of the judge at the start or finish could sway the ultimate results of the competition. The other major problem for the accuracy of the judges' decisions was **visual subjectivity**. The judges observing the race viewed the event from different perspectives, and that might introduce variability in measurement. For example, differences in perspective might affect marking the point of contact with the pool wall. The sources of the changes, independent of the judges themselves, were the **lighting conditions, the optical refraction of water, or even the specific manner of movement of the athlete towards the end of the race**. Judges may have interpreted the moment of breaking the finishing line as the finish, even when the player hadn't reached contact with the wall. In that case, the possibility of mis documenting the time increased.

For concealing potential mistakes in manual assessment, the **concept of an average result** was followed, where several judges marked the time at the same instant, and the average value was calculated. Nevertheless, this was not able to offer absolute objectivity since the errors of individual judges could still influence the final result.

Despite the seeming limitations, hand judging also had several points of strength that ensured its existence in the long run. Among the major advantages was the **absence of a requirement for advanced equipment**, allowing competition to be carried out in any setting, including where technical specialist systems were absent. Moreover, manual judging provided **flexibility in interpreting complex situations**. In the case of technical malfunction or unexpected circumstances, such as false start of an athlete or violation of the finishing regulations, judges would be able to render swift verdicts by visual control. This helped avoid automatic result annulment due to potential technical failures of the system. However, the drawbacks of the manual method ultimately prevailed over its advantages, requiring more accurate and reliable solutions. Computerized judging systems became a solution to the issue posed by the limitations of manual systems.

Digital judging systems in swimming

The introduction of digital systems makes it possible to record the swim results with unprecedented accuracy, minimizing the likelihood of errors related to delayed reaction of judges, inaccuracies in the stopwatch or visual observation deficiencies. These systems rely on the use of high-precision sensor and optical systems, integrated into a single data processing mechanism (fig. 1).

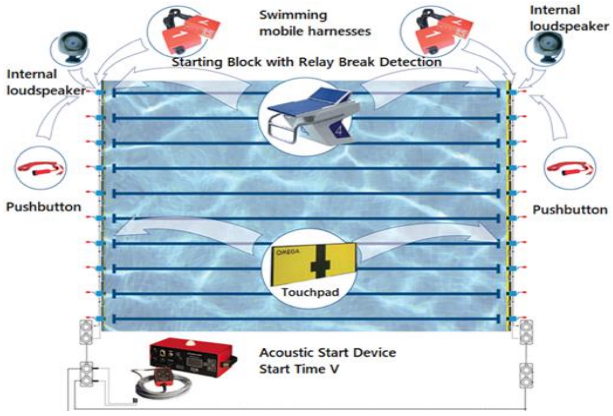

Figure 1. Digital judging system in swimming

The main element of time recording is the **sensor panels** installed on the finish wall of the pool. These devices react to the athlete's touch, automatically recording the moment the distance is completed. This method eliminates delays related to judges' reactions and allows results to be recorded with accuracy to the thousandth of a second [3].

Another important element of digital judging is **video recording systems**, which provide additional control over the race process. Underwater and above-water cameras capture the moment of the finish from different angles, allowing for the analysis of potential disputed situations. This also plays a crucial role in evaluating the execution of technical elements, such as touches during turns or the final approach to the finish line.

At the largest international competitions, digital judging systems have become an integral part of recording results. Technological companies that develop equipment for sports competitions play a leading role in their development. One of the most widespread and reliable systems is **Omega Timing**, which is used in events under the auspices of the International Swimming Federation [4]. This system combines sensor panels, laser measurement devices, and computerized data processing units, allowing for the instant recording and transmission of race results to official databases.

Despite the obvious advantages, digital judging systems **require careful setup, adaptation to competition conditions, and regular technical control**. An additional problem associated with digital judging is the dependency on technical equipment. Any malfunction in the system can lead to data distortion or delays in the publication of results. As a result, large competitions include additional technologies, such as manual timekeeping and independent video analysis. Moreover, automated systems **must adapt to the various conditions of the competition**, considering factors such as humidity levels, water temperature, and pool lighting. These parameters can affect the performance of sensor devices and optical systems, requiring additional calibration and checks of equipment functionality before the competition begins.

