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Design and Development of IoT based Intelligent Sensor Network for the Performance Analysis of Athletes

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Abstract

Athletics is one of the sports which can be played in tracks and fields. It includes more number of events like walking, running, throwing and swimming. Athletics took a major part in sports with almost all the nations in the world were eagerly ready to participate in the competition. A number of aspects is implemented for leading a healthy lifestyle and for the importance of the human concern is being determined. It includes increasing rate of healthcare for the life span to exceed longer. The profits of the residual work leisureliness, and the personal fulfilment. The persistence of this study is to inspect the increasing role that the knowledge has been based on the training and observing performance in the strength of athletic procedures by the athletes. The emphasis on the sport of triathlon (swimming, bicycling, running) which is being faced by a phenomenal growth which universally changed for men and woman of all ages and to measure the capability of an athlete. Due to lack of the proper training and feedback, performance of the athletes cannot be improved. To overcome this, effective training and feedback to the athletes from the trainers is required. We propose the new technique called Intellectual Sensor Network which works on the principle of Feedback mechanisms. The discussed technology which is employed on the basis of wearable sensors which includes power measurements and biomechanics of an individual. The gained data from the assortment of these related works in the athletic training will show the value of the information gained to the athletics. Developed technology is used to predict the athletic training and the checking performance of the athlete will be deliberated.

Keywords: *Intelligent sensor network, Wearable system, feedback mechanism, IoT.*

1. Introduction

The main scheme of conducting the examination is to hire a fresher who is well versed in reading the art and has a huge knowledge in updated technological growths in athletics. The emphasis is about the sport of triathlon which includes key basics of ability in athletic actions like strength, endurance, tenacity, flexibility etc. Through Triathlon the phenomenal growth of the athlete is increased globally. Athletics is today a crude activity encompassing building, material science, brain research, biomechanics, kinesiology, sustenance and prescription to around a couple. Innovation has improved in looking at the execution and diminishes the reason for extreme wounds, an activities of the competitor can be characterized down into parts of components in which each size of Nerves associated with the given movement, which can be abused for advancement. Both Aerobic and anaerobic execution can be erased and improved with games based preparing rehearses.

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Competitors can choose their nutritious foodstuff and apparel to be worn amid the athletic occasion for underlining their quality, adaptability and for the perseverance of the preparation. Inventiveness of the framework which is financially savvy, where the electronic gadget is exceedingly utilized based on close to home data of the competitor. As of late, all kind of innovation is being utilized for developing the occasion started by the occasion supervisors to exact the planning of members. Creative with cutting edge specialized development from scholarly and mechanical research labs are giving incredible new quality gadgets that improved the athletic experience when utilized as inexhaustibly to, however not a substitute not for, the essential physical preparing. Innovation is the fundamental explanation behind the improvement of the competitor.

Administration rule creators are involved in enhancing the usage of incomes with endorsing proper lifestyle for reducing national financial shortage sensing from the expenditure of healthcare. The person who are physically fit will have more knowledge about athletics for effective training and to avoid injury. Healthcare and the fitness professionals are fascinated in giving the knowledge of technically emerging medical and the technological areas. Real-time physiological monitoring of participants and provides response to athletes during sports events have wonderful potential for exploiting athlete's performance. For the past few decades, WSN is a popular expertise for various tenders for doing their research work in this area [7]. With the arrival of WSN and embedded systems several sports management and control systems have come into a reality.

These methods also been developed for the fitness and training management systems which is more suitable for the growth of the athletes. The proposed network is so called as Intellectual Sensor Network in that where the networking between the trainers and athletes take place and based upon the response data's from the input motion of the athletes, trainers can virtually see their errors and can be rectify their problems. It will leads to the finest performances in the field events. When the wireless sensor network is integrated with the dissimilar intellectual instructions which leads actual training techniques for the athletes with regardless to members. A currently updated evaluation defines the usual action and the workout capability that linked with positive terms of aging which is subsequently reducing the cause for many diseases. Both the developed scheme for the research in biotic devices for the crucial avoidance of many diseases.

