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Developing Android-Based Running Monitor Software to Measure Sprint Speed

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Abstract: This research aimed to develop an android-based speed test instrument called SprintA. SprintA can measure acceleration, length, and the number of steps. This research is development research. The research phase consists of a feasibility test and trial. Participants in the feasibility test consisted of 3 athletic trainers and 1 electrical doctor lecturer. To increase the feasibility, the researcher enlisted the help of four athletic trainers who were not subject to expert judgment. Meanwhile, 15 sprint athletes competed in the trial. The trial was conducted by comparing sprintA with a stopwatch. The root means square error correlation value is a data analysis technique. The results of four experts' evaluations yielded an average score of 86.08, placing them in the "very good" category. In the usability aspect, the results of the assessment from 4 experts show the product helps athletes and coaches to increase scores (33.4%); the product has a real team nature (13.3%); the product can know the speed, acceleration, number of steps (20%); the product is effective for measuring sprints by percentage (20%); and other answers (13.3%). The scores on the safety aspect are the product safe and comfortable to set up (26.70%), the product is easy to use (40%), the product does not interfere with exercise (20%), and other answers (20%). Furthermore, the test results of the sprintA vs. stopwatch correlation score found a value of 0.99 and an RMSE score of 0.47. In conclusion, SprintA is feasible to measure speed, acceleration, and the number of steps. The comparison test for SprintA vs. stopwatch got an RMSE value that was not much different. The creation of this tool is said to facilitate the evaluation of short-distance running athletes.

Keywords: development, software, running monitor, Android, sprint speed.

安卓监控软件的运行开发测量冲刺速度

摘要：本研究旨在开发一种名为短跑一种 的基于安卓的速度测试仪器。短跑一种 可以测量加速度、长度和步数。这项研究是发展研究。研究阶段包括可行性测试和试验。可行性测试的参与者包括 3 名运动教练员和 1 名电气博士讲师。为了增加可行性，研究人员寻求了四名不受专家判断的运动教练的帮助。同时，15 名短跑运动员参加了选拔赛。该试验是通过将短跑 A 与秒表进行比较来进行的。均方根误差相关值是一种数据分析技术。四位专家的评估结果平均得分为 86.08，属于“非常好”类别。在可用性方面，4 位专家的评估结果显示，该产品帮助运动员和教练员提高分数（33.4%）；产品具有真正的团队性质（13.3%）；产品可以知道速度、加速度、步数（20%）；该产品可有效地按百分比 (20%) 衡量冲刺；和其他答案（13.3%）。安全方面的得分是产品设置安全舒适（26.70%）、产品易于使用（40%）、产品不干扰运动（20%）和其他答案（20%）.此外，短跑一种与秒表相关得分的测试结果发现值为 0.99，均方根误差得分为 0.47。总之，短跑一种可以测量速度、加速度和步数。短跑一种与秒表的比较测试得到的均方根误差值相差不大。据说这个工具的创建是为了方便对短跑运动员的评估。

关键词：开发，软件，运行监视器，安卓，冲刺速度。

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1. Introduction

Era 4.0 is characterized by the development of advanced technology related to digitalization. This increasingly developing technology is in line with the expert opinion, which reveals that evolution has so far been marked by four major leaps called the industrial revolution. These namely major discoveries culminated in technology and information at the end of the 20th century with the peak achievement of industry 4.0 [1]. The industrial revolution has reached many things in the order of people's lives [2]. According to previous research, the industrial revolution offers effective and efficient solutions for manufacturing goods and tools using modern technology [2]. The presence of the 4.0 industrial revolution has an impact not only on society as a whole but also on sports, where advances in technology and information have been perceived to support practical and academic performance.

Over time, sports systems and sports equipment have developed and implemented digitalization [3]. Sports systems equipment has evolved and implemented digitalization [3], allowing easier data input, sports performance, sports tests, and measurements.

Exercise tests and measurements are closely related to device-related tools. Advances in sports technology have been shown to improve the educational process, increase training effectiveness, manage education and training, and monitor athletes' physical condition [4].

Equipment is organized in a modern and scientific manner using qualified science and technology [5]. In particular, the development of instruments such as the speed test for short distance runs has shown progress through digital-based tools, where the tool previously used was only a stopwatch.

The 100-meter short distance run is one of the most familiar sports in athletics. Athletes who run short distances are often referred to as sprinters [6]. Three parameters that determine the performance of sprint athletes are stride length, number of steps, and speed [7].

