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Design, Manufacturing, and Test of a Wearable Device to Monitor Athlete's Body Movements

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ABSTRACT: In this paper, a device based on wearable sensors is introduced to describe quantitative body movements in different sports. This device can be an alternative to Image processing techniques. Image processing devices have always been used to describe quantitative body movements, which in addition to being costly, have to be used in specific conditions. The device is built from a number of wireless modules that are easy to use in real-world environments with no limitations. In this method, a quantitative description of movement is made by wireless modules and is performed by the data collected from these modules. In order to analyze the data that was extracted from an athlete's body movements with these wearable sensors, the outputs are simulated in Matlab, and some of its kinematic and kinetic parameters have been studied. Then, at the end of this paper, the quality of movement of a professional athlete and a beginner athlete are compared, and the result is shown. Kinematic and dynamic analyzes on the above activities showed the following results: The movements are generally correctly recorded. The kinematic analyzes performed for the various movements are consistent with the facts. For example, the kinematic analysis of the recorded motions showed that the coaching movement was more beautifully performed, and this was evident qualitatively during the movement.

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1- Introduction

Motion tracking technology can be used in sports in order to analyze, evaluate, and, consequently, improve the performance level of the athlete's skills [1]. There are three types of motion tracking systems: marker-based systems (optical or electromagnetic sensors that track a person's body and provide high-precision measurements), and marker-free methods (which require video image processing to track the motion of objects without the participation of physical markers) and the tracking of the motion of inertia (measures three-dimensional motions and can be used in various settings) are discussed, which leads to developmental applications [2]. The comparative filter method is proposed based on parameters related to uncertainty, simulation, and experimental signals. Due to the processing method, instructions for optimizing dynamic biomechanical measurements and considering the contribution of measurement uncertainty are provided [3]. A wearable sensor can be used as a multifunctional data collection device to analyze functional data, which has been proposed, which provides a tool for scientists and physicians to measure the patient's body movements [4]. analyses the classification, technology, and current situation of a wearable sensor, discusses the problems of a wearable sensor from the aspects of human-computer interaction experience, data accuracy, multiple interaction modes, and battery power supply, and summarizes the direction of multi-sensor fusion, compatible biosensor materials, and low power consumption and high sensitivity [5]. Inertia sensors are a useful tool for long-term monitoring in health care. In some cases, having information from multiple inertia sensors, rather than relying on one sensor, may increase the accuracy of the analysis and better tolerate sensor errors [6].

In this research, in order to reduce the limitations of measuring the kinematic quantities of the body and its costs, a sensor called a motion football device is designed and manufactured and is nationally registered in the Iranian Patent Database under the number 139450140003003745. This device, by obtaining cinematic measurement, can describe the skills, techniques, and possible injuries to the athlete. Using the information recorded by the sensors in various sports by simulation in MATLAB software can be analyzed in order to improve the performance of the skill. The basis of this system is to obtain the angles of the athlete's body, without the use of image processing and in wide environments.

2- Methodology

In this research, a device has been designed and built to quantitatively describe sports movements that can be extracted and described using kinematic values of movements. In the construction of this device, items such as low cost, reduction of movement limitation, and being wireless have been considered. This device is made of a number of modules to extract the kinematic parameters. Each module consists of

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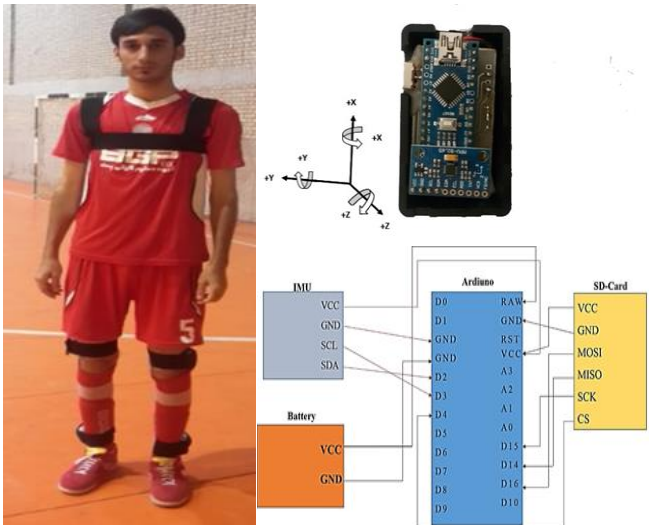

