

Tracking and Monitoring Fitness of Athletes Using IoT Enabled Wearables for Activity Recognition and Random Forest Algorithm for Performance Prediction

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ABSTRACT

Purpose: The progression in technology is made the best use of in every field. Sports analytics is an essential sector that has gained importance in this technology-driven era. It is used to determine the hidden relationships among different quantitative parameters that affect the performance of athletes. This type of analysis requires a large amount of data to be stored periodically. Cloud acts as a scalable centralized repository that can store the massive data essential for analysis purpose. From the technological perspective there are numerous wearable activity tracking devices, which will be able to provide feedback of physical activities. With the help of random forest (RF) algorithm it is possible to classify huge datasets to perform predictions. In this paper, different smart devices that can be used to measure physical activity, use of RF algorithm for converting data obtained from smart devices into knowledge are explored. A conceptual model that uses wearable devices for tracking and monitoring and RF algorithm to predict the performance is suggested.

Methodology: The study was conducted by referring to scholarly documents available online and by referring to websites of companies offering healthcare and sports related services. A conceptual model is developed based on the theoretical perception that incorporates the components needed for measuring the physical activities to predict the performance of athletes.

Findings/Result: In this paper the proposed system contains four major activities as Capture, Store, Analyze, and Predict. The model considers use of IoT-enabled wearable devices to measure the physical activities of athletes and the information collected will in turn be used to analyze predict their performance and suggest them how to increase the chances of winning. However, the outcome of a game does not only depend upon the PA of athletes. It depends also upon the physical, mental, emotional health, nutrition and many other factors.

Originality: In this paper, a theoretical model is deduced to integrate IoT and RF Algorithm to track and monitor fitness of athletes using wearables for activity recognition and performance prediction.

Paper Type: Conceptual Paper

Keywords: Physical Activity, IoT, Wearable Devices, Fitness Tracking, Performance Prediction

1. INTRODUCTION :

Health and fitness are the most prominent sectors that utilize the technological advancement to a large extent. Physical activity (PA) increases the blood circulation without stressing the body. It tones the muscles and enhances strength, endurance and flexibility. It is through PA the cardiovascular system is strengthened and hence heart and lungs will be stronger. Researchers have demonstrated several advantages of PA and negative impact of sedentary behavior. PA reduces the risk of heart attacks by 50% and decrease the blood pressure and blood-glucose levels. Hence, PA has become increasingly prominent when determining the fitness of athletes. Sports are a type of physical activity that enhances a person's overall health. Obesity, asthma, diabetes, and a variety of other health issues develop as a result of physical inactivity at an early age. Taking part in sports and games decreases the risk of cardiovascular disease, diabetes, and some cancers. Compared to others, athletes would have a more positive outlook. According to studies, athletes are less prone to use drugs or tobacco. People who compete in athletics during the school days do not drop out from schools and score much well in tests and examinations. Sports participation helps instill character values such as honesty, equality, team spirit, and respect for teammates and competitors. It teaches people to be humble, humane, and self-confident. It allows people to strengthen their leadership capabilities. It has a stronger influence on personal characteristics including consciousness, assertiveness, and communication abilities. Sports have a pivotal role in promoting positive youth. It necessitates a great work ethic, dedication, determination, and commitment. Training sessions and involvement in sports meet is needed to increase the performance [1]. Sports and games are organized PAs that can be practiced by people of all age groups. The one who participates in sports and games demonstrate leadership quality, team spirit and disciplined behavior. Participation in sports helps all-round development of an individual. The positive effects in sports are because of PAs. If an athlete wants to participate in sports and games, he is expected to practice organized PAs, which aim at the betterment of results. Because of PAs, the muscles get strengthened and excess fat will be reduced. Physical fitness will increase the energy level and boost mood. Participation in sports makes the students physically fit and mentally steady [2].

Athletes' success is influenced by their fitness. In the early stages of training, individual athletes show varying levels of progress and skill sets. Athletes are to be appropriately prepared for game-specific variables in order to gain fitness and increase performance. Two types of training models that are used include: general training and sports-specific training. For the sporting case, the generic model excludes any technical skills. Athletes are prepared for short-term training using this model, with 2-4 training sessions a week. Athletes who participate in sports-related training are taught how to use techniques and strategies that are specific to their sport. Athletes are prepared for long-term training using this model, with 5-6 workout sessions. Athletes who participate in sports-related training are taught how to use skills and tactics that are specific to their sport. Athletes are expected to keep fit throughout their careers. Athletes will benefit from sports-specific preparation and coaching activities that will help them develop the skills they should enhance their performance. Throughout an athlete's career, their fitness should be closely monitored [3].

