e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

PHYSICAL FITNESS MONITORING AND PREDICTION USING INTERNET OF THINGS BASED ON ARTIFICIAL INTELLIGENCE

Ragavarshini G[*1], Jayavarshini R[*2], Daffinia Bency J[*3], Swetha V[*4], Dr. R. Saminathan[*5]

[*1,2,3,4]Student, Department Of Computer Science And Engineering, Annamalai University, Chidambaram, Tamilnadu, India.

[*5]Associate Professor, Department Of Computer Science And Engineering, Annamalai University, Chidambaram, Tamilnadu, India.

DOI : https://www.doi.org/10.56726/IRJMETS36429

ABSTRACT

The revolution of Internet of Things (IoT) is pervading many facets of our everyday life. Among the multiple IoT application domains, well being is becoming one of the popular scenarios in IoT which aims to offer new services including smart fitness. In this work, an IoT architecture for public fitness equipment, internet of public fitness equipment, with software and hardware is proposed and implemented. MCU6050 with Bluetooth module to implement IoT hardware on public fitness equipment was implemented in this work. Furthermore, it was also implemented web service, database and user interface which provide thorough individual exercise prescription and monitor service. From the experimental results, all the participants' physical fitness improve significantly. It shows the interconnection of public fitness equipment which can significantly improve body health by providing an efficient exercise way using data generated and implemented machine learning. Data collected from IoT based smart fitness and users could be used for enhancing training performance by Artificial Intelligence (AI) based algorithms. Sensor to AI relationship is been implemented by social IoT criteria that can share data, information and experiences of users' training from different types of exercises conducted on daily basis.

Keywords: Internet Of Things (Iot), Public Fitness Equipment, MCU6050 Bluetooth Module, Machine Learning (ML), Artificial Intelligence (AI).

I. INTRODUCTION

The advances in Internet of Things (IoT) lead to an increased number of devices generating and streaming data. These devices can be useful data sources for Activity Recognition (AR) by using Machine Learning (ML). However, as the set of available sensors may vary over time, e.g. due to mobility of the sensors and technical failures, the feature space might also change over time. Moreover, the labeled data necessary for the training is often costly to acquire. Active learning is a type of interactive machine learning where the model is given a budget for requesting labels from an oracle, and aims to maximize accuracy by careful selection of what data points to label. It is generally assumed that a query always gets a correct response, but in many real-world scenarios this is not a realistic assumption. Ongoing advances in IoT technology led to new possibilities within the application area of smart environments and Activity Recognition (AR) [1-3]. With an increasing number of devices in our surroundings streaming data, the opportunities to collect information about those surroundings increase. The set of sensors streaming data is varying over time by a dynamic set of sensors. The reasons for the dynamicity may vary, e.g. the sensors might be mobile and can enter or leave the environment at different points of time, this might stop streaming due to sensor malfunction, or there might be network problems.

Medical research shows that physical exercise can provide positive benefits for human healthcare, including reduced risks of cardiovascular disease, obesity, stroke, and cancer [4], improved musculoskeletal health and stress regulation [5], and reduced psychological health burden and mental disease [6]. Physical Activity Recognition (PAR), which uses information acquired from a variety of sensors to automatically detect and analyze physical activities [7] and it has broad applications such as behavior correction and medical detection. PAR can quantify activity levels, improve exercise quality, and reduce healthcare costs. It has been regarded as an important research direction in Human Computer Interaction (HCI). [8] found that a racquet sport seems to

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

be the best forms of exercise for reducing the risk of death. Therefore, from the perspective of health and recording exercise effects, it is necessary to provide a reliable racquet sports detection device.

Objectives of the Proposed Work

- To develop an fitness management system using IoT and prediction system.
- To develop a model for identifying the Acc level accordingly to maintain fitness environment with prediction.
- To develop a system that can be monitored online in the Blynk app where the status can be live.

The following concepts are involved in the implementation of smart IoT based physical fitness monitoring and prediction system using artificial intelligence. The remaining portions of this article are divided into the following sections: In Section II, the Literature survey on the related works is discussed. In Section III, the proposed methodology and its implementation are presented. The results and discussions for the proposed framework is shown in Section IV and in Section V the conclusion is discussed.