2. Related Works

D.R Seals, et al speaks to competitors checking that may offer mentors and the specialist organizations with a more noteworthy level of assurance while endorsing and modifying the preparation load, with the goal of the advancing and the execution. This will decreases the danger of over preparing, wounds and infection. Thusly it is required to screen the competitor's execution all through the preparation. Nonetheless, the usage of the competitors requires time, monetary and HR for getting and using the information viably [1]. F.W. Booth, et al speaks to the Self-report estimates, for example, surveys and journals are an exceptionally basic and low costly to screen the competitor reactions. The Self-report estimates that can be progressively delicate and solid the conventional physiological, biochemical and the execution that can be estimated. Competitor Self-report (ASRM) incorporates view of prosperity and mental factors (e.g. mood) which are impacted by both preparing and non-preparing stressors [2].

O' Toole, et al archives that the unsettling influences in the Self-revealed prosperity partners with the exceeding and over preparing. These unsettling influences may likewise reflect in expanding the danger of wounds. The supporting writing for ASRM has regularly utilized in distributed surveys with proof of legitimacy and unwavering quality, for example, the profile of Mood states [3]. M.Fitzgerald expresses that the Reclamation-Strain Survey for the Athletes and

Regular Studies of life Stresses for Athletes. Thus actions may likewise leads in applying setting, their length, slender concentration or absence of explicitness to the donning setting has driven numerous games projects to build up their very own ASRM to address their issues. This will decreases the competitor trouble and expanding pertinence. The Design and the usage of ASRM is educated by exact measures and the individual encounters [4].

The planning of ASRM that have the capacity to limit the confinements of Self-report and the blunder estimations. These scares legitimate to the subjective and situational factors. Subjective components prompt impeccable guidelines and limit the period. This strategy causes us to improve the inspiration to react precisely [5]. Conscious inclination depends on the over revealing great responses and under-announcing positive reactions. In games competitors 'FAKING GOOD' to show up for adapting or to pick up determination or 'FAKING BAD' will have their preparation diminished. It is critical to consider both the Self-report measure and furthermore the individual and situational factors that outcome in precise, important and reliable information from competitors. It tends to be utilized in alternate fields likewise, for example, training and wellbeing for the stratagems that influence the consequences of advancement and the counteractive action programs [6].

Matthew D, et al recognized individual, socio-logical and framework factors which is affected for damage observation framework in network of games clubs. To recognize and address factors ASRM is utilized to look for the points of view of the end-clients. The conclusion clients of ASRM are the competitors can total the portion alongside the mentor and backings athletic knowledge and medication supervise. The end-clients are to counsel the improvement and pilot of another measure in ASRM which are as of now set up. In this manner a definitive point is to think about the end-clients of previous ASRM for the better understanding in applies sport and connected social natural structure [8]. McKenzie JE outlines a social natural perfect between the authoritative, relational and singular dimensions. In games the social environmental dimension has been considered as the games damage stoppage Initiatives. The progressive structure in games (competitor, group, mentor, club, territorial, national and worldwide donning associations) that has been utilized for the duties and potential change for staggered execution methodologies. Like the social natural the information for damage observation is firmly lined up with ASRM [9].

3. Proposed Methodology

Intellectual Sensor Network(ISN) is particularly designed for the training and feedback communication between the trainers and the trainees. The characteristics of this network includes Intellectual Decision Nodes(IDN) and Feedback mechanisms.

3.1 Intellectual Decision Nodes

The IDN is the wearable sensor node, and it is integrated on the sportsman for the detection of various activities of the individual and sent to the trainer through the gateways. The sensor nodes are placed various points of athlete. The sensors are integrated with the nodes which are intellectually programmed for collecting the Physical Activity of the Sportsman, Intellectual Programming for the Sensor Nodes and Interfacing with the Cloud Infrastructure. Various sensors are used to collect the physical activity of the sportsman. Intellectual Programming has been integrated in the IDN for taking the effective decisions and interfacing techniques. It relates the input sensor values with the real time values for the betterment of the training process. The transceivers which can be interfaced with the data centers or cloud

infrastructure for the analysis of the effective training of the trainees. The Flow of the ISN is shown in *Figure 1*.

3.2 Feedback Mechanism

The data from the different athletes has been received in the format which is given in *Figure 2*, and this format is given as Transmit Signal Data (TSD). Once the TSD is required by the services the most intelligent algorithm is involved in the calculation of sensor data. The training aids give the range of values depends upon the various external parameters with respect to the sensor details observed from the different Persons.