According to some literature, the test instrument in sports is extremely advanced, as described in Zenner's research on running monitors [7]. Zenner's research has developed electronic equipment implanted in shoes and equipped with an inertial measurement unit (IMU) type sensor where the selection of the sensor is based on its light and small shape, so it is very suitable for wearing in shoes. Haugen [8] developed a fairly complex system that involves video recording. In the experiment, tools prepared along the running track were used, such as lasers and radars, cameras, and photocells. Research by Jonathon Neville [9] developed a tool using a wearable (GPSsport) to record the acceleration data of a runner. The data obtained is then extracted to obtain data related to the number of runner steps.

In their study, Healy et al. [10] created an application that runs on an iPhone with timing photocells and a radar gun. By recording video, this application attempts to measure runner performance. The force, power, and velocity are then extracted from the video.

However, some of the research's shortcomings are in terms of the practicality of application. So far, the number of Android applications available is still quite small. Furthermore, it is well known that the development of tests and measurements in sports in Indonesia is still underdeveloped, as evidenced by previous research. That is due to a lack of synergy between sports experts and technology experts, making it difficult to find a solution to the problems faced [11]. Previous research has provided colors, solutions, and innovations, but they have not been utilized to their full potential. As a result, a solution to this problem is still required.

According to the above description, the goal of this study is to create a tool that can be used to track sprint running and inform sprinter athletes' performance parameters. The developed tool is an Android smartphone application that can display the performance parameters of sprinter athletes in real-time. The development of this tool is called the SprintA application.

2. Literature Review

This section describes the development of SprintA. SprintA is a development and innovation that has been developed by researchers running on smartphones with the Android operating system. SprintA is a system that uses a numerical integration method to get speed and distance values from acceleration values derived from accelerometer data. The number of steps taken by the runner is obtained by formulating the value of stride length, distance, and travel time. SprintA works well on Android Oreo OS or later. SprintA only retrieves data on the Z-axis (Z-axis) of the accelerometer from a smartphone. This one-axis retrieval is intended to obtain accurate data considering that the running movement only moves on one axis [12]. As an illustration, Fig. 1 shows the Z-axis position of the accelerometer on a smartphone. The Z-axis points to the front and back of a smartphone. Therefore, the X-axis will cover the left and right side sliding movements, while the Y-axis will cover the up and down movements.

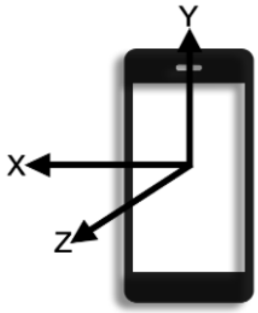

Fig. 1 Accelerometer orientation axis

2.1. Procedure

SprintA was developed to provide more detailed information about the performance of a sprint athlete. This tool has a significant difference from the stopwatch. SprintA not only describes the run's duration while running but also shows the pre-matter values while running. The expert opinion states that the parameters to determine travel time duration when running are acceleration, speed, and the number of steps per second [13]. Fig. 2 presents how sprintA works.

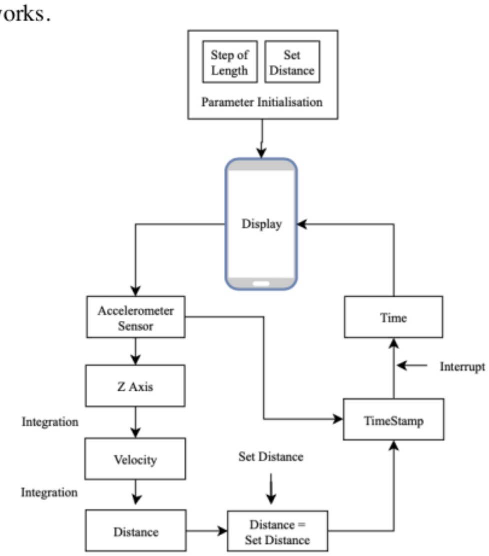

Fig. 2 Tool work process diagram

SprintA runs on Android OS Orea or later series. Looking at Fig. 2, sprintA requires initial input in the form of the running distance traveled and the stride length of the sprint athlete. After making the settings, sprintA is placed on the athlete after making the settings, as shown in fig. 1. SprintA will automatically calibrate the accelerometer on the smartphone shortly after sprintA is activated. Calibration is used to ensure the Z-axis is 0 before accelerometer acceleration data while the runner is running.