II. LITERATURE SURVEY

In recent years, the advances in wearable sensor technology (smaller size, non-invasive, long battery life) and its potential application to studies that monitor physical activity have attracted wide attention. Since, physical activity is one of the main determinants of healthy ageing, from early 2000 until today; there is a significant increase in ageing studies using such devices [9]. The authors [10] give an extensive comparison of up-to-date studies using wearables or/and stationary sensors to monitor physical activity in adults. In this section, considering wearables sensors as predictors have a systematic analysis that makes the study into perspective with others, with special attention to activity recognition in healthy people.

Sport tracking systems for tracking aerobic exercises are both common and commercially available [11]. These systems use GPS, heart-rate monitors and pedometer to track the distance of a person whether he is walking, running or cycling, and to estimate the burned calories. Systems for tracking strength training are far less common. FitLinxx proposes a strength training tracking system that is mounted to weight-lifting machines in the gym [12]. The user can log on to their personal training profiles using touch screens. The system tracks the amount of weight the user is using; the number repetitions performed, and give users direct feedback of their progress. The system requires the gym to be equipped with special exercise machines and infrastructure, which is very expensive and not suitable for average user.

Other systems exploit only the inertial sensors in smartphones to detect and count sport exercises. The smartphone has gained a lot of attention in activity recognition, since it can through its sensors capture user's motion, analyse it in real time, provide instant user feedback, and log data for long term analysis. Muehlbauer et al. investigated how a holster worn smartphone can recognize different upper body exercises and count repetitions [13]. Pernek et al. build upon this work by supporting a broader range of exercises including some gym machines [14]. In [15], the authors focused on important applications of activity recognition in several fields such as healthcare, wellbeing and sports systems. In [16], the researchers proposed activity recognition systems as links among the common diseases with the degrees of peoples' physical activity.

III. PROPOSED METHODOLGY

An IoT based fitness monitoring and prediction system is represented in this work that identifies the calories burnt and the exercise pattern to manage the environmental scenario. It is deployed to increase health pattern of a person by giving the calorie burnt level to predict the future pattern of calories burnt with the exercise to be conducted. The calories burnt or the steps to be walked is been generated through an app where the data is stored locally in the app. The app maintains the level of calories that is generated for a period of time and then the data is used to predict the calories of the future days that would be generated on the live basis. Figure 1 shows the proposed system which is used to identify the axis level of the position where it is placed with the Arduino UNO connecting the MPU6050. The Bluetooth HC-05 is connected to the Arduino to transmit the data of the live positions of IoT. The proposed system consists of sensing of parameters, storage of data in App, display in dashboard with prediction through Fb Prophet machine learning.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

The proposed system is divided into two modules namely:

