SPERTA – Taekwondo Athletes Performance System

Authors:

Pedro Cunha [(1) (2)]
Paulo Barbosa [(3)]
Fábio Ferreira [(5)]
Carlos Fitas [(3)]
Tânia Silva [(4)]
Vítor Carvalho [(1) (2) (3)]
Filomena Soares [(1) (5)]
Nuno Martins [(4)]

(1) Algoritmi Research Centre, Minho University
(2) 2A-EST, IPCA, Barcelos
(3) School of Technology (EST), IPCA, Barcelos
(4) iD+,School of Design, IPCA, Barcelos
(5) Dep. Industrial Electronics, Minho University

Abstract:

Assessing athletes' performance is a constant challenge for coaches. Taekwondo methods of evaluation used are mainly manual. Research in motion analysis area has enabled the development of affordable and easy to access technological solutions. This study presents a friendly and low-cost system for assessing the performance of Taekwondo athletes in real time. Thus, the system uses a 3D camera with depth sensor, a computer, a software developed for data collection and processing and Inertial Measurement Units (IMUs). Aiming to identify and quantify the movements performed by the athlete during training sessions using deep learning techniques applied to the data collected in real time. Several approaches and methodologies were tested along with a dataset previously developed in order to define which one presents the best results. It was concluded that the best results were obtained with convolution layers models, such as, CNN, LSTM and ConvLSTM, with more than 90% in terms of accuracy validation.

Introduction

Taekwondo martial art emerged in Korea became an Olympic sport in the Sydney 2000 Olympic Games. The evaluation of Taekwondo athletes' performance is still carried out by traditional methods. Assessing the performance of athletes is a complex and difficult task in any sport. In order to assist this task, studies have been carried out, where systems were developed evaluation allows to obtain relevant information of the athlete's performance like velocity, acceleration, force, displacement, among other features [1] [2] [3] [4]. For that, motion analysis techniques were used in the practice of sport to assist in this task.

The presented project intends to design a system for identifying and quantifying the movements performed by taekwondo athletes during training sessions using deep learning methodologies applied to the data collected from the taekwondo athletes' movements in real time. This project allows a new methodology for evaluating performance in Taekwondo training.

Project Development

The presented project aims to contribute with a technological solution that allows the assessment of the performance of Taekwondo athletes in real time during training sessions. Thus, a system was developed to collect and process data on the movements performed by Taekwondo athletes (figure 1).
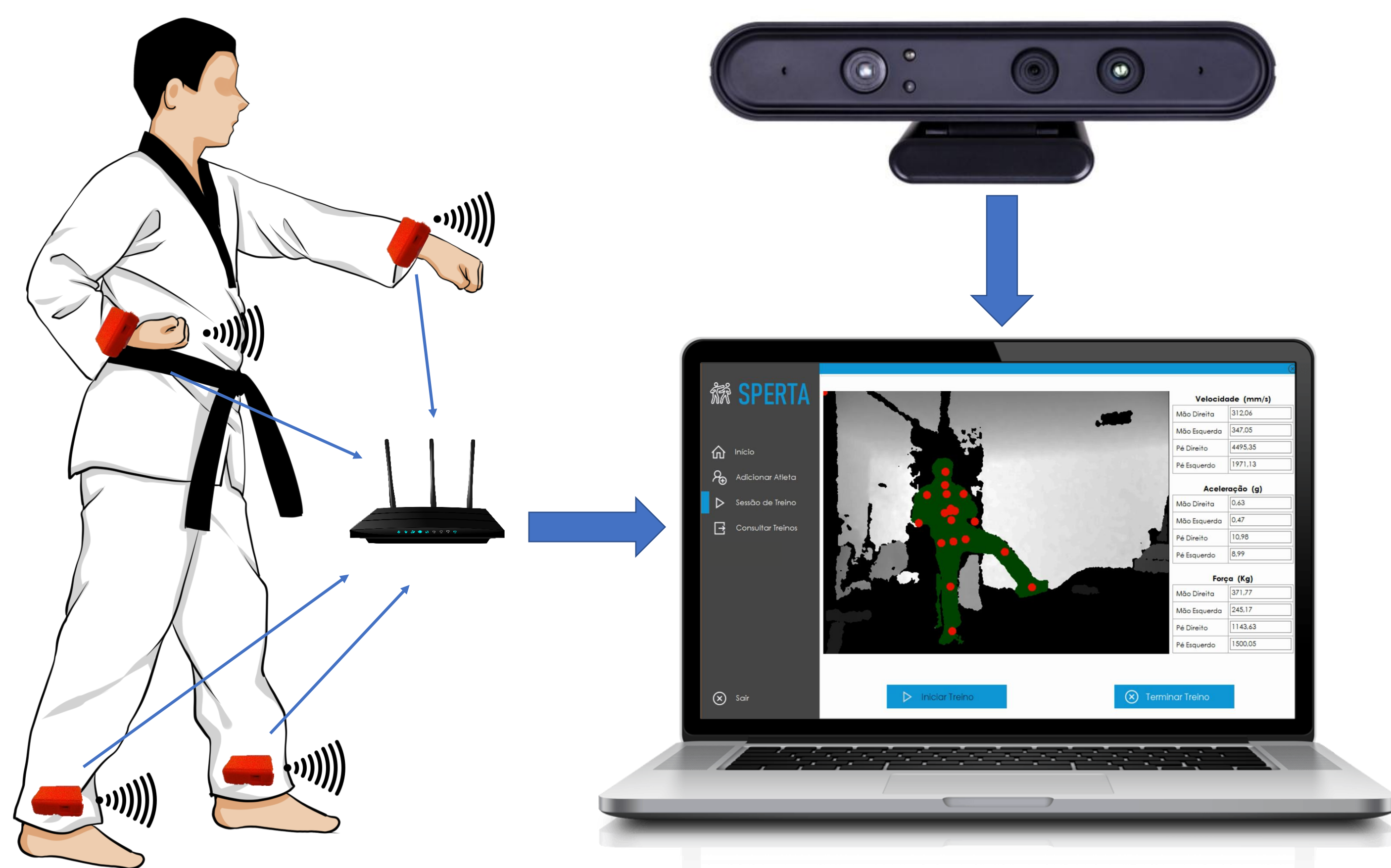

