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TECHNIQUE FOR TACKLE DETECTION USING INERTIAL SENSORS ATTACHED TO SOCKS USED IN FOOTBALL

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***Abstract*—The main idea of this technique is to identify the authenticity of a tackle performed during a football game and analyzing the intensity of the tackle to arrive at a decision. Decision-making by the referee on the pitch with respect to tackles has always been a tedious one and may end up in wrong decisions. Although cameras are used to witness the performance of players, it is difficult to monitor every movement of the player in detail and manipulate them. Hence a 50$ wearable device comprising of IMU (Inertial Measurement Unit) sensor, a Microcontroller unit and a wireless transceiver that would be attached to the rear side of cuff region located in socks. In case of a tackle, the data from the socks of players involved in a tackle will be analyzed, processed and transmitted through the transceiver to the required device. This could solve the problem of tackle detection and will make it easier for the referee to arrive at a decision within a short span of time.**

***Key-Terms*—Tackle, Socks, Inertial Measurement, Transceiver,Machine Learning, Mobile App.**

I. INTRODUCTION

Sports not only play an important role in fitness and entertainment but also acts as a platform for exhibiting every player's talent throughout the world and to make their country proud. The ultimate aim of any sportsman is to win in an international stage like world cup and to earn the respect and dignity among fans and fellow players. Football is the most followed sport the world with more than 3.5 billion fans.Every sport has its own pros and cons. Likewise, Football also has some negative effects such as foul-play, cheating etc., These effects has also lead to serious changes in the outcome of a game such as injuries or result in favor of other team.

Tackling an opponent player and grabbing the ball is an extremely difficult technique that requires lot of skill and training. According to the rules of football, the player must tackle the opponent only under certain safety measures such as he shouldn't injure the opponent with any kind of intention. If the player is found to be guilty of being involved in a harsh tackle he/she may be sent off by the referee by issuing Yellow/Red cards. When the foul occurs to a team player inside the opponent's box the referee may award them a penalty kick.

Tackles are generally considered to constitute serious foul play that involve lunging at an opponent with both legs, and may be sent-off for serious foul-play regardless of whether the ball is won or not[1].Tackles from behind that endangered the safety of an opponent mandated a sending-off for the offender was considered before. But from 2017 tackles from any direction that endanger an opponent's safety result in the offender being sent-off. It also explicitly includes "scissoring" (tackling with legs apart, so as to trap the opponent's leg or legs in between), which is likely to be punished with a send-off (red card), as it poses a high risk of severe knee injury to the player being tackled.

Tackling with studs up is an extremely dangerous one as it may lead to injuring players and they may be penalized severely for using studs-up tackle. Referees are encouraged to at the very least caution (yellow card) players who commit such challenges.

The need for arriving at a decision especially in tackle is a game changing one. A wrong decision might change the progression of a match and referee may award a penalty or send-off innocent player[2]. As a result, the team that does not deserve victory may win. One great example is that an intentional dive performed by Suarez inside the penalty area to earn his team a penalty in a crucial fixture between Barcelona and PSG where the former won 6-5 on aggregateand progressed to the next stage of the prestigious Champions League final tournament. That dive was considered as a serious tackle by the referee. Using the technique proposed one could easily distinguish between a genuine tackle and a foul one.

Proportional Study	Tackled	Running	Tackling	Shooting
Proportion of injuries (%)	23.5	19.6	12.2	10.3
Proportion of risk (%)	23.7	17.4	12.7	11.9