1. Sensing of parameters (acceleration values)
2. Machine learning prediction setup

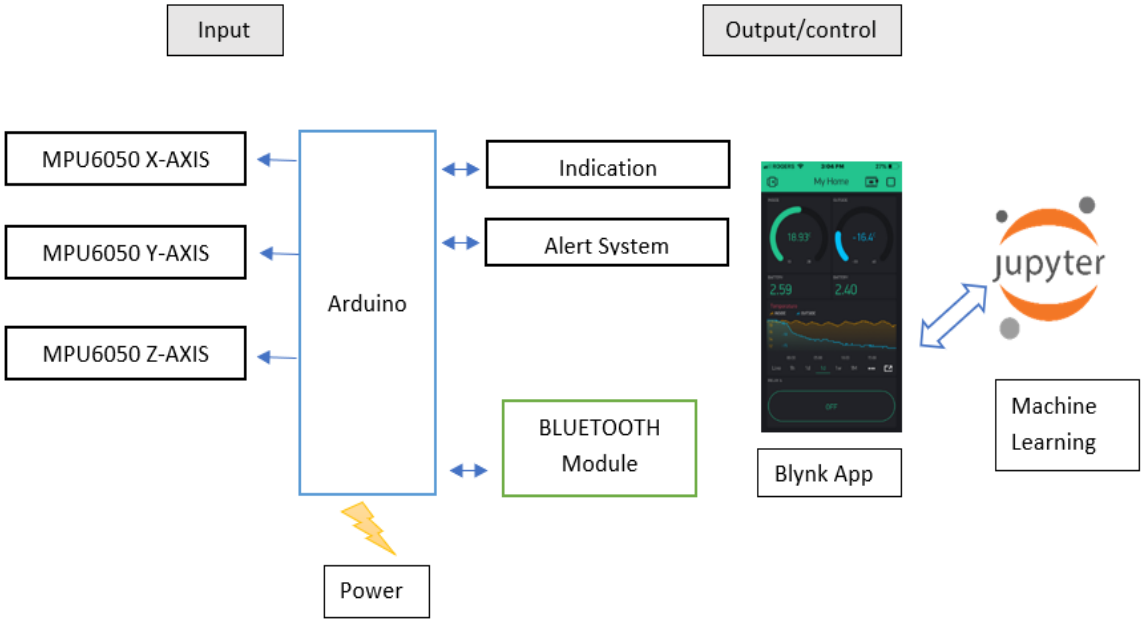

Figure 1: Proposed Architecture of Fitness

1) Sensing of Parameters

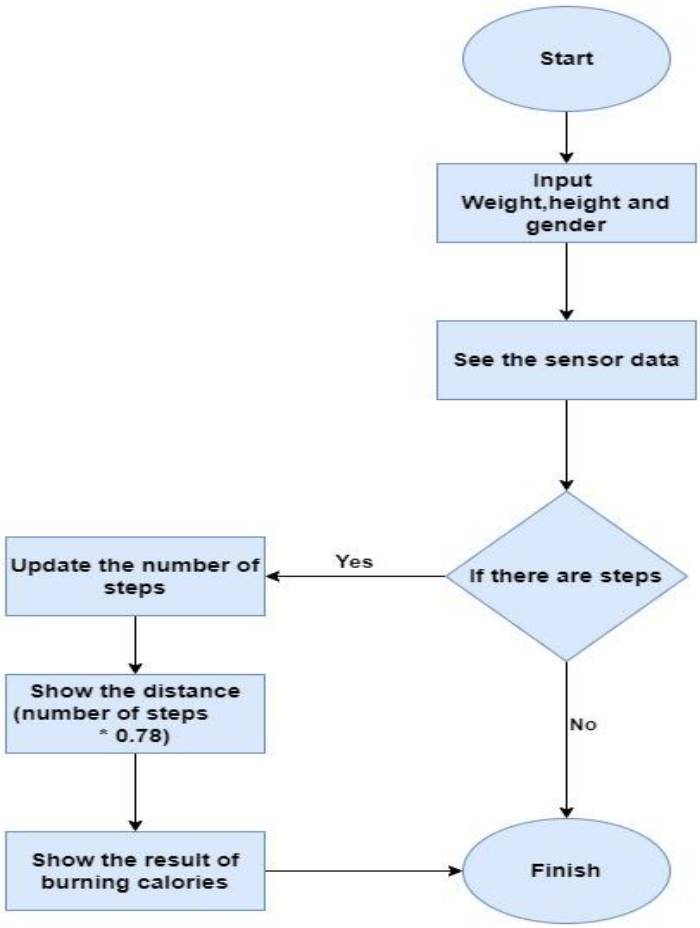

Figure 2: Proposed flow chart

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

An accelerometer sensor used to measure the acceleration of an object. The operating threshold (acceleration and energy) is used for impact detection in the accelerometer smart sensor. Current accelerometers are electromechanical devices that can measure static and linear / dynamic acceleration. The accelerometer sensor can be used to detect the tilt in the form of the angular values of the X, Y and Z axes. The angular values are converted in the form of a waveform graph to easily determine the upper and lower threshold. From the three acceleration values, one of the axes is taken then determined the threshold value for the upper and lower limits or it can also be called as threshold above and threshold below. The size of the footsteps is 78cm on average or it is assumed to be a human step along the 0.78m. Then to calculate the number of calories burning, the number of steps, time taken, and initial body weight are needed.

In this work, an application was developed using a smartphone as a data acquisition platform, because this device provides a user-friendly interface. Smartphones with touch screens have become very popular and have changed people's behavior due to the many applications and features attached to them. This application will count the number of footsteps taken as well as the number of burning calories produced during exercise, then monitored using the Android application. The presence of android smartphone technology that already supports the accelerometer sensor which has accuracy in calculating footsteps on the android operating system. The working way of this proposed application is shown in Figure 2.

2) Machine Learning Setup

At the beginning of this system, it was asked to input the height, weight, and gender of the user. Then the athlete started jogging. During exercise, the accelerometer sensor worked to detect the number of footsteps. Next, the system displayed the total distance traveled based on these footsteps multiplied by 0.78 and at the same time, the system also displays the amount of burning calories produced during steps. To know the results of calories burning, there are several steps that must be followed. First, determine the value of the magnitude. This value is used to determine the acceleration value in three axes, namely x, y, and z axes, each of which is symbolized in Ax, Ay, and Az. In order to determine how many calories an individual would burn, this study is all about gathering the right dataset to train our machine learning models. Pre-processing of the records is necessary before the statistics feeding operation. After that, data processing is completed, and the data is arranged as plots and graphs using several visualization techniques. Here, we use Fbprophet as a Machine Learning (ML) model for making comparison and then evaluating these models.