The field of sports and gaming has been influenced by the influx of info. As a result, the term "scientific athleticism" has become common. Athletes' diet and physique have been altered by a powerful surge of information. It is possible to assess all the athletes do with the aid of sufficient data. Data analytics is also used to guide decision-making in the sports and gaming industry. IoT devices, GPS trackers, smart cameras, and other similar devices track athletes' on-field performance, while machine learning (ML), artificial intelligence (AI), and predictive analytics are used to identify the next champion or superhero. Anything in sports has become computer-driven, thanks to the professional sports world's embrace of analytics and data. Athletes and coaches will be under continuous pressure to improve their performance. This has opened up many opportunities for analytics in sports to get reliable and real-time insights. These days, teams hire data management specialists to offer them a data advantage to maximize their performance [4].

In the world of sports and games, the use of data to calculate the success is not new, but the use of state-of-the-art data to forecast future performance is. Athletes' essential parameters can be measured using wearable IoT devices. It creates a massive database for a single athlete. It is also possible to store an athlete's former performance. In the analysis process, historical experience is used as a training set. All of the raw data collected from various sources are processed to provide useful information. Every move an athlete performs

on the field generates data that can be analyzed in some way. Information comprehension demonstrates an athlete's precise health and fitness. By analyzing asymmetric movements, it can be used to assess possible injuries. It will be used to decrease the risk of serious injuries. Athletes will learn precisely what they performed to be good or unsuccessful by evaluating their performance. Coaches and athletes will be able to make the best decisions in real - time and produce consistent outcomes because of the information gathered in this manner. It facilitates athletes in areas such as preparation, game planning, and post-performance assessment. It facilitates athletes in the development of technical ability, technical expertise, decision-making abilities, and confidence. It helps coaches recognize athletes' strengths and shortcomings, improve coaching style and conduct in-depth performance reviews [5].

IoT is a network of physical devices or 'things' that can communicate and share data. Several sensors are built into IoT products to track critical parameters. Wearable technology has given physical fitness a whole different dimension. They use various sensors to capture real-time data and display the current fitness of whoever is wearing them. They can immediately send the data to the monitoring program; using advanced processing tools, the data will be analyzed and improvements recommended. Based on exercise data and calorie intake, the system can also prescribe nutritional plans. A wearable device's sensors generate data. The data obtained in this manner requires a huge centralized storage system that can efficiently hold the data. The cloud platform is used to store the vast amounts of data produced. IoT systems can be used to monitor athletes' progress and assess their performance. Wearables that monitor vital parameters such as blood pressure, heart rate, and body temperature are examples of IoT products. On-body, off-body, and in-body devices are examples of different types of devices. IoT sensors are also be embedded on various pieces of equipment, such as footballs, basketballs, and other sports equipment, to monitor data in real time throughout the event [6].

A large amount of data that is generated using wearables have to be analyzed for effective decision-making. The data can also be used for performing predictions. For analysis, the data need to be classified properly. There are numerous classifications to predict the outcome of an event or to identify hidden relationships among various parameters. RF algorithm is a powerful tool to classify the data and convert it into knowledge, which is most crucial for predictions. It divides the huge amount of data into smaller subsets and constructs trees using some criteria. To enhance the accuracy of results multiple decision trees can be constructed based on different criteria. When multiple trees provide the same output that is treated as the final one. To increase the success rate, the RF algorithm also use boosting technique [7].

This paper highlights the objectives of the study, different parameters that are used to measure the PA, different methods that can be used to measure PA, the architecture of the conceptual model and technologies that are adopted in the conceptual model.

2. OBJECTIVES OF THE STUDY :

The objectives of the study are

1. To analyze the quantitative parameters affecting the PA
2. To explore different methods and techniques to measure the PA
3. To elucidate the use of IoT-enabled wearable devices to measure PA
4. To design a conceptual model that uses IoT enabled smart devices to measure PA
5. To understand the use of RF algorithm in analyzing the PA

3. RESEARCH METHODOLOGY :

The study was conducted by referring to scholarly documents available online and by referring to websites of companies offering healthcare and sports related services. A conceptual model is developed based on the theoretical perception that incorporates the components needed for measuring the PA to predict the performance of athletes. The model is built through the analysis of existing information and it is in its infantile stage. It uses only abstract ideas. To test the feasibility of the model, further study is necessary.

4. MOTIVATION :

Monitoring the performance and fitness of athletes continuously is considered the key to their success. It is essential for athletes to sustain or improve the performance. If there is constant monitoring, the coaches will

realize the progress of the athletes easily. Monitoring is also needed to check whether the athletes are following the prescribed amount of PA, keeping their body hydrated, following the necessary diet, taking adequate rest, etc. The real challenge is how to gather the necessary data? If athletes follow a self-reporting mechanism, there is a possibility of miscomprehension, error or bias. During the process of selection, there is a chance of “faking good/sick”. Monitoring is a continuous process it develops a bond between coaches and athletes. Hence, if coaches are asked to create activity logs, there is a chance of inaccurate or biased log information. Also, there are several parameters to be measured on a daily basis. Entering all the essential data is time-consuming job. If there is a means by which the data related to the essential quantitative parameters is sent directly to the monitoring system it would help the coaches to identify the strength and weaknesses of athletes. Hence if the accurate data related to the PAs of athletes are recorded properly, it will enable the coaches to train the athletes. Use of IoT-enabled wearable devices makes monitoring process easy and interesting. All data gathered will be of no use if it is not used for the improvement. If algorithms are used to identify the hidden relationship different parameters, it would help the athletes improve their performance.