Table.1: Distribution of injuries and risk as a function of injury mechanism

II. BLOCK DIAGRAM

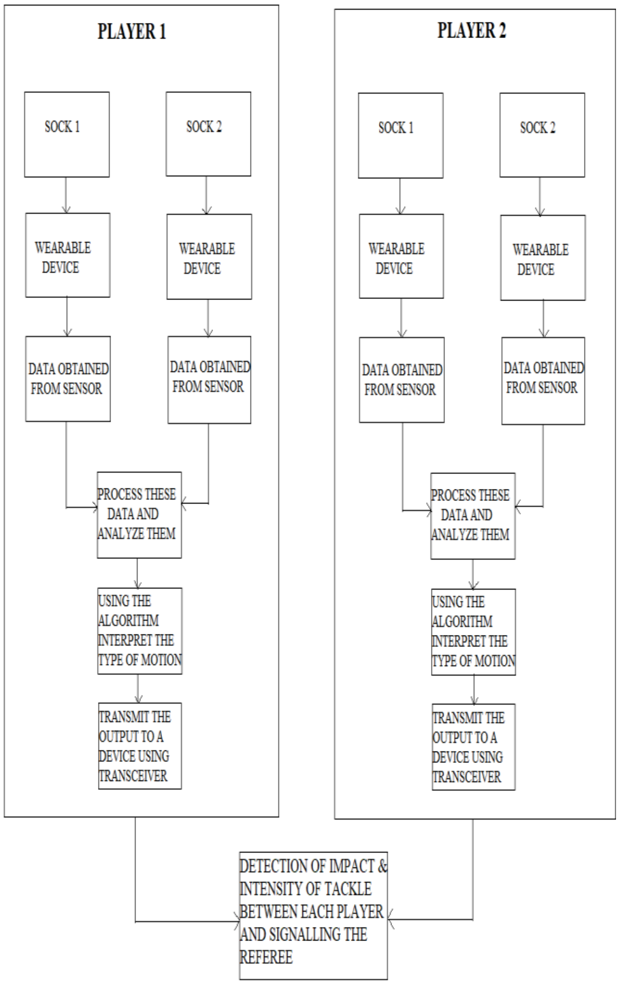

Fig.1: Overview of the whole process

The block diagram represents the method flow from wearable present in the socks to data processing, transmission and viewing it in a smart watch or mobile application[3]. The main part of the system is where the data between the players involved or supposedly involved in a tackle are compared and processed. Pre-loaded test cases will be present for the data to be easily checked for the type of tackle involved, intensity of tackle and alerts the referee regarding this.

III. HARDWARE

The hardware comprises of a micro-controller, a 9-axis DOF IMU sensor and a transceiver all of which powered by a battery.

1. MICROCONTROLLER

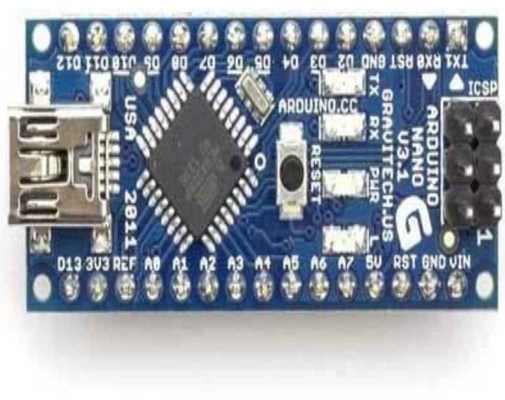

Fig.2: Arduino Nano comprising ATmega 328p

Arduino Nano, a smaller form factor of the Arduino UNO is used. It uses the same processor ATmega328p as that of UNO board. It works with a Mini-B USB cable instead of a standard one and lacks only a DC power jack. Gravitech designed and produced the Arduino Nano.It runs on a ATmega328 processor with 32 KB of which 2 KB used by bootloader. Arduino Nano has a clock speed of 16Mhz with the dimension of 68.6mm x 53.3mm. Additional shields can be attached to the Arduino Nano expand its functionality. It usually operates at 5v through a voltage regulator that regulates the power supplied to the board and prevents it from any damage.Power Consumption is 19 mA it weighs about 7g.