Fig. 1 Framework structure components.

The system is composed by a 3D camera, a software, a computer and Inertial Measurement Units (IMUs). As 3D camera it was used the Orbbec Astra, the software was developed from scratch according to the established requirements and as IMUs was used the GY 521 MPU 6050 which is a three-axis gyroscope and acceleration module together with Wemos D1 mini - a Wi-Fi board based on ESP-8266 for data processing and transmission (figure 3).

Fig. 2 : Deep learning methods testing system diagram [3]

In order to identify and quantify the movements performed by Taekwondo athletes during training sessions, motion analysis is performed according to skeleton-based action recognition, through deep learning methodologies (figure 2).
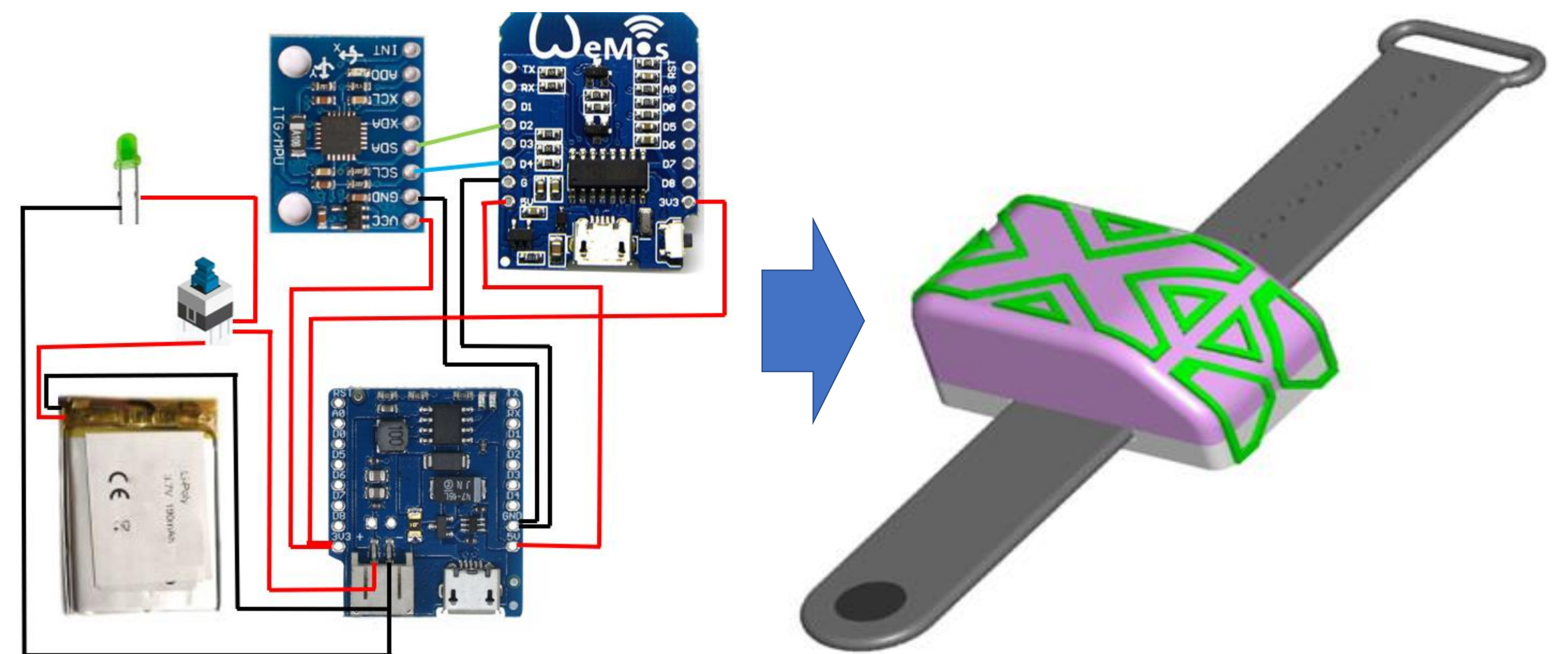