5. RELATED WORKS :

Table-1: Summary of Related Works between 2010 and 2021 by different researchers

SN	Author(s)	Year	Inventions/Findings/Results
1	Magalhaes <i>et al.</i> [8]	2014	Analyzed the use of inertial sensor-based IoT devices such as an accelerometer, gyroscope in swimming for the purpose of continuous monitoring of swimmers.
2	Ahmadi <i>et al.</i> [9]	2014	Developed a layered architecture containing wearable devices, cloud infrastructure, internet, smartphones and other related technologies to motivate the use of IoT in sports.
3	Rein & Memmert [10]	2016	Explicated the use of big data to perform tactical analysis in a team game. The analysis is performed using ML algorithms.
4	Gowda <i>et al.</i> [11]	2018	Illustrated the application of IoT in cricket. Explained how different objects included in the game can be made smart and help effective decision-making.
5	Tang, F., & Ishwaran [12]	2017	Explained how to handle missing data and several types of data by using RF algorithm. Also explained how RF algorithm is efficient to handle premature, impute and pre-impute data when constructing the forest
6	López <i>et al.</i> [13]	2018	Identified different factors involved in injury-risk prediction. Compared numerous ML methods for injury prediction and found RF algorithm is the most accurate one. Developed a model that performs injury prediction using RF algorithm
7	Wilkerson <i>et al.</i> [14]	2018	Analyzed different types of injuries and developed a model that uses IoT devices to mitigate injury-risks.
8	Morgulev <i>et al.</i> [15]	2018	Explained how sports data can be analyzed to determine human behavior.
9	Apostolou & Tjortjis [16]	2019	Explained how ML algorithms enable the coaches to identify reason for decline in the performance of athletes
10	Silva <i>et al.</i> [17]	2019	Explained different artificial intelligence techniques that can be used to perform injury prediction among athletes