Basal Metabolic Rate (BMR) is the number of daily calories which the body needs to survive and perform physical activity. For every sport movement, the MET (Metabolic Equivalent of Task) value is sough which is the estimated number of calories burned while doing sports activities within a certain time, then compared with the estimated body muscle mass volume. In addition to finding calories burned while exercising, the same calculation can also be used to calculate how many calories are burned for daily activities. The basic formula of MET can be seen on Equation 1 below.

$$EC = \{MET \text{ x } 7.7 \text{ x } (BB200 \text{ x } 2.2)/200\}\ x\ Duration/\ 60 \qquad (1)$$

Where,

EC = Exercise Calories, which is the result of calorie burning calculation.

MET = Metabolic Equivalent of Task, which is the estimated calories burned during sports activities.

The MET value for jogging is 2.8 based on the India Sport Nutritionist Association (ISNA))

BB = Weight (kg)

Duration = Time spent exercising (in seconds)

The position of the body will start rising up when we perform exercise or some heavy workout. The variables used here are the timescale of the person is training, the average heart rate per minute, and the positions. Parameters that can be considered for input are the duration of exercise, average heart rate per minute, temperature, height, weight, and gender. A machine learning Fbprophet regressor algorithm is used to predict calories burned depending on exercise time, temperature, height, weight, and age.

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

IV. RESULTS AND DISCUSSION

a) Circuit Diagram

Figure 3 depicts the circuit diagram of the proposed system. MPU6050 sensor is used to detect Ac X-axis, Ac Y-axis and Ac Z-axis. MPU6050 is a very low price and low power consumption sensor that has basic capability data logging, converting from analog to digital. It is good at 0-50ºC temperature reading with ±2ºC accuracy and 20-80% readings with 5% accuracy. Arduino UNO is used to enable Bluetooth module connection. Low cost module HC-05 is added to the prototype to support local connection. Using such connection, the data that has been processed in Arduino which will be transmitted to the IoT platform.

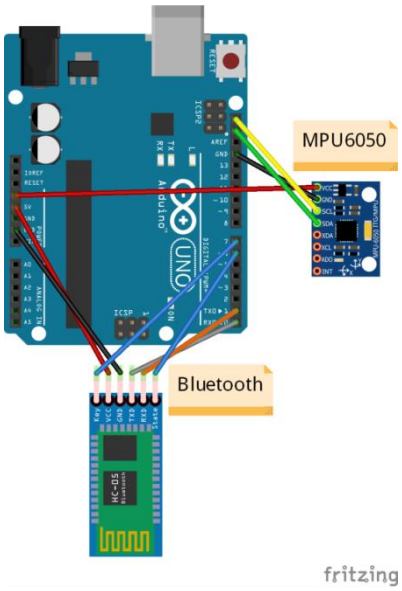

Figure 3: Circuit diagram of the proposed system

b) Blynk Cloud representation

Blynk app is used as a platform to control and monitor the deployed device. This platform is also very useful to connect the device to the Blynk cloud server and analyze the telemetry data over. It has several libraries to support data analysis. Another pro is Blynk cloud server is open-sound deployable in minutes. The sensor is then installed in the physical fit setup attached to any person physically. Sensor is recorded with 0.5 milli sec in hardware. The monitoring prototype is deployed and obtaining data from the sensor that is connected using Bluetooth. Such measurement is suitable enough for any movement's measurement. Each device consists of different sensors and sends the data continuously to the Blynk server, which has predefined limits for calories, steps and distance. Alerts or notifications are generated and send to Blynk App services and the user to take desired action and further used for the prediction of the data. Figure 4 represents mobile application viewed in the cloud named Blynk app.