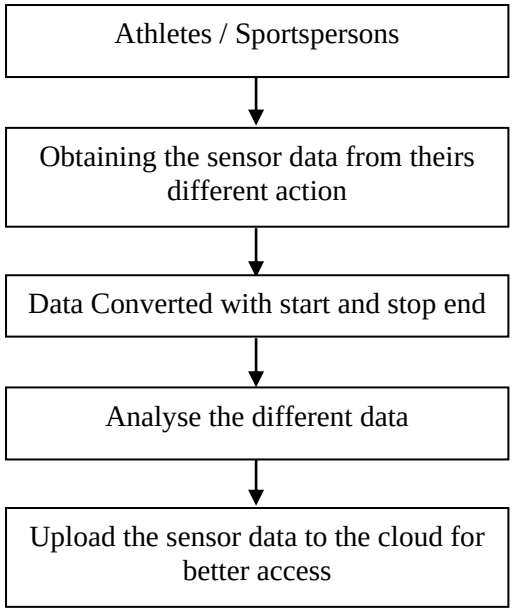

Figure 1. The Process flow of ISN

Start Bit	ID Number	Sensor Data 1	Sensor Data 2	….	Sensor Data N	Parity Bit + Stop Bit

Figure 2. Feedback mechanism format

4. Experimental Setup for Hardware Implementation

4.1 CPU Unit

The Intel Galileo is used as main core unit for this work, which is developed with Intel Quark SoC x1000 single core architecture. Due to the low power consumption it is more suitable for wearable and IoT devices. It runs on Linux platform and Arduino libraries. The Galileo has an on-board real time clock, so that the board can therefore keep accurate time without being connected to either a power source or internet. The features are most suitable for smart monitoring of practitioner and athletes. All the sensor units are interfaced with Galileo to gathering sensor data. The intellectual programming module is developed on tis board to analyse the various sensor data. Based on the conditions used in intellectual programing the sensor data is categorized and the useful data is uploaded in the cloud platform. iBeacon Bluetooth module is interfaced with Galileo to communicate with users.

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4.2 Sensor Units

4.2.1 MEMS Acceleration Sensor: Accelerometers are utilized to gauge speeding up along a touchy pivot and over a specific scope of frequencies. Since they measure increasing speed because of gravity and development, the real segment of development related quickening should be isolated from the gravitational. The gravitational segment is by and by helpful in characterizing a subject's postural introduction [10]. There are a few kinds of accelerometers accessible dependent on piezoelectric, piezo-resistive, or variable capacitance techniques for transduction. They all utilize a similar guideline of activity of a mass that reacts to quickening by causing a spring or a comparable segment to stretch or pack relatively to the deliberate speeding up (Hooke's law). The tri-axis ADXL335 sensor is used in this work with its accuracy and speed of operation. It measures the acceleration of gravity in tilt sensing applications resulting motion, shock or vibrations. Sportsmen and practitioner motion and angle is calculated by measuring x, y and z axis values of sensor. With this values the motion and angle of sportsmen is calculated.