2. 9-AXIS IMU SENSOR

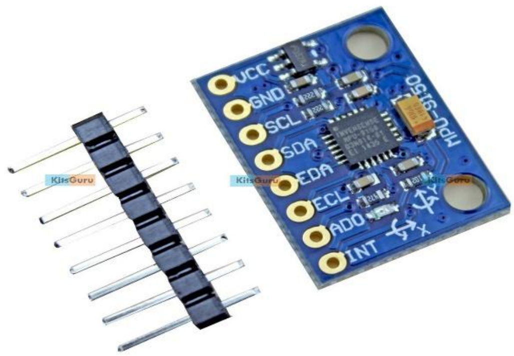

Fig.3: MPU-9150 IMU sensor breakout

MPU-9150 is the 9-axis DOF IMU sensor that is used. The MPU-9150 consists of two chips: the MPU-6050, which contains a 3-axis gyroscope, 3-axis accelerometer, and an onboard Digital Motion Processor (DMP) and is a System in Package (SiP) that is capable of processing complex 9-axis Motion, Fusion algorithms. The part's integrated 9-axis MotionFusion algorithms access all internal sensors to gather a full set of sensor data. MPU-9150 comes in a 4x4x1mm LGA package and is upgrade-compatible with the MPU-6050 integrated 6-axis MotionTracking device[4].

3. DATA TRANSMISSION DEVICE

Fig.4: nRF24L01 Transceiver

The nRF24L01 is a 2.4GHz transceiver that will be used. It is also a Wireless Module Single Chip operating at 1.9-3.6v. It has a baseband logic including the Enhanced ShockBurst™ hardware protocol accelerator supporting a high-speed SPI interface for the application controller. It also integrates aRF transceiver and a RF synthesizer and does not require external loop filter, resonators, or VCO varactor diodes.It has a low cost ±60ppm crystal, matching circuitry, and antenna[5].

4. POWER SUPPLY

Fig.5: 9V 680mAh lithium polymer battery

Since Arduino Nano has an operating voltage of 5V, power supply greater than this voltage and good current output should be used. 9V battery could be used because it is cheap and highly reliable one. Moreover, it is found to have several advantages over other batteries and is a universal one. A battery with better current output can be used for good performance of the system.

5. PCB SHIELD

Connecting all these components becomes a messy one. Especially when developing a wearable, wired connections are mostly avoided as it may disconnect and may harm the body due to short circuit current. Hence, we designed a PCB shield to incorporate all the components to obtain a neat and a perfect device.

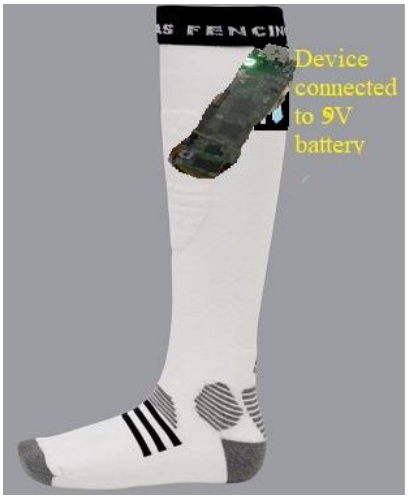

Fig.6: Prototype Model

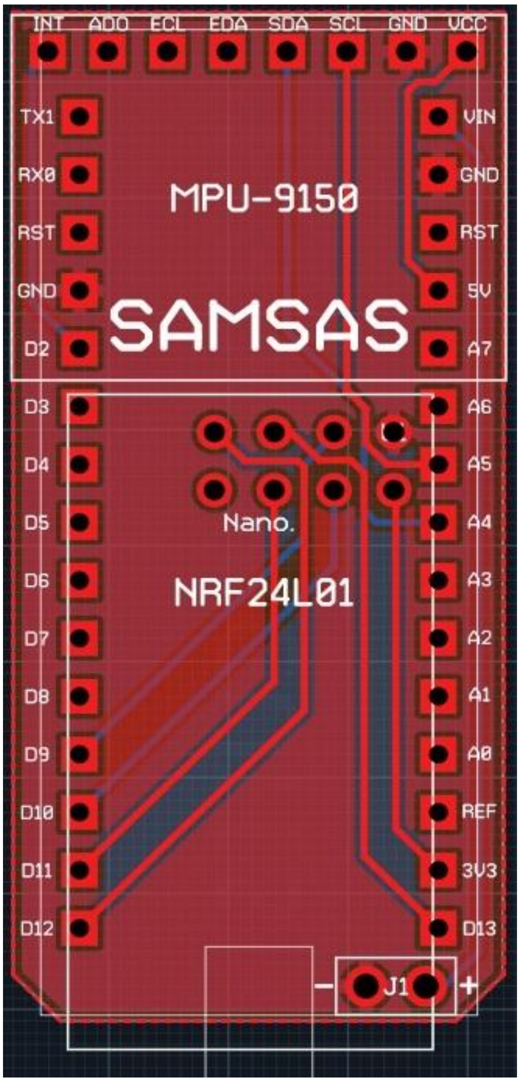

Fig.7: Front View of the PCB shield

The only work would be soldering all the components in the PCB shield and powering up the device to complete the whole hardware setup.