6. PARAMETERS USED TO MEASURE PA :

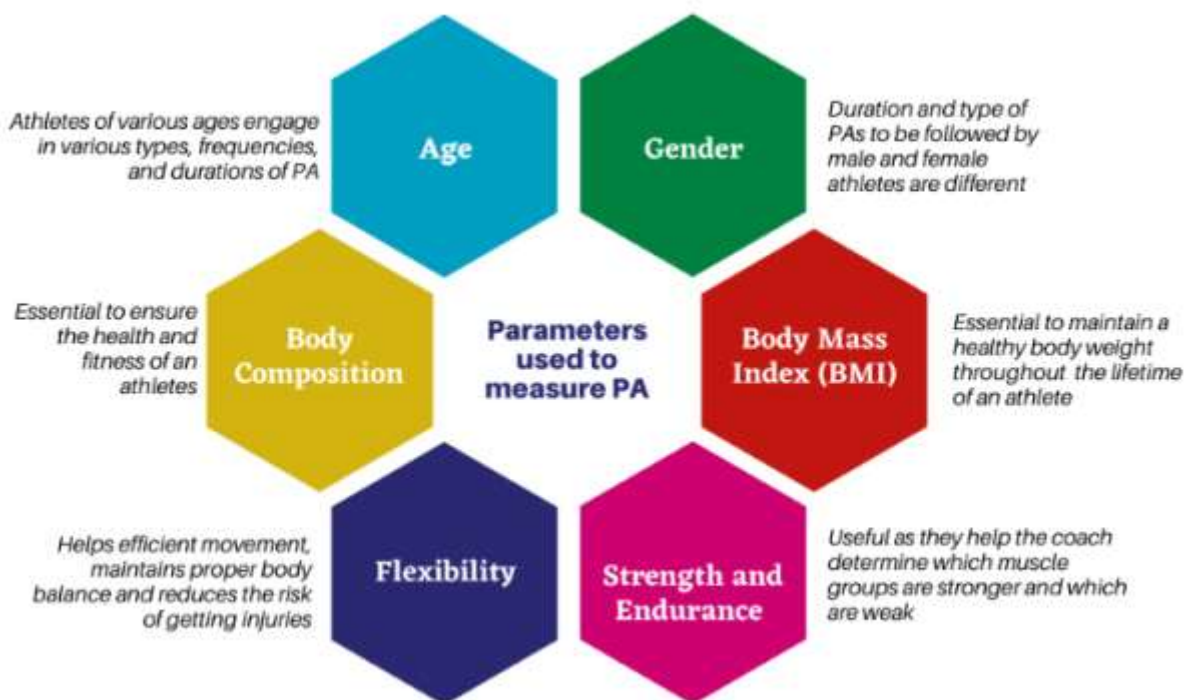


Fig. 1: Parameters used to measure PA

- **Age:** As far as PA is concerned, age of an athlete plays a crucial role. Athletes of different age groups different type, frequency and duration of PA. There is a tendency that adults are more likely to skip the PA when compared to youngsters. Age, lack of motivation, improper time management, lack of interest in PA, pre-existing medical conditions, injuries, etc. act as hinderance for PA among adult athletes. Researches show that youngsters are keener to meet the guidelines of PA when compared to adults. Following same type and duration of PA for athletes of different age groups is not recommended.
- **Gender:** It is recommended to design gender-specific PAs. Duration and type of PAs to be followed by male and female athletes are different. Female athletes prefer lighter PAs like walking, running, etc. where male athletes are more interested in PAs that strengthen their muscles. Fatigue, overtraining, muscle pain, etc. are more faced by female athletes than males. When designing the PAs, the coaches ensure that male and female athletes follow different set of activities and have different targets to achieve.
- **Body Mass Index (BMI):** It is much essential to maintain a healthy body weight throughout the lifetime of an athlete. If athletes are overweight or obese, they tend to show poor performance in their motorability skills. Overweight leads to serious health issues such as diabetes, hypertension, etc. Athletes must follow a healthy diet to maintain an optimal BMI because overweight hinders the PAs and in turn acts as a hurdle in the fitness of athletes. Hence, PAs are to be tailored in such a way that they ensure a steady BMI in athletes.
- **Strength and Endurance:** Strength is the amount of force the group of muscles can exert at unit time. Strength and endurance assessments are useful as they help the coach determine which muscle groups are stronger and which are weak and in need of focused attention PAs are to be designed to increase the strength and endurance of athletes.
- **Flexibility:** It is the ability to move the muscles without straining them. It helps efficient movement, maintains proper body balance and reduces the risk of getting injured. Forward bending, backward

bending and stretching are used to measure the flexibility of athletes. After the PA the flexibility should be increased.

- **Body Composition:** It describes the amount of fat, bones, muscles and water in the body. Body composition and growth are essential to ensure the health and fitness of an athlete. Based on the analysis of parameters such as skinfold thickness, BMI, waist circumference, etc. it is possible to predict the body composition of athletes using ML algorithms. A healthy body contains adequate proportion of muscles, fat, bones and water. The body composition of an athlete important to measure the fitness [19–21].

7. APPROACHES TO MEASURE PA :

As shown in Fig. 2, there are four different approaches to measure PA of athletes.

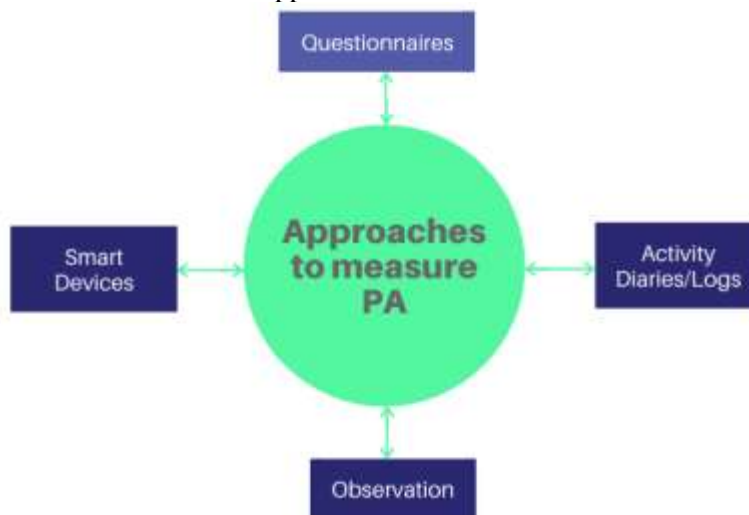


Fig. 2: Different Approaches to measure PA

- **Questionnaires:** Questionnaires are the most common way of gathering data from a group of respondents. In case of monitoring PA, the athletes are asked to fill a form containing multiple questions related to their PA. These questions seek quantitative information related to athletes such as mode of PA, type of PA, frequency, duration and calories, etc. These questionnaires mainly depend upon the athletes' recall ability. Questionnaires are more specific and cost-effective way of gathering personal data. With the help of questionnaires, it is possible to collect data from a large set of respondents. Hence, the technique is fast and scalable. However, this technique of collecting data has some inherent limitations. When the personal data are entered by individual athlete, the accuracy of data is a major issue. The truthfulness of responses depends upon the athlete. There is a chance of inaccurate information about the personal data of PA. Also, there are chances of misinterpretation of questions. In most of the cases, questionnaires do not contain personalized questions.
- **Activity Diaries/Logs:** Activity log is the best way to measure the progress of athletes. They enable athletes to record their activity every day. They enable athletes to store the real-time data related to the amount of PA done by them. In case of activity logs, athletes are asked to create a table that is used to store the details of PA such as date, duration, time spent, goal, etc. Athletes can get a clear picture about the improvement in their performance. It will boost their confidence and keeps them committed to the regular PA. The log contains descriptive answers in the form of explanation of activities. The athletes also need to record the future goals to improve or sustain their performance. These logs increase the time-management skills of athletes. Activity logs contain more explanatory data and hence creating them is a time-consuming task. Also, they are not recommended for athletes in the age group 5–10 years because athletes of this age group find it extremely difficult to write explanatory answers.
- **Observation:** In this case PAs of athletes are monitored by another person. In many situations coach himself observes and records the PA of athletes or else a person is appointed to monitor. The observation is practiced worldwide where coaches become mentors and keenly observe the PA of athletes to identify their strengths and weaknesses. However, this method is also not free from problems. It is hard for a

single person to focus on variety of parameters and is even harder to retain the vast information collected. Also, there is a chance of personal bias when using this method. This method is useful for athletes in the age group 5–10 years.