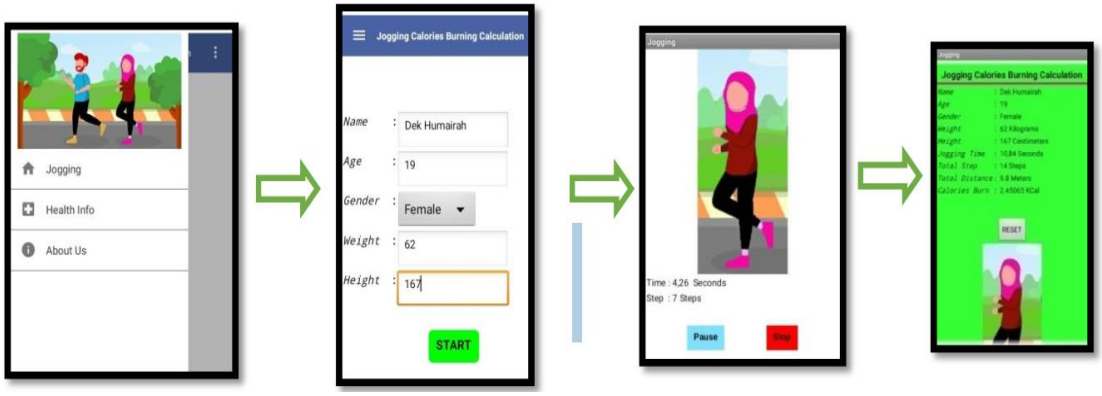

Figure 4: Fitness management dashboard developed in Blynk App

e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com

c) Prophet Code

Prophet Forecasting Library Prophet, or "Facebook Prophet," is an open-source library for univariate (one variable) time series forecasting developed by Facebook. Prophet implements what they refer to as an additive time series forecasting model, and the implementation supports trends, seasonality, and holidays. Prophet models are a natural fit for this problem due to the following two reasons. First, Prophet is capable of handling long sequential data processing because the design of gates allows intact memory propagation, shown as the state passing, which avoids to some extent, the gradient vanishing and exploding issues. Second, compared to conventional RNN, Prophet is relatively insensitive to the "gap" length, i.e., the 'interval' between two adjacent cells. Calories data have a similar characteristic because extreme high calories may break the internal pattern existed in calories data. Figure 5 represent the training, testing and predicted data of calories burnt.

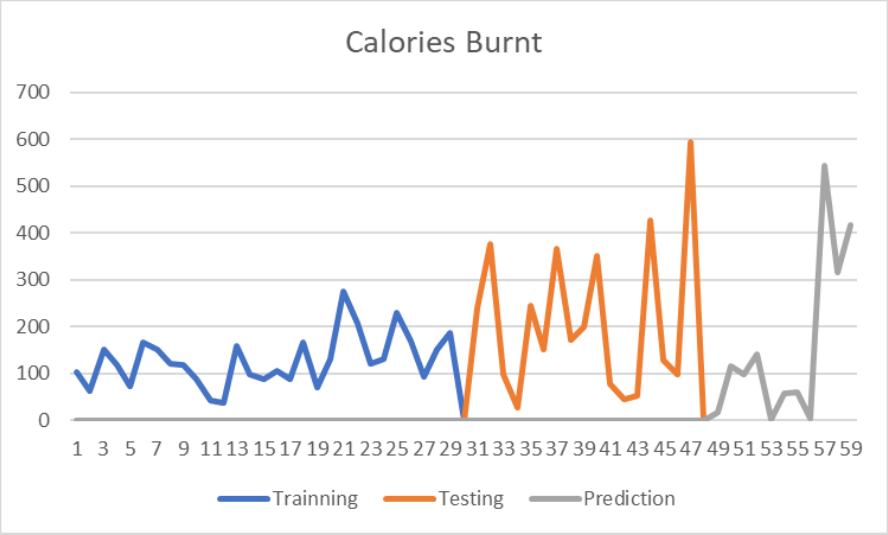

Figure 5: Training, testing and predicted data of calories burnt

V. CONCLUSION

In this work the system makes use of movement axis data sensing along with speed and angle sensing to increase the productivity of movement detection and calories burnt. The sensor data is constantly scanned to record values and check for acceleration and gyro data is transmitted online. The Bluetooth module is used to achieve the live communication functionality. In this work, it is proposed to develop a monitoring movements around the physical exercises at any movement conditions. This proposed model will monitor and alert the user through instant alert on harsh conditions. From the results, it was found that the calorie burning results in the application were in accordance with manual calculations based on body weight and there were no differences, so it could be concluded that this application was suitable and fit for athletes when jogging to find out the results of burning calories during exercise. In this work, the data stored in the app is analyzed further for predicting the calories to be burnt. The predicted data can be used for future goal setting of doing the physical activity by maintaining the health through this system.