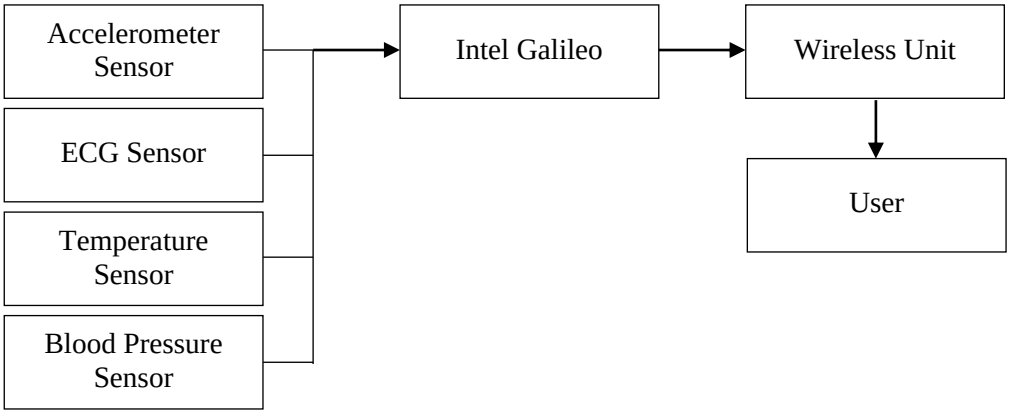

Figure 3. Wearable sensor node

4.2.2 ECG Measurement: Physical preparation -especially vigorous training- induces practical and morphologic progressions in the heart that could be a chance to reflect in the electrocardiogram. Beat issue and transforms in the repolarization design are the major basic discoveries in the athletes. Separation of the middle “normal variant” and abnormal designs may be often challenging and obliges different tests such as an echocardiogram or exercise trying to search for repolarization abnormalities. Despite this ECG might additionally help to identify a portion subjacent cardiovascular issue identified with harmful arrhythmias on patients performing sports act. Moderate and asymptomatic sinus bradycardia (HR 40-50 bpm) will be the majority issue in basic jumble on sport practitioners. Regardless of the benchmark heart rate, sinus bradycardia may be recognized considerate whether the tolerant remains asymptomatic than an ordinary heart rate throughout practice. Previously, regarding 2% for sport practitioner’s persistence ECGs, it will be time permits to discover long P waves, at times bimodal, likely identified with inter-atrial conduction disturbances [11]-[12]. Intra ventricular conduction disturbances are possibility be expected to an increment for ventricular mass, and preferably influence the terminal portions of the good bundle-branch. It is precise incessant to figure high-voltage QRS complexes in the athlete’s ECG. QRS complexes are larger in those athletes practicing highly dynamic sports requiring high cardiovascular work (decathlon, cyclism, rowing), in whom electrocardiographic criteria of left ventricular hypertrophy are found in 29% of participants. The ECG may be useful to identify these disorders, which are necessary to be consider in an athlete’s life.

4.2.3 Temperature Measurement: Nowadays, because of globalization, Competitors undergo most extreme exhibitions from their physique due to climatic condition. In spite

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of the fact that body temperature may be a critical element throughout preparing and rival procedure there might have been no sensor answer to ceaselessly measure it throughout the movement. Humans, as homoeothermic (warm-blooded) beings, have a steady working temperature as tolerance go for 37 °C, ± 0. 5 °C in the center muscle to those mankind's body. An increment of the center body temperature throughout action is proportional of the relative execution as stated by study. Because of bulky strain, high temperature may be created and later dispersed through the blood stream in the muscle to center. The middle of 37 °C and 39 °C of body temperature sweat preparation may be expanding of the most extreme temperature.

However, though the center body temperature proceeds on rise, those blood stream may be increased by the muscle to center and scattered of the fringe in place with have the capacity should chill off. Notwithstanding the blood is out absent in the core, which prompts a cardiovascular drift, which intends an expanded heart rate with more level stroke volume. Well-trained Competitors on comparison with non-athletes, a superior thermoregulation framework of sweat handling starts quicker for an athlete with terrific degree. Proficient well-trained competitors might bring a body center temperature of up to 40°C throughout activity. Standard estimations about body temperature to focus the "critical value" (= abort criterion) and the essential administrative techniques.

4.2.4 Blood Pressure Measurement: Competitors delight in preferred cardiovascular wellness over their lesquerella animated counterparts. This ordinarily prompts an easier resting heart rate of a prepared competitor capacities additional effective. Same time Competitors have bring down pulse over the individuals who are sedentary, the same ideal ranges apply. Ideal pulse to every one grown-ups may be under 120/80 mmhg. Abnormally low pulse prompts insufflate blood conveyance with your body tissues. However secondary blood pressure, or hypertension, increments your hazard for cardiovascular and kidney sickness. According to the American Heart Association and the National Institutes of Health, blood pressure ranges for adult athletes and non-athletes alike are:

- Normal: less than 120/80 mmHg
- Prehypertension: 120 to 139 mmHg, or 80 to 89 mmHg
- Hypertension: 140 mmHg and higher, or 90 mmHg and higher

The majority significant considerations for finding about systemic hypertension are the right Circulatory strain measuring technique, particularly choice of the right extent for Circulatory strain. Those measure of the pulse sleeve ought to be decided by the thickness, not those length of the arm. Those arm might generate Circulatory strain readings that would near typical. For subjects of normal weight to height, yet this sleeve might make readings of blood pressure.