- **Smart Devices:** Smart devices are containing sensors and are portable devices that can monitor the PA effectively. They can be easily connected with other devices such as smartphones to share the information. The information from smart devices can easily be transmitted to the external storage medium and in the future the same can be used to track the progress of athletes. These devices are cost-effective and energy-efficient. They contain multiple sensors and can measure numerous parameters and are trendy these days [22–23].

8. WHY SMART DEVICES IN SPORTS :

Health and fitness are the largest industry that extensively uses smart devices. These smart devices ensure ubiquitous monitoring of athletes. They contain numerous sensors and are extensively used by athletes these days. They can sense many parameters such as temperature, speed, blood pressure, calories, etc. during the PAs. The data they created can easily be sent to the external storage medium without any human intervention. Hence, the accuracy of data will be high. Since the activity data can automatically be stored there will not be errors when entering data [24].

A balanced workout is as important as a balanced diet. It enables athletes to maintain fitness. It requires a combination of standing workouts, twists, leg exercise, forward bending, back bending, running, weight training, etc. If athletes fail to perform balanced workouts, they feel strain and sprains. It causes injuries at later stages. IoT enabled tracking system allows hassle-free workout sessions as they provide detailed tracking of workout sessions. The devices can be implanted on gym-equipment to improve the quality of the workout.[25].

Table 2: List of PAs that can be measured using wearable IoT devices

S.N.	PA	Description
1	Squats	It is a PA that is practiced by athletes specially to burn more calories and strengthen the muscles. It also increases the mobility and flexibility of an athlete. Number of squats done by an athlete can be counted by wearable devices such as wrist-bands
2	Box Jumps	They strengthen the muscles and increase the swiftness.
3	Deadlifts	This PA strengthens many muscles. They improve body balance and prevent injuries.
4	Planks	It is an abdominal PA, which used to strengthen the core. It mainly helps to stabilize and balance the body. The duration of planks and number of planks can be counted using wearable devices. The aim here is to increase the duration of plank.
5	Walking	It is a PA used to increase cardiovascular and pulmonary fitness. Using smartwatches, it is possible to count the footsteps, distance covered, duration and calories burnt.
6	Running	It is a weight-burning and bone-strengthening exercise, which also improves cardiovascular fitness. Using smartwatches, it is possible to count the footsteps, distance covered, duration and calories burnt.
7	Bench Press	This PA is mainly used to strengthen the upper-body. It has many variations in this PA and the basic one is using a barbel without weights. The number of bench presses can be counted.
8	Ladders	This PA is used to enhance their speed. It is the most effective lower-body workout especially practiced by athletes during their warm-up sessions.

9	Dot Drills	In this type of PA, several dots are placed on the floor in different patterns and the athlete is made to jump from one dot to another. It is mainly practiced to increase quickness, agility and balance.
10	Swimming	It is practiced by athletes of all age groups. It strengthens the muscles and the cardiovascular system. It is considered the whole-body exercise without putting stress on the body. Almost all the wearable devices are water-resistant and hence they can be used to measure distance, speed, stroke type, velocity, efficiency, lap time, etc.
11	Cycling	It is an aerobic PA which enable the athletes to increase cardiovascular fitness. It regulates blood circulation and improves overall fitness of the body.
12	Pull-ups	This PA is used to strengthen the upper-body. It requires the involvement of multiple-joints and is good to improve explosiveness and body balance. The PA also involve weight training.

This list of generic PAs the quality of which can be assessed using wearable devices. Besides these there will be event-specific PAs, which are in the athletes are also suggested to practice games like football, golf, soccer and relaxing techniques such as Yoga and Pranayama. The ultimate aim of any PA is to enhance the fitness and enhance the chance of winning [26-27].