Fig. 3 : Motion sensors system architecture diagram and container

For a proper functioning of the system, the IMUs will have to be positioned on the extremities of the upper and lower limbs, hands and feet. In order to be possible, containers were designed and built for the components in order to fix them in the athletes in a comfortable and non-evasive way (figure 3).
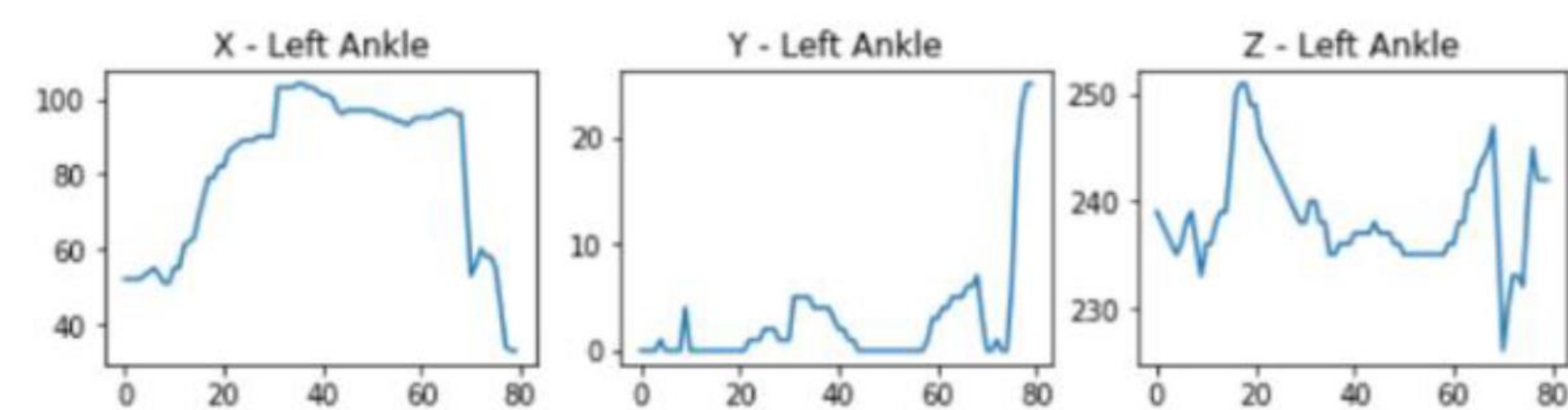

Fig. 4 : Raw data from Left Ankle Joint

The Human Action Recognition (HAR) is a process of identifying, analysing and interpreting which kind of actions a person is taking. Allowing to understand how it is possible to categorize movements/actions of the human body. As a human action recognition specific study area there is the skeleton-based action recognition that uses the data obtained of the human joints placed in a three-dimensional environment to perform motion recognition.

The developed dataset with information about the Taekwondo athletes' movements is used for training deep learning classification methods [3]. The obtained dataset consists of eight classes, where each class represents a different technique/movement performed by the athlete. In figure 4 it is possible to view the raw data along a sequence of 80 samples for the Left Ankle joint movement, in x, y, z coordinates, respectively.

Several deep learning methodologies (CNN, LSTM, ConvLSTM, CNN+LSTM, GNC) were tested with the dataset of the athletes' movements in order to establish which one presents the best results for the specifics of the system.

Final Remarks

The methodologies used by the different approaches presented in the area of HAR applied to our dataset made possible to realize that for the purpose of identifying the movements of taekwondo athletes the best result was obtained with convolution layers models. This fact may be related to the spatial features of the data used in this study. Both methods, CNN+LSTM and ConvLSTM, managed to get results above 90% on accuracy validation. On the other hand, the results obtained by the LSTM method, where the spatial features are not considered, were inferior.

References

[1] P. Cunha, V. Carvalho and F. Soares, "Real-Time Data Movements Acquisition of Taekwondo Athletes: First Insights", in HELIX International Conference on Innovation, Engineering and Entrepreneurship, Cham, Springer, 2018, pp. 251-258.

[2] P. Cunha, V. Carvalho and F. Soares, "Development of a Real-Time Evaluation System for Top Taekwondo Athletes: SPERTA", in SENSORDEVICES 2018: The Ninth International Conference on Sensor Device Technologies and Applications, IARIA, 2018, pp. 140-145.

[3] P. Barbosa, P. Cunha, V. Carvalho and F. Soares, "Classification of Taekwondo Techniques using Deep Learning Methods: First Insights", in BIODEVICES - 14th International Conference on Biomedical Electronics and Devices. [online], SCITEPRESS – Science and Technology Publications, Lda, 2021, pp.201-208.

[4] P. Cunha, P. Barbosa, F Ferreira, C. Fitas, V. Carvalho and F. Soares, "Real-time Evaluation System for Top Taekwondo Athletes: Project Overview", in BIODEVICES - 14th International Conference on Biomedical Electronics and Devices. [online], SCITEPRESS – Science and Technology Publications, Lda, 2021, pp.209-216.