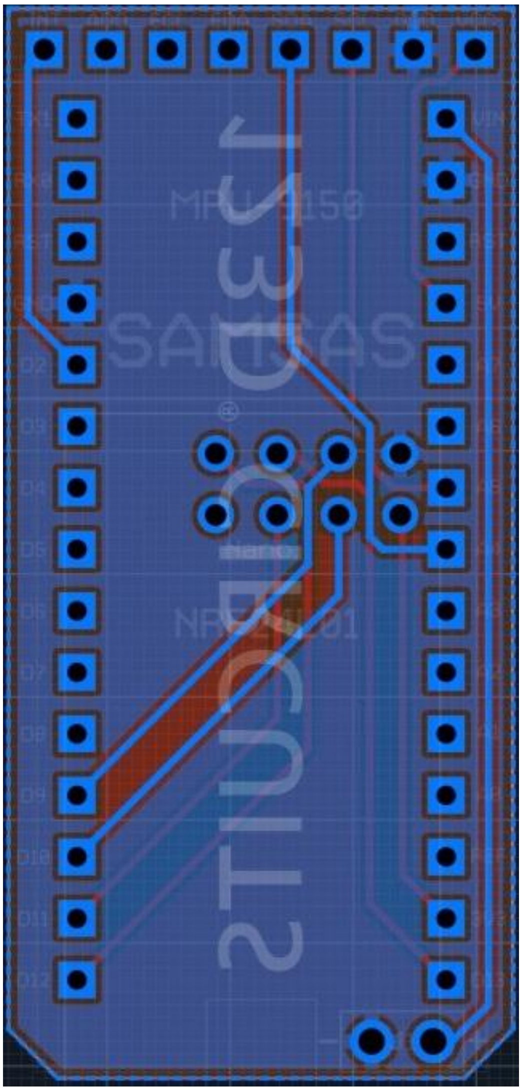
Fig.8: Rear View of the PCB shield

IV. PROGRAMMING THE MODULE

The Arduino Nano is easy to program using Arduino IDE like that of Arduino UNO as it has the same processor ATmega328p.

The next step is to transmit the data to a mobile phone using the transceiver and displaying the data by means of simple GUI(Graphical User Interface) for easy interpretation of the output.

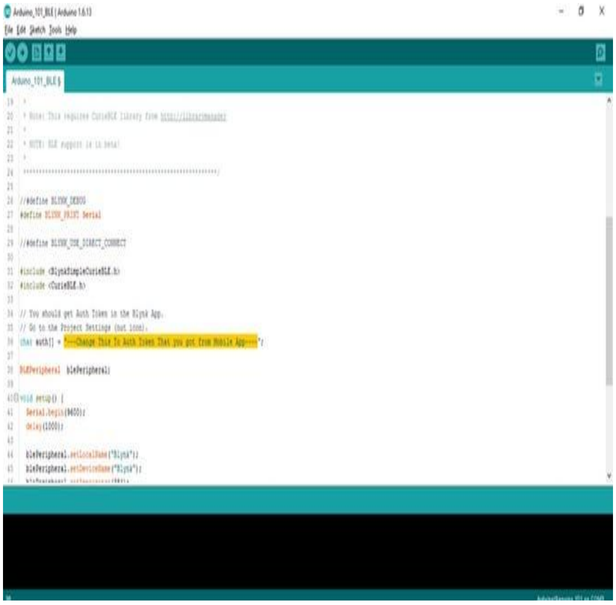

Fig.9: Programming in Arduino IDE

The program structure is made in a way that the 9-axis raw data from the IMU sensor is obtained and is processed in the microcontroller and these data are transformed into yaw, pitch and roll to obtain angular movements. Also, the accelerometer data is used to measure the acceleration during every instant of the game. The magnetometer allows the data to be more accurate since the data varies with respect to distortions and other pressures applied on it.