When the position of the Z-axis value is 0 or close to 0, then sprintA will give a signal by issuing a "beep" signal which indicates that sprintA is in the ready position. After a few moments, sprintA will make a beep sound like a countdown sign. Runners will start running at the 7th second, marked with a long "beep" signal. SprintA will record linear acceleration data for the entire duration of time during a run. During a run, sprintA will record linear acceleration data for the specified duration. SprintA performs calculations in real-time to get the acceleration and distance values through acceleration data captured from the smartphone's accelerometer.

Linear acceleration data is acceleration data that excludes gravity's acceleration.[14]. Before being processed, the acceleration data is filtered using the Low Pass Filter (LPF) method. After the filtered data, the integration method is applied to obtain speed data. After getting the speed data, the integration method is applied to the speed data to get distance data.

The integration method is applied by the Trapezoid method. Some researchers also apply this method to obtain speed and distance data. [15] Formula 5 shows the application of the trapezoid method to acceleration data. The speed and distance calculation is carried out based on the equations of formulas 1 and 2.

SprintA stops recording data when the real-time distance calculation results are the same as the distance entered in the initial settings before running. After getting the distance value, sprintA will record the time (last second) on the distance that has been reached. Then sprintA displays data in the form of speed values, distance reached, time duration, step length, number of steps per second, and seconds used to complete one step. The calculation of the value of the number of steps per second and the time used for one step is determined by using formulas number 3 and 4. Meanwhile, formula (5) is the equation used to calculate the incremental steps during running.

$$v_i = v_{i-1} + \frac{a_{i-1} + a_i}{2} x\,\delta t \quad (1)$$

$$d_i = d_{i-1} + \frac{v_{i-1} + v_i}{2} x\,\delta t \quad (2)$$

$$S_{time} = \frac{T * S_{length}}{d} \quad (3)$$

$$S_{freq} = \frac{1}{S_{time}} \quad (4)$$

$$S_{tot} = S_{freq} * T \quad (5)$$

Fig. 3 SprintA trial

3. Research Methods

This research is development research [16]. With a quantitative approach [17-19]. This research consists of two stages, namely feasibility test and product trial. Participants for the feasibility test are 4 experts consisting of 3 experienced and nationally licensed athletic trainers and 1 lecturer in electrical engineering with a Doctoral degree. To strengthen the feasibility of the product, the researchers added 4 athletic sports coaches outside of expert judgment as supporting data so that the results obtained improved. The trial of the SprintA product based on the android application was carried out using 15 sprint athletes from the Central Java Student Sports Education and Training Center (PPLOP) and the athletic student activity unit (UKM) at Semarang State University. A comparison was made between the developed SprintA application and a stopwatch to measure the speed of a short-distance run. The data analysis technique used is the correlation value and the root means square error (RMSE).

4. Results and Discussion

4.1. Product Feasibility Test

A feasibility test or expert validation is an assessment of products that have been developed before conducting field trials [16]. Based on the results of the assessment of experts, the following results have been found:

Table 1 Results of SprintA product feasibility test

No	Expert	Score	Category
1	Expert 1	85.8	Very Good
2	Expert 2	88.1	Very Good
3	Expert 3	85.5	Very Good
4	Expert 4	85	Very Good
Average		86.08	Very Good

Originality, innovation, usefulness, simplicity, security and convenience, acceptability, completeness and support, and economic aspects were all considered in the assessment by four experts on the validation and feasibility of SprintA products based on Android applications. It was discovered that there were assessments from four experts, including athletic expert 1 (86.8), athletic expert 2 (8.91), electronics expert (87.1), and information technology expert (87.1), based on the compiled aspects (86.3) as presented in Table. 1 above. This assessment's results can all be classified as excellent or very good. In addition, data from four athletic trainers outside of the athletic experts above is used to strengthen the data on the feasibility test results. The results obtained are presented in the diagram below:

Fig. 4 Aspects of tool usefulness

As shown in the diagram above, the score obtained for the question that the product developed is suitable for use as a medium to assist athletes and coaches in the training process is 33.4%. A score of 13.3% is given to questions about the ability of products with the nature of a real team. Furthermore, product-related questions that determine the runner's acceleration, speed, number, and stride length receive a 20%. Finally, the developed tool effectively measures the sprint run, yielding a score of 20%, while other answers yield a score of 13.33%.

