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NATALIA STOUMPOU, PANAGIOTIS KYRATSIS
University of Western Macedonia, Greece

SMART FABRICS IN SPORTS INDUSTRY

Purpose. *To facilitate the rhythmic gymnastics training routine and the scoring during the games by a wearable sensor system.*

Keywords*: smart textiles, rhythmic gymnastics, fashion, wearable, sportswear.*

Objectives. The objectives of this work are to create two wearable garments for rhythmic gymnastics, one wearable suit for training and another for scoring athletes in competitions. The training suit should measure some physical parameters and the second should measure the parameters related to incorrect position, uncontrolled arm position, and the level change, so that the athlete's score can be estimated in the most accurate and easy way.

Methodology. A research about the technology of the two wearables' creation has been conducted. Two wearables for rhythmic gymnastics, were created, one for training and another for scoring athletes in competition. The training suit has integrated sensors, such as heart rate sensor and triple axis accelerometer. The wearable suit for competition has integrated flex sensor, magnetometer, gyroscope, barometric pressure sensor in order to estimate the athlete's performance in competitions.

Research results. Today's sports industry uses the innovation of textiles with an aim to record the temperature, sweat and muscle condition of the athletes who use them. Wearable technology is gaining more and more athletes' interest (Firtikiadis at al., 2024; Minaoglou et al., 2024). Smart wearables include a power source, wiring and electronic devices, that are integrated into the garment. The training suit produced, has integrated triple axis accelerometer, that is placed on the wrist and counts the number of steps taken by the athlete during training. The heart rate sensor is placed on the chest, as the rest of the components, and has measured the athlete's heart rate every minute and has calculated the average value. It is important to secure, that the garment can measure effectively the parameters. This wearable product is easy to use and convenient for the user. It fits very well on the athlete's body, successfully measures the parameters, does not disturb her during training and does not hinder her during the execution of the exercises.

The second wearable product produced for competition could be worn by an athlete during the performance. Sensors however could not be attached to competition leotard, because gymnasts wear more than one leotard in the competition. It should be a thin garment that can be worn underneath from any competition bodysuit and measure the appropriate parameters. The competition suit is made of transparent elastic, so that it can be easily adjusted to the body and goes unnoticed under the competition bodysuit. It could be worn by the gymnasts, under their competition bodysuit. It includes a bend sensor, a barometric pressure sensor, a magnetometer, a gyroscope and an accelerometer. The flex sensor is placed on the outside of the joint (elbow), in order to check if the athletes have uncontrolled arm position. The barometric pressure sensor is placed on the chest and records the change in altitude. It will check the athlete's level change during the program and inform the respective judge. It will count how many times the athlete changed her level of movement and it will show how frequent this change was. The magnetometer is placed on the chest and detects the direction of athlete movement. In combination with the accelerometer and the gyroscope it detects the orientation. With this specific sensor, the athlete's use of the carpet will be monitored. Also, if the parameters are measured satisfactorily, the data is recorded correctly and it finally offers the desired help to the competition judge. It is important to find out if the garment can accurately measure the parameters and while at the same time, it is convenient and functional. The magnetometer controls the athlete's movement on the carpet (direction), the barometric pressure sensor records the athlete's altitude change, the flexion sensor controls the flexed-relaxed arms, and the gyroscope accelerometer controls the athlete's body movement.

First, the athlete should wear the garment, and then the wearable can be activated. The athlete begins performing her program and the measurement of the data are recorded. The athlete completes her program and the outfit records the data. Although, she was able to execute her program, she was bothered by the number of wires and the bulk of the sensor assembly. Additionally due to the multiple sensors this wearable becomes bulky, with multiple connections and a large number of cables. It is also difficult to adapt to the garment and has the effect of disturbing the athlete during the execution of the exercises. The miniaturization of sensors and all data collection systems should take place and thus improving, that measurement of various complex characteristics, such as position, speed,

acceleration, absolute angle relative angle could remedy this uncomfortable situation (Smith at al., 2022).

In order for smart clothes not to include wires and sensors, they had to be replaced by fabric with conductive threads. Smart clothes include fibers, yarns, fabric coatings, finishes and membranes. Conductive fibers (E-textiles) are fibers that carry electricity through smart clothes (Scataglini et al, 2020). Based on rapidly changing global demands and technological improvements, the development of responsive functionality in textiles has led to the emergence of smart textiles. This new category of wearable electronic systems is designed to meet new and innovative applications and therefore its application fields are very diverse such as healthcare, fitness, sports, lifestyle, space exploration, public security and the military (Ghahremani-Honarvar and Latifi, 2017). Smart fabric design is crucial to achieve the best results. A smart fabric has a close relationship with the human body. The elasticity of the fabric plays an important role because it allows close contact between the sensor and the skin. Flexibility is achieved by enforcing design criteria that maintain the comfort and wearability of smart clothing. High elasticity fabrics provide mobility, tight fit and improved performance (Scataglini et al, 2019).

Fig. 1. **3D representation of first wearable**

Fig. 2. **2D sketches of second wearable**

Conclusion. Smart fabrics allow greater and more precise control of the athlete's performance. The miniaturization of sensors and all data collection systems results in collecting data with high accuracy. Smart fabrics have potential applications in smart clothing and could significantly change the experience of athletes during sports

References

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