4.3 Wireless Interfacing Unit

Beacon module can keep broadcasting its Bluetooth information, and because of its low power consumption, it can communicate at far off distances. IBeacon module has a communication radius of 30 meters, it uses the button battery, and can last 4 months. Each IBeacon module has different MAC address. So the cell phone can tell which is which by reading the MAC address. It can also read the UUID to tell the type of the module. The module keeps broadcasting in a predefined interval, and not controlled by any cell phone, and it will not push any data to the cell phone actively. The cell phone uses the MAC address and the distance to tell its own location, and download the service related information from a server battery is required to use this device.

4.4 Uploading Data to Cloud

The sensor data which are obtained from the different persons are uploaded in the cloud which are allocated a specific IP address. The separate space has been given for the storage of the person's details. The GPRS is used as an Internet gateway and Cloud. The Overall Working Mechanisms for the ISN Implementation of different persons shown in *Figure 4*.

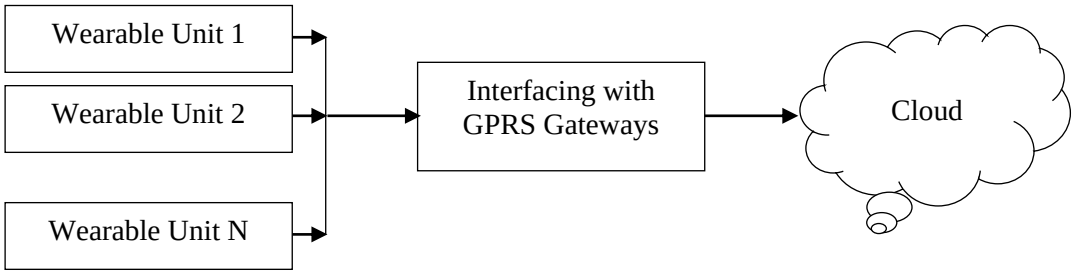

Figure 4. Overall working process of different persons

5. Results and Discussion

The proposed system is mainly developed for the athletic training program. The wearable unit is developed on the Intel Galileo platform and all the sensor units are connected in it. For any athlete, the angle measurement is very useful to improve their posture and getting good performance. The ADXL335 accelerometer sensor used to get their x, y and z values. Similarly, the ECG, Temperature and blood pressure values are also measured by using appropriate sensor units. These values are directly given to the Intel Galileo for validation. The intelligent program is running on the Galileo, through which the sensor values are categorized by the range. From the ranges, the performance of the athlete is calculated are the same as the athlete is shared through the wireless unit. The feedback is given, with this, the sportsmen know his performance and suggested further improvement. All the sensor nodes are connected with the gateway, the gateway collects the athlete information and upload in the cloud. In this system, we used the open-source cloud platform. The sensor node values are shown in *Figure 5-11*. Athlete's daily performance is uploaded in the cloud in their unique identity, through which the athlete and practitioner can understand the performance and improvement.