Thus, digital technologies have radically changed the approach to judging in swimming, making it more accurate and objective. However, complete automation of the process is still not possible, as the final decision-making in disputed situations still requires the involvement of the judging panel.

Comparative analysis of manual and automated judging in swimming

The accuracy of judging in swimming is crucial for determining the winner, especially in high-level competitions. This makes the choice between manual and automated judging methods particularly significant. Both approaches have their strengths and weaknesses, making their analysis important for understanding the current standards of judging (table 1).

Table 1. Comparative analysis of manual and automated judging in swimming [5, 6]

Parameter	Manual judging	Automated judging
The accuracy of time recording	Limited, the error can reach 0,1-0,2 seconds.	High, up to thousandths of a second.
Objectivity	It is subject to subjective errors, and there may be discrepancies between the judges.	Eliminates subjective decisions, an automatic locking system is used.
Reliability in real-world conditions	It may vary depending on the concentration of judges and the quality of the chronometers.	It depends on the serviceability of the equipment and the correctness of the calibration. Technical failures are possible.
Efficiency of data processing	It takes time to verify the results, especially in controversial situations.	Allows you to instantly capture and transmit the results.
Possibility of appeal	Based on the opinions of the judges, review is possible, but not always objective.	It uses video recordings and digital data, which simplifies the decision review process.
Cost and availability	It is cheaper to implement, does not require complex equipment.	High cost of implementation, requires maintenance.
Application in international tournaments	It is used as a backup mechanism in case of failure of digital systems.	The main method of judging at major competitions.

In the author's opinion, the transition from manual to automated judging in swimming was driven by the need to improve the quality of measurements and eliminate subjective influence on the results. However, automation of judging is not a universal solution and also has certain limitations.

Therefore, manual judging remains as an additional method, providing extra control in case of electronic system failure.

The Olympic Games and World Aquatics Championships are the main arenas where types of judging are tested under maximum competitive pressure. A good example of this is a contentious moment at the 2022 World Short Course Swimming Championships in Melbourne. During the final, the difference between the first and second teams was a fraction of a second, so accurate recording of results was of the utmost importance. Visually, the athletes touched the finish wall almost simultaneously, and without high-precision technology, the judging could have led to disputes. However, the Omega Timing system, with accuracy to thousandths of a second, recorded that one team finished first with a margin of only 0,06 seconds. Despite the initial doubts from the losing team's coaches, the judging panel confirmed the correctness of the measurements by checking data from the sensor panels, video recordings, and backup control systems. The panels were activated simultaneously, but the stronger touch on the panel by the winning team ensured the immediate activation of the time recording. This case became further confirmation of the effectiveness of digital judging, as the difference was too small to be determined visually. The use of automated technologies allowed for the elimination of the human factor and ensured the objectivity of the winner's determination, which, in turn, increases the trust of athletes and coaches in the judging system at major international tournaments [7].

Another example is a controversial incident in the final of the men's 50-meter backstroke at the 2022 World Championships. Swimmer Isaac Cooper set a world record among juniors and finished first, but after the swim it turned out that the start was mistakenly invalidated due to an incorrect signal. As a result, the race had to be held again an hour later. In the rerun, Cooper recorded a worse result, and Ryan Murphy won, but his time was slower than Cooper's in the first race. This case highlights the importance of digital judging systems, such as Omega Timing, which could have informed participants about failures more quickly and accurately. It also demonstrates how manual judging must respond promptly to such errors [8].

The analysis of examples shows that digital technologies have significantly reduced the number of disputed situations in swimming. However, their application is not completely error-free. At major international tournaments, automated systems provide extremely high accuracy, but in some cases, nuances arise that require manual review using video recordings.

Conclusion

Computerized adjudication systems have immensely improved the objectivity and reliability of results in swimming, lessening the influence of the human factor and providing faster and more reliable decisions. Nevertheless, despite the obvious advantages, there is no system entirely free from technical faults, and hence it is necessary to have backup procedures, including manual timing and video examination. Examples from the Olympic Games and World Championships, where disputed moments were managed with Omega Timing and other computer-based technologies, demonstrate that automated systems play a pivotal role in ensuring fairness and transparency of results. However, in moments of ultimate objectivity, the judging panel remains important.

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