Fig. 5 Aspects of tool safety and comfort

The picture above shows that the product developed is safe and comfortable and can be adjusted, which is indicated by 26.70%. The score on the easy-to-use product question is 40%. Questions related to the tool do not interfere with the exercise course maker a score of 20%. Another answer related to the safety and comfort factor is a score of 20%. Based on the usability aspect of the tool and the security and convenience aspects, it can be concluded that the SprintA product based on the Android application can be said to be feasible. The next step in this research is thus a product trial.

4.2. Product Trial

At this point, the researchers conducted an effectiveness test, which involved putting the developed products to the test. The Android-based product developed by SprintA will be compared to a stopwatch. The following are the results that have been obtained:

Table 2 The test results of SprintA vs. Stopwatch

Participant	Distance (meter)	SprintA (second)	Stopwatch (second)	Deviation (second)
1	20	6.3	6.10	0.2
2	20	5.9	5.2	0.7
3	20	5.8	4.5	1.3
4	20	4.2	4.1	0.1
5	20	5.2	4.0	1.2
6	30	4.7	4.8	-0.1
7	30	6.7	4.6	2.1
8	30	6.2	7.3	-1.1
9	30	5.5	5.3	0.2
10	30	5.5	4.7	0.8
RMSE				0.99

The correlation value of the RMSE (Root Means Square Error) is used in the accuracy test of the developed SprintA application. The term "correlation value" refers to the swing value of both the SprintA and stopwatch scores being the same. In this case, the stopwatch's output value is the reference value, while SprintA's output score is the dependent variable. When the stopwatch value rises, SprintA rises with it. Similarly, if the stopwatch score drops, so do the SprintA scores.

Meanwhile, the RMSE determines how closely the two points (values) are related. The ideal RMSE value is zero, indicating that the two values are identical (have the same output value). For example, SprintA and the stopwatch generated based on the findings of this study have a correlation value of 0.99. The accuracy test using the correlation value revealed that SprintA's output value had a pattern that was very similar to the stopwatch's output value. The RMSE value is the square root of the average square difference between the values generated by SpintA and Stopwatch when the difference is 0.99.

The output of this research is an Android-based running monitor software product that measures speed, stride length, and sprint frequency based on the stages that have been completed in this development research. This running monitor is known as sprintA, and it falls into the category of high novelty products because it is unlike anything else on the market. That is because the primary training instrument has been a stopwatch, which can only measure the passage of time. This sprintA tool, on the other hand, can be used to determine the athlete's parameters, such as acceleration, speed, stride length, and the number of steps. Furthermore, because this is a product developed through research and development, this tool is completely new for athletic sports, particularly short-distance running.

Based on the expert feasibility test results, it has been stated that the product developed meets the practical, valid, and effective criteria. The product feasibility assessment yielded a score of 86.08, placing it in the very good category. In addition, it demonstrates that experts believe the developed product falls into a usable category, as evidenced by seven factors: innovation, excellence, usefulness, originality, economy, safety, convenience, and the completeness of supporting data.

According to the test results, SprintA still has a measurement difference of 0.99 compared to the developed products, namely sprintA and the stopwatch. The result differs from the results obtained by using a stopwatch. SprintA can be used to determine and measure the running characteristics of a short distance athlete based on two aspects of testing. First, the information in sprintA can be used to give coaches and athletes direction and instructions on how to provide training so that it can be monitored. The running performance of the sprinter is also expected to increase with evaluating each exercise using the sprintA tool.

5. Conclusion

The development of an Android-based running monitor software tool called sprintA based on an expert judgment can be said to be feasible to measure speed in short-distance running athletes, based on the results and discussions described. According to the findings, field trials comparing the sprintA tool to a stopwatch revealed that the root means square error (RMSE) value was not significantly different. As a result, the sprintA tool can be used to assess short-distance runners' speed. SprintA is a tool developed that can be said to be new and rarely done, particularly the development of an android-based tool to measure speed, particularly in athletics, so the sprintA tool is considered a high novelty. However, SprintA can determine the parameters of acceleration, stride length, and several running steps in short-distance runners and measure their speed time.

Furthermore, the sprintA tool can be practical because the data input process can be done via an Android smartphone. The creation and development of the sprintA tool ultimately succeeded in providing innovations and simplifying measuring and evaluating tests for athletes and coaches in athletic sports. For example, a short distance runner's speed, acceleration, stride length, and the number of steps are all measured. However, there are still limitations in this development since the sprintA tool can only be used on smartphones running Android Oreo or a newer series of Android.

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