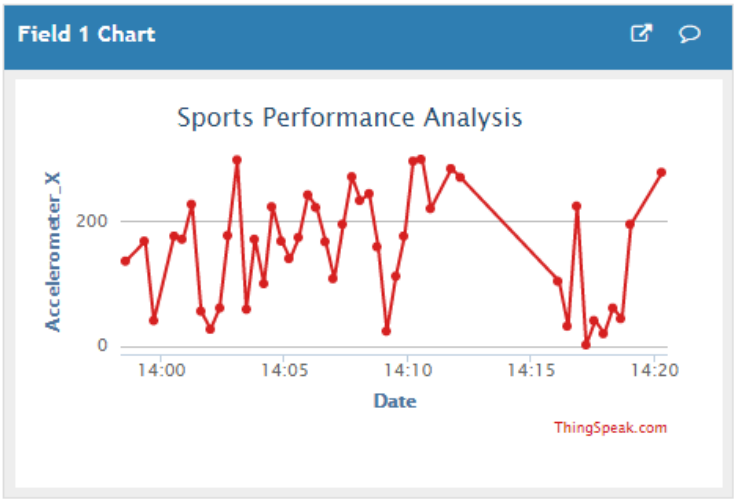

Figure 5. Accelerometer x-axis values

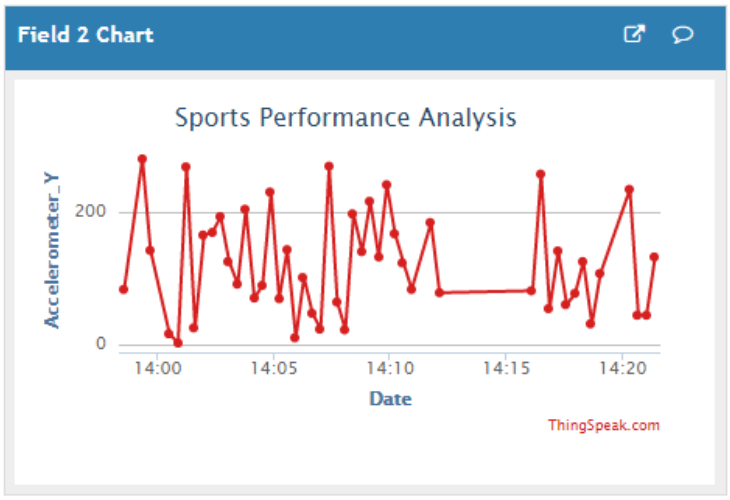

Figure 6. Accelerometer y-axis values

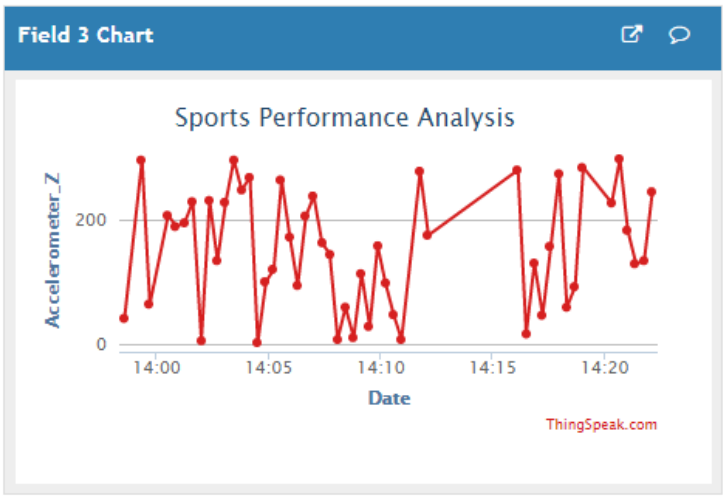

Figure 7. Accelerometer z-axis values

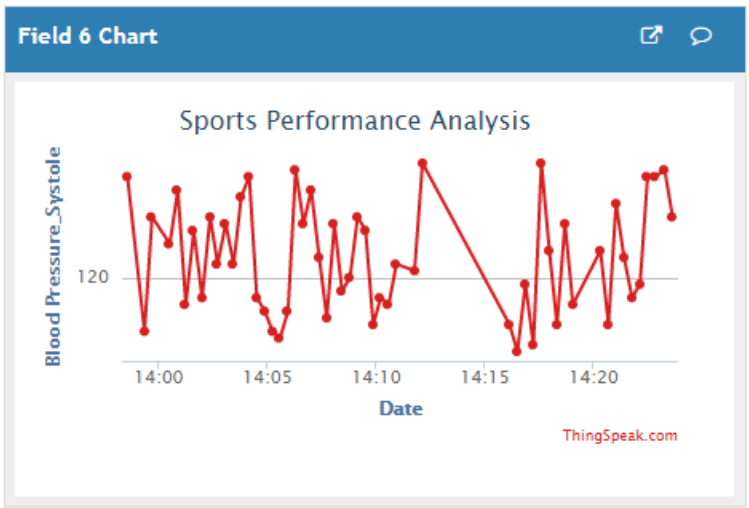

Figure 8. Blood Pressure Systole Measurement

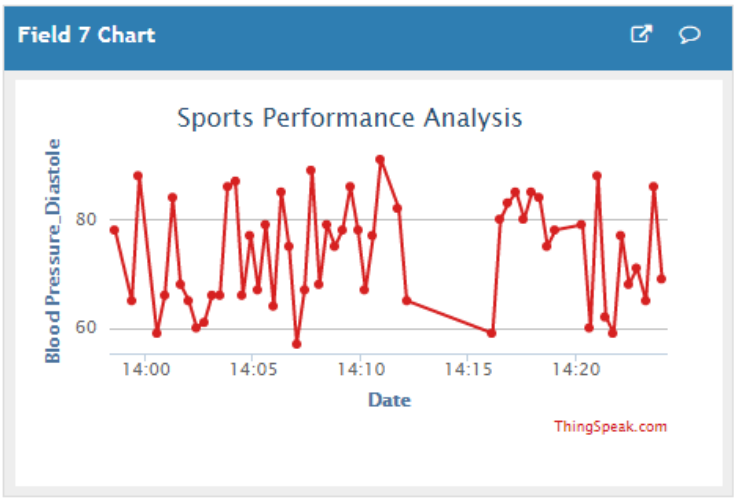

Figure 9. Blood Pressure Diastole Measurement

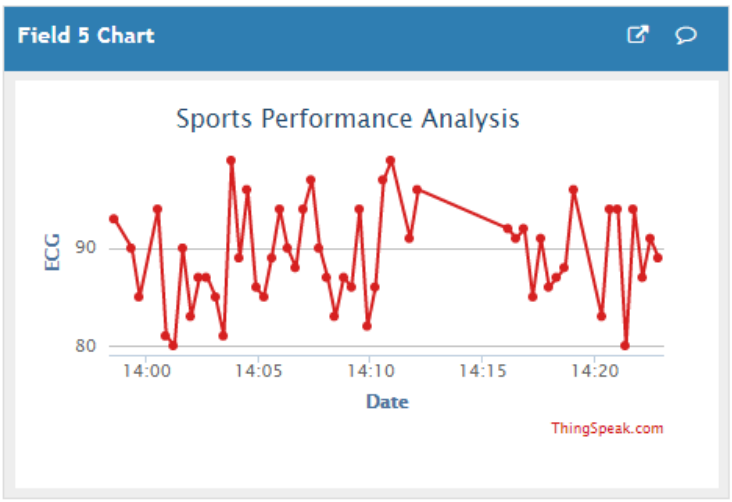

Figure 10. ECG Measurement

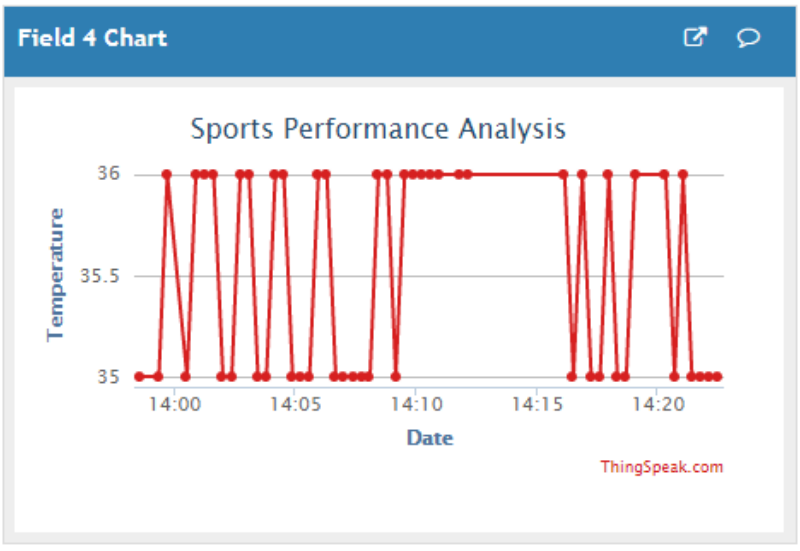

Figure 11. Temperature Measurement

6. Conclusion

Today, innovation has been utilized in different jobs in the fields of games in no bad habit, beginner, experienced and proficient competitor. In our undertaking we have built up equipment and programming to assist a competitor with doing their work normally and effectively. There is no need of an ace to deplete and screen them consistently. For kids marathon is a sound option to exceptionally focus and increasingly forceful games. The physical and the psychological development exchanges to the emphatically impacts to every one of the parts of an individual's adventure through the life. The method which has been integrated in the ISN shows the better accuracy which can be used for the training of the n number of athletes in an effective manner. Based on this Intellectual Sensor Networks (ISN) and Feedback mechanism anyone can approach the best coach for betterment of their training, this act as a bridge between the best coach and who are all want to take training and also this is suitable for any kind of sports.

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