Fig. 1. The designed wearable sensors

four parts: data mining sensors, noise filter, power supply, data storage, and processing. An Inertial Measurement Unit (IMU) inertia module was used to extract the data in this study. Due to the oscillating output of this sensor, a low-pass filter is used to smooth the outputs. The other part of this module is the data storage part, which in this research, an SD card module has been used as a database. In order to feed the module in this research, a lithium polymer battery with a size of 2.5cm*3cm has been used. This battery supplies the voltage required (3.7 Volts and 3700 mAh). The processing unit of this system consists of a Nano-type Arduino board, which has been considered due to the low space occupied and easy to work with this type of module.

The wearable device designed in this study is installed on the body by a special cover. So that it can be used for motion analysis. The designed wearable sensors are shown in Fig. 1.

3- Results and Discussion

The purpose of this section is to present a mathematical model to simulate the recorded motion by the module that use in this research. This simulation provides a dynamic analysis of motion. For this purpose, the Sim_mechanic toolbox has been used in MATLAB software.

In this way, the user can use this environment to observe momentary changes in the joint variables and mechanical parts in the model. It is not necessary to obtain a mathematical model and differential equations to define the system, the software creates the mathematical model after describing the geometry and the characteristics of the mechanical elements. In this simulation, body limbs are introduced as rigid links according to human body structure. To simulate the movement, a designed module is installed on the athlete's body. An act is asked to perform by Karate athlete that it called KARATE- MAE GERI. After performing the movement, these modules are connected to the computer to extract the obtained information to simulate the movement. Fig. 2 shows

Fig. 2. A professional athlete is doing KARATE- MAE GERI

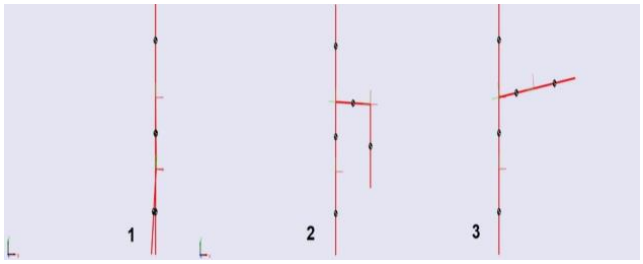

Fig. 3. KARATE- MAE GERI steps are shown in simulation

how to perform this movement correctly in three steps by a professional athlete, and Fig. 3 shows a simulated model of this movement.

4- Conclusions

In this study, a new method has been proposed to study body movements and describe them, quantitatively. This method uses a wearable device that has the ability to record data for a long time in sports at the lowest cost. After making several wearable modules, it was used to study MAE GERI in karate. Also, to check the accuracy of the recorded data and calculate the torques and dynamic forces for activities, a model was developed in the mechanical modeling section of MATLAB software. By simulating this movement in MATLAB software and comparing the data, kinematic and dynamic analyzes performed, some movement defects of the beginner compared to the professional, were identified that can be used to improve the movements of the beginner. The advantages of this design are being wireless, wide usability in open spaces, and its cheapness.

References

[1] H.S. M. Hafezi, A. Banai, Design and fabrication of three axes accelerometer, Research in Sport Medicine and Technology, 2(4) (2012) 11-17.

[2] J.E. van Schaik, N. Dominici, Motion tracking in developmental research: Methods, considerations, and applications, Progress in Brain Research, 254 (2020) 89-111.

[3] F. Crenna, G.B. Rossi, M. Berardengo, Filtering Biomechanical Signals in Movement Analysis, Sensors,

21(13) (2021) 4580.

[4] A. Ancans, M. Greitans, R. Cacurs, B. Banga, A. Rozentals, Wearable Sensor Clothing for Body Movement Measurement during Physical Activities in Healthcare, Sensors, 21(6) (2021) 2068.

[5] R. Xiangfang, S. Lei, L. Miaomiao, Z. Xiying, C. Han, Research and sustainable design of wearable sensor for clothing based on body area network, Cognitive Computation and Systems, (2021).

[6] U. Jayasinghe, W.S. Harwin, F. Hwang, Comparing clothing-mounted sensors with wearable sensors for movement analysis and activity classification, Sensors, 20(1) (2020) 82.

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