V. DATA ANALYSIS

When a player imparts a perfect tackle, the opponent player does not have any distortions in his motion data recorded at that instant or would have experienced free fall due to of sudden grappling of the ball without any intention.

When the player imparts a rigorous tackle on an opponent with intention, there will be several spikes or distortions in the motion data or he dives intentionally to choose a decision in their favor will reflect on the player's motion data that it has been a freefall without any contact. Using this the referee may award decisions based on his interest.

Analysis of various parameters such as acceleration, force, angular movements of bat, ball contact, joint movements of players has been analyzed. By finding out the average acceleration from the raw acceleration data produced in the accelerometer force can be easily calculated[6].

Avg.acceleration, A=sq.rt((Ax^2)+(Ay^2)+(Az^2))

Where, Ax=acceleration along x-axis

Ay=acceleration along y-axis

Az=acceleration along z-axis

F=m*A

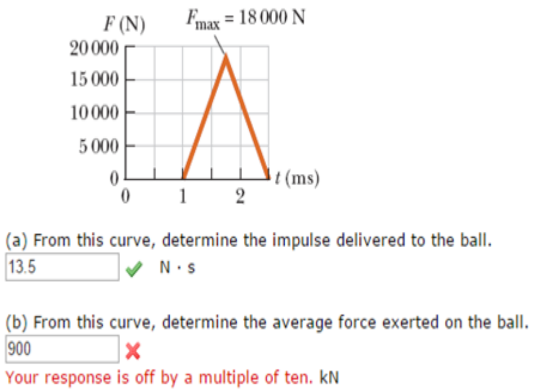

Fig.10: Sample data during contact with ball

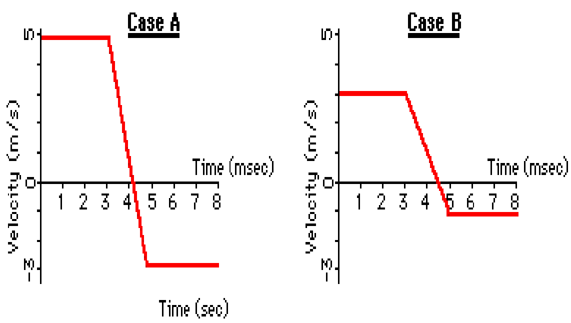

Fig.11: Theoretical data charts during vigorous tackle and normal tackle

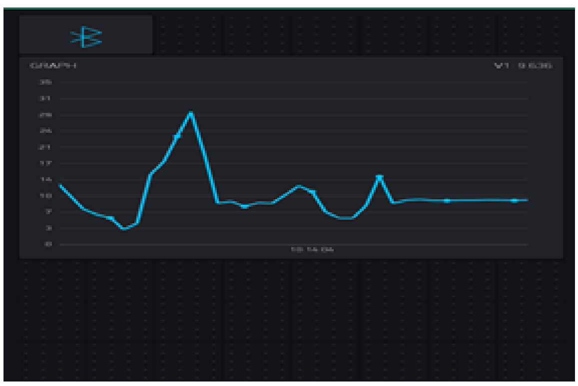

Fig.12: Genuine Tacklehaving less distortions displayed in mobile App

Fig.13: Vigorous Tackledisplayed in mobile App

Moreover, this technique could be adapted for measuring many parameters and training the players more remotely for improved performance and ability to monitor many players at the same time[7].

Fig.14: Future method could be adapted for measuring infinite parameters

VI. CONCLUSION

The need for this technique arises from several factors. Many teams and its players have been given the wrong judgement due to referees being unable to focus on all players at the same time. Using a simple Machine Learning algorithm several inputs could be fed at the same time and trained to perform calculations more accurately based on previous observations[8]. Life-threatening tackles and cheating can be easily identified, and the referee could be able to penalize the players more effectively.

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