9. LAYERED ARCHITECTURE OF THE PROPOSED SYSTEM :

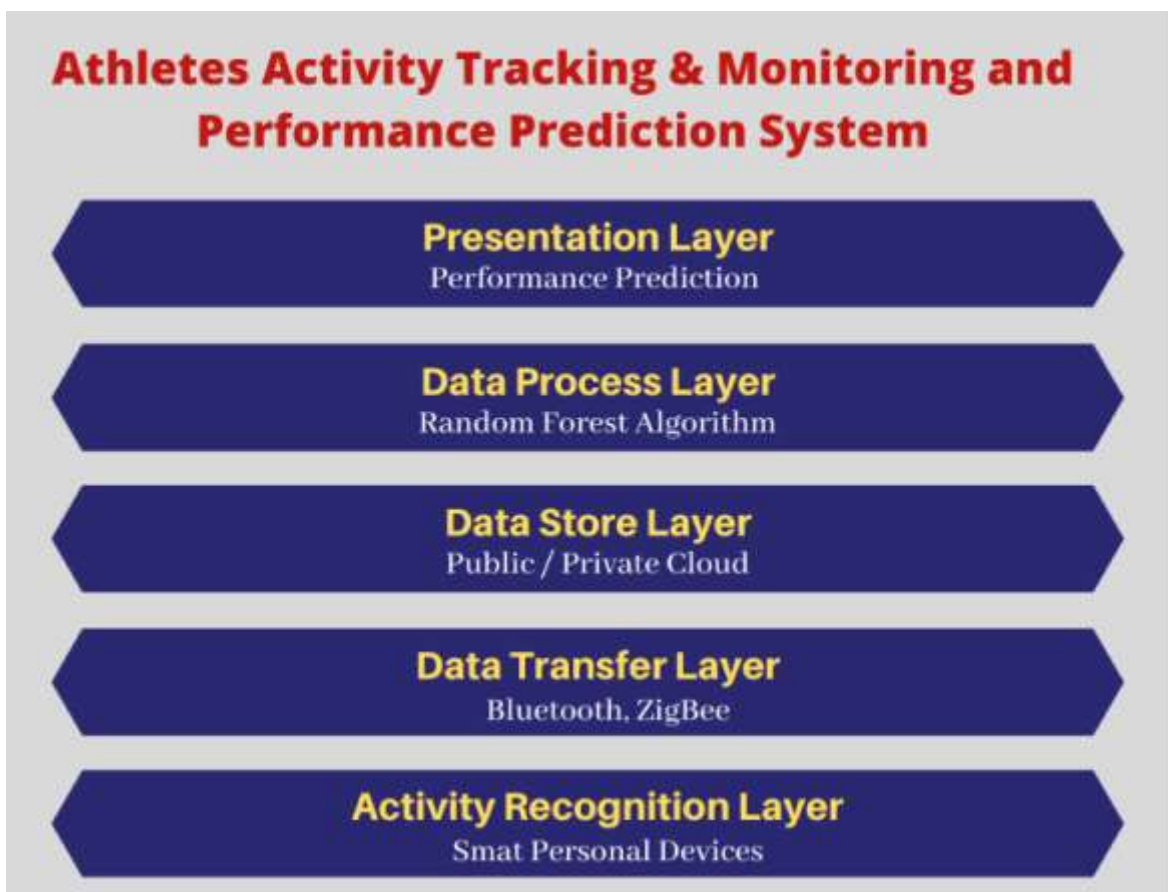


Fig. 3: Layered Architecture of the Proposed System

The layered architecture represents the design in smaller pieces so that it is easy to understand, code, test and debug. Fig-3 indicates the layered architecture of the proposed system.

- **Activity Recognition Layer:** This layer comprises sensors or wearable devices that are used to capture parameters such as body temperature, blood pressure, heart rate, respiration rate, calories burned, etc. While designing this layer, cost and energy consumption capability of the sensing devices are important aspects to be considered. Due to the advancement in technology, several power-efficient, accurate IoT devices are available in the market these days.
- **Data Transfer Layer:** The job of IoT is to connect a number of 'things' for data sharing reason. Bluetooth, ZigBee are a few examples of the technology used for connectivity. The Device management, energy consumption, protection and privacy of are some points to remember when designing this layer. The data generated by smart devices are to be sent to the central repository using mobile applications. To connect wearable devices and mobile applications, Bluetooth or ZigBee are extensively used.
- **Data Store Layer:** The wearable devices produce voluminous data that that must be stored efficiently and processed for decision-making purposes. The voluminous data create a data pile and every bit of information is needed for the analysis. Keeping entire data at a single location makes it easy to store, access and analyze. Several cloud services available to efficiently store the data.
- **Data Process Layer:** This layer contains the processing units and the software required to aggregate the data. Raw data generated by the devices can be converted to standard format. This layer converts information stored on the cloud into valuable knowledge that is much needed for decision taking purposes. In this step algorithms are used to learn from sample data automatically and when test data is given, they easily categorize the same to arrive at conclusion.
- **Presentation Layer:** Once analysis is over there are numerous data visualization tools that present the data in an appealing manner. This step provides a visual summary of findings with the help of maps, graphs, etc. when the data are presented in a pictorial format human brain can easily comprehend the same. Also, it is easier to identify trends, patterns and outliers within a large dataset [28].

10. COMPONENTS OF THE PROPOSED SYSTEM :

The proposed system contains four major activities, as shown in Fig. 4. IoT enabled wearable devices are used to capture the essential parameters.