VI. REFERENCES

[1] Azizah, Fakhrun Nisa'ul, Tubagus Mohammad Akhriza, and Andri Prasetyo. "Aplikasi Android Untuk Membantu Program Diet Berbasis Aktivitas." In Seminar Nasional Sistem Informasi (SENASIF), vol. 1, pp. 587-597. 2017.

[2] Kasim, Shahreen, and Faten Azmira Zakaria. "Daily calorie manager for basic daily use." In Third International Conference on Innovative Computing Technology (INTECH 2013), pp. 437-442. IEEE, 2013.

[3] Jain, Yash, Debjyoti Chowdhury, and Madhurima Chattopadhyay. "Machine learning based fitness tracker platform using MEMS accelerometer." In 2017 International Conference on Computer, Electrical & Communication Engineering (ICCECE), pp. 1-5. IEEE, 2017.

[4] Reddy, G. Karthik, and K. Lokesh Achari. "A non invasive method for calculating calories burned during exercise using heartbeat." In 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), pp. 1-5. IEEE, 2015.

[5] Kusuma, Wahyu Andhyka. "Monitoring Langkah Kaki dengan sensor MPU6050 untuk Menghitung Jumlah Kalori Terbakar Berdasarkan Analisis Gaya Berjalan." In Prosiding SENTRA (Seminar Teknologi dan Rekayasa), no. 4, pp. 50-55. 2019.

[6] De Cillis, Francesca, Francesca De Simio, Floriana Guido, Raffaele Antonelli Incalzi, and Roberto Setola. "Fall-detection solution for mobile platforms using accelerometer and gyroscope data." In 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 3727-3730. IEEE, 2015.

[7] Kusuma, Wahyu Andhyka, Zamah Sari, Hardianto Wibowo, Siti Norhabibah, Sabrina Nurul Ubay, and Diah Ayu Fitriani. "Monitoring walking devices for calorie balance in patients with medical rehabilitation needs." In 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), pp. 460-463. IEEE, 2018.

[8] Rahman, Taufik, and Dedy Kurniawan. "Perancangan Pedometer Berbasis Sensor Accelorometer Android." JITK (Jurnal Ilmu Pengetahuan dan Teknologi Komputer) 2, no. 2 (2017): 122-130.

[9] Mokaya, Frank, Hae Young Noh, Roland Lucas, and Pei Zhang. "MyoVibe: Enabling inertial sensor-based muscle activation detection in high-mobility exercise environments." ACM Transactions on Sensor Networks (TOSN) 14, no. 1 (2018): 1-26.

[10] Khan, Aftab, James Nicholson, and Thomas Plötz. "Activity recognition for quality assessment of batting shots in cricket using a hierarchical representation." Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 1, no. 3 (2017): 1-31.

[11] Ó Conaire, Ciarán, Damien Connaghan, Philip Kelly, Noel E. O'Connor, Mark Gaffney, and John Buckley. "Combining inertial and visual sensing for human action recognition in tennis." In Proceedings of the first ACM international workshop on Analysis and retrieval of tracked events and motion in imagery streams, pp. 51-56. 2010.

[12] Tian, Yiming, Jie Zhang, Lingling Chen, Yanli Geng, and Xitai Wang. "Single wearable accelerometer-based human activity recognition via kernel discriminant analysis and QPSO-KELM classifier." Ieee Access 7 (2019): 109216-109227.

[13] Fu, Zengjun, Kuang-I. Shu, and Heng Zhang. "Ping pong motion recognition based on smart watch." In 3rd International Conference on Mechatronics Engineering and Information Technology (ICMEIT 2019), pp. 617-625. Atlantis Press, 2019.

[14] Wang, Yufan, Meng Chen, Xinyu Wang, Rosa HM Chan, and Wen J. Li. "IoT for next-generation racket sports training." IEEE Internet of Things Journal 5, no. 6 (2018): 4558-4566.

[15] Mencarini, Eleonora, Amon Rapp, Lia Tirabeni, and Massimo Zancanaro. "Designing wearable systems for sports: a review of trends and opportunities in human–computer interaction." IEEE Transactions on Human-Machine Systems 49, no. 4 (2019): 314-325.

[16] Khan, Aftab, Nils Hammerla, Sebastian Mellor, and Thomas Plötz. "Optimising sampling rates for accelerometer-based human activity recognition." Pattern Recognition Letters 73 (2016): 33-40.