SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA17107
STSM title: Developing and integrating pressure sensors into karate body protector
STSM start and end date: 08/07/2019 to 06/08/2019
Grantee name: Dr. Derya Tama

PURPOSE OF THE STSM:

The main aim was to develop flexible piezoresistive material based pressure sensors and study their integration into wearables, taking as a practical study case, the development of a smart body protector for sports karate.
Karate is a combat art that can be described as a weaponless self-defence system. The body is used for defence, and the physical contact between opponents is limited and subjected to rules. According to the World Karate Federation (WKF) wearing a WKF approved body protector is compulsory for all athletes in both Kumite and Kata competitions. Nowadays, in tournaments the contestants either go through the motions without making contact with their opponent or they wear protective clothing to permit execution of their motions. In either case, several officials observe the contestants in combat and then determine the winner through their judgment. Depending on subjective judgment, improperly awarded points or missed points can result. Due to these drawbacks, the necessity of using intelligent products in competition and training appears in order to assist in scoring properly. Electronic scoring/awarding systems exist for Taekwondo sport, giving room for every athlete to be accountable of their success and as well as their failures. The products in the market and the existing literature show that the researchers focused on the Taekwondo sport, however, researches on smart body protector on karate sport is a niche field to investigate. This was one of the main motivations to continue working on developing a smart body protector for karate sport.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

Regarding to the preliminary studies carried out by the research team in the host institution and the post-doctoral fellow, the essential materials to build the flexible pressure sensor such as piezo-resistive film, conductive fabric and bonding materials, the karate body protector and the consumables for building the circuit were supplied.
In the light of our previous studies, medium-level electrically conductive polyethylene film (Linqstat; Caplinq) was used as piezo-resistive material and conductive fabric was used as electrodes. The sensors were built regarding to the construction shown in Fig.1. In order to achieve bonding between materials, a thermoplastic-bonding net and two-sided tape were used. The sensors were produced by scaling up the dimensions of the sensors built and tested before. It was found out that, the best sensor in big scale was the one produced with two-sided tape used in some spots.

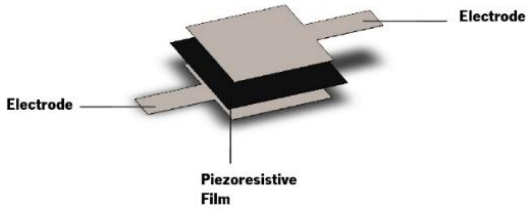

Fig. 1. Construction of the flexible pressure sensors

The sensors were firstly tested with a setup for the cyclic compression test using a Hounsfield universal testing machine. During the test, the output voltage was acquired by a data acquisition board and stored, and the data of force and voltage during the tests was brought together in a spreadsheet program.
Afterwards, the sensors were integrated into the karate body protector. The supplied body protector was unstitched; and a pocket was sewn onto the inner layer to place the sensor into (Fig. 2).


Fig. 2. The unstitched body protector and the pocket sewn inside

In order to evaluate the smart body protector, the real practice tests were performed. The sensor was connected to a signal conditioning which converts the resistance to the voltage. The output voltage was acquired by a data acquisition board and stored in the connected laptop, the data was evaluated in a Labview software. The sheme was presented in Fig. 3.

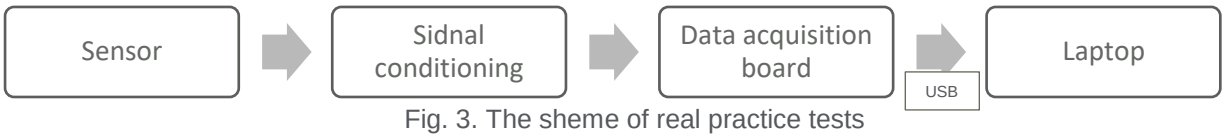

Fig. 3. The sheme of real practice tests

As real practice tests (Fig. 4), the sensor firstly was sticked to the wall connected to the sensor signal conditioning equipment, and the punches applied by different forces. Afterwards, the sensor was placed into the sewn pocket and the body protector was put on a male dummy and the process was repeated.


Fig. 4. Real practice tests; on the wall (left), on the dummy (right)

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The sensor was primarily tested by cyclic compression in a Houndsfield universal testing machine (Fig. 5), at 10 cycles and 50 mm/sec, 0 to 500 N. To provide mechanical protection and amplitude for the compression test, a layer of 3mm EPDM (ethylene propylene diene monomer rubber) foam was placed on each side of the sensor. The tests were done at 5 different areas on the sensor (four corners and the center).

Fig. 5. Setup for compression test (left), testing areas (right)

Regarding to the obtained data, the sensor reacted to the pressure applied and also the reaction was similar in different areas of the sensor. Although there were some hysteretic behaviours observed, the resistance value was high, which makes the sensor more sensitive.

In real practice tests, the change in voltage by applied force by time was evaluated. The results proves that the sensor can detect the applied punch in different forces for real-use conditions. The sensor was sensitive enough to detect even the light punches and when a high-force punch was applied the resistance went down consequently the voltage went the highets value.

Future work will also focus on determining the value of applied force and also building a wireless circuit.

FUTURE COLLABORATIONS (if applicable)

The STSM action helped to continue the initiated research work between the visitor and hosting institution regarding the development of flexible sensors and their integration into wearables for high-competition sports.
The network has been strenghtened and enhanced the future collaborations; as an output, the visitor, two senior researchers in the hosting institution and a company in Turkey are planning to apply to a EUREKA call.
Additionaly, the outcomes of this research will be will be published in an international conference or journal.