Fig. 4: Activities in Performance Analytics

- **Capture:** The first step of every activity that involves data analysis is data acquisition. Data related to PAs of athletes is generated using wearable devices and is collected automatically. The data is periodically transferred to mobile applications using technologies such as Bluetooth to the access point. Every wearable device comes with a mobile application which can be used as access point that sends the data to the data store. All quantitative data collected using wearable devices that contain multiple sensors is collected by the data acquisition system.
- **Store:** Once all the required parameters are collected using wearable devices it has to be stored safely in a centralized repository. Since the data is growing exponentially the conventional DBMS may not be of much use to store and manage data. Cloud platform provides a scalable storage medium.
- **Analyze:** The purpose of collecting and storing a huge amount of data is to utilize the same in the future to make predictions. Different events require different strategies to be adopted to improve performance and maximize the chance of winning. In most cases, analysis is based on the statistical pieces of evidence obtained from the performance records. However, it is not recommended to solely depend upon the statistical techniques for prediction.

- **Predict:** Based on the analysis, a prediction model is to be designed to predict the performance of athletes based on their PA. The model should be designed in such a way that it generates reliable and accurate results.

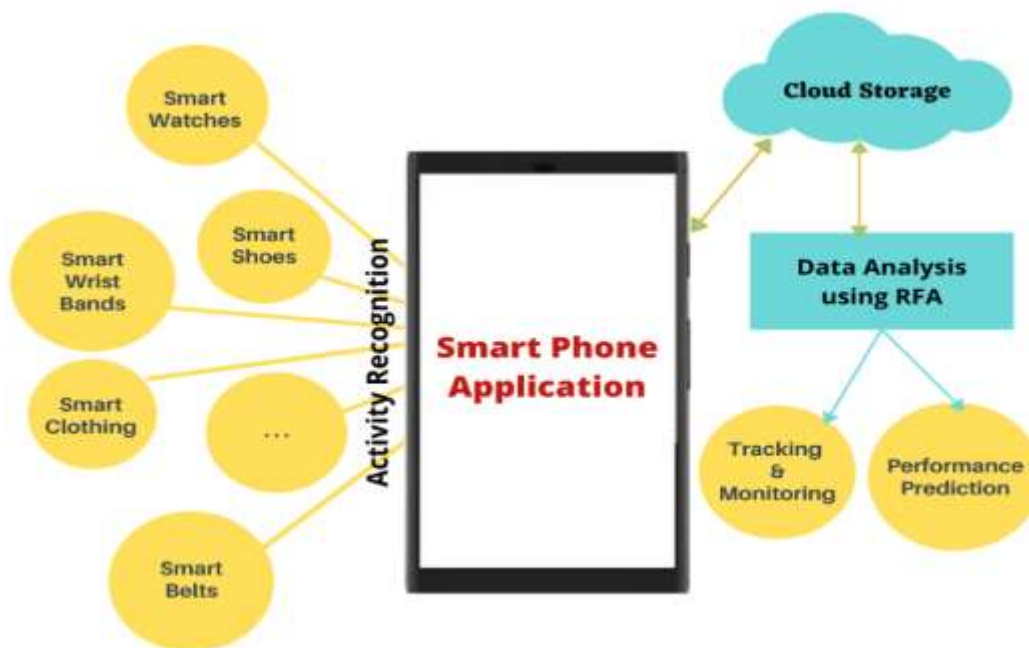


Fig. 5: The Conceptual Model

Fig. 5 gives the block diagram that indicates the functioning of the conceptual model. During PA athletes use wearable IoT devices that measure the required parameters. Data generated by these wearables is communicated to the mobile application using Bluetooth or ZigBee technology and the smartphone will send the data to the cloud storage. Once the data are stored in cloud ML algorithms can be applied so that the data can be analyzed to predict the performance.

11. TECHNOLOGIES USED :

- **IoT:** It is an emerging technology that uses sensor-based wearable devices to capture the activity data of athletes. The intelligent devices such as arm bands, smartwatches, smart shoes, smart clothing, etc. capture data related to the quantitative parameters involved in the PA of athletes. IoT is not a single technology, instead it incorporates multiple elements such as devices, sensors, actuators, etc. These days it has become the backbone of every sector, including sports. The sensing devices, which are the heart of IoT infrastructure collect tons of data that can be used to gain insights. IoT is mainly used to decrease the burden of data collection and make it more accurate one [29].
- **Communication Technology:** Data from wearable IoT device are to be sent to the cloud for effective storage. Every wearable device can be mapped to a mobile application so that the smartphone of an individual can be paired with the wearable device for data sharing purpose. Bluetooth and ZigBee are two popular short-range wireless technologies that can be used to send the data from wearables to the smartphone [30].
- **Cloud Computing:** The data captured using wearable devices undergo into three different stages. The first stage is data creation which is done at the device-end based on the PA of athlete. In the second stage, the created data are sent to the mobile application using Bluetooth or ZigBee technology. In addition, in the third step it is stored in the centralized repository for further analysis. Due to the dimension of data its storage, retrieval, analysis and management become major issues. Having data in a centralized repository reduces redundancy and updating time. Cloud computing can be used to store the voluminous data effectively [31].

- **Machine Learning (ML):** ML uses statistical analysis with the help of which computers learn from examples and to detect hidden patterns from huge noisy or complex data. Several ML algorithms are extensively used in predicting the performance. They automatically analyze the stored data and the result of which is used in decision-making. The building blocks of ML are algorithms that categorize enormous amount of data to provide variety of decisions, predictions or suggestions. Training or sample data are fed to the ML algorithm and the algorithm creates a new set of rules based on the inferences. Then the test data or actual data is given to the ML algorithm and it generates a set of solutions. One ML algorithm can be used for many problems. Arriving at a conclusion by using new data supplied is the major role of an ML algorithm. This conceptual model used RF algorithm for analysis [32–33].

12. USE OF RF ALGORITHM FOR ANALYZING THE DATA :

The study of different sets of skills in athletes is most essential for predicting their performance. Performance is not only dependent on skills; it relies on various other parameters. Surprisingly, there is no linear relationship between these parameters and their performance. It is required to identify the hidden relationships between different these so that it allows coaches to see the strengths and weaknesses of their athletes and to design their training programs following the individual needs of their athletes [33].

The accuracy of performance prediction requires a predictive model that uses ML techniques. It is a real challenge to choose the one which is best suitable for the problem under consideration, since many algorithms are used in ML. Different models and algorithms show a different level of accuracy. A model is to be chosen in such a way that it provides the most accurate results to increase the trustworthiness.

Random forest is a supervised learning algorithm that contains “forests”, which is a group of multiple decision-trees. The decision-trees drawn using this algorithm are constructed either by using “boosting” or “bagging” technique. RF algorithm is flexible, simple and easy to use. Hence it is extensively used in healthcare, business and other sectors for accurate decision-making. It can be applied for both classification as well as regression types of problems. Random forests incorporate expected values from a set of trees to make predictions. Each tree predicts the outcome as a function of the values of the predictor variables [34]

The decision-making process in RF algorithm starts with the root node X and then gets split into several nodes. This process is repeated until the leaf node is reached. In each node there will be a question and the branches represent different possibilities that the question in the node may lead to. RF contains several trees, each with same nodes but use different data that leads to the leaf node. Finally, the trees are merged and the average of all decision trees will be the answer. When using RF algorithm to solve regression type of problems the mean square error (MSE) is used as the parameter. It is calculated using the formula

$$MSE = \frac{1}{N} \sum_{i=1}^N (f_i - y_i)^2 \quad (1)$$

In equation (1) N is the number of data points f_i is the output of the node and y_i is the actual value of data point i. It estimates how well the RF forecasts the outcome.

When using RF algorithm for classification type of problems, the parameter used is Gini index instead of MSE.

$$Gini = 1 - \sum_{i=1}^C (p_i)^2 \quad (2)$$

In equation (2) P_i is the frequency of the class under consideration, c is the number of classes.

When branching nodes in decision tree entropy is used to determine how nodes are branched in a decision tree. It is calculated using formula (3)

$$Entropy = \sum_{i=1}^C - P_i * \log_2 (p_i) \quad (3) [35].$$

13. DISCUSSION & FUTURE WORK :

Application of technology in sports and games has undergone an exponential growth these days but still remains in its infancy. Undoubtedly IoT has automated the process of data collection and made it error-free but the process of data capture is not accurate as anticipated because of the sensors. The model designed in this paper is a conceptual one and the implementation issues related to the same are yet to be explored. The

model considers use of IoT-enabled wearable devices to measure the PA of athletes and the information collected will in turn be used to analyze predict their performance and suggest them how to increase the chances of winning. However, the outcome of a game does not only depend upon the PA of athletes. It depends also upon the physical, mental, emotional health, nutrition and many other factors. In future an integrated model can be built that incorporates all the factors related to athletes and analyses them to improve the performance. In this model only one ML algorithm is considered and hence the accuracy of prediction depends solely on that algorithm. In future a comparative study of different algorithms can be conducted. Also, the conceptual model only predicts the performance of athletes. With ML algorithms it is possible to perform personalized training, injury prediction, nutrition predictions and many more. In future they can also be implemented. It is also possible to provide personalized training based on the skillsets of athletes.

14. CONCLUSION :

The success of athletes depends mainly on their fitness. Fitness is attained by PA. Athletes of different age groups require different types of PA to gain fitness and optimize their performance. Monitoring the PA of athletes makes the coaches learn their strengths, weaknesses, habits and behavioral patterns. The data captured using IoT-enabled wearable devices can be evaluated and analyzed so that the coaches can guide the athletes to perform to the best of their ability. The building blocks of an intelligent sports framework are wearable devices or smart objects. PAs make a bigger difference in physical and mental health of athletes. Athletes and health enthusiasts can benefit from wearable sports equipment in many ways. These systems are low-cost and have revolutionized the way sports are played. To automate the data collection process, smart devices can be linked together. As several devices are connected in order to simplify the data collection process. Protocols must ensure safe data transfer while data from these devices is used. Smart devices can be used to actively track events and gain more insights into them.

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