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Fall Detection of Riders using Inertial Sensors: A Smart Helmet

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Abstract : **A helmet is a protective headgear used by riders to make driving safer and avoid injuries. In this paper, a smart helmet is designed which is capable of detecting fall of riders and then transmitting a message through a global system of mobile (GSM) module along with the location of fall using global positioning system (GPS) avoiding delays to rescue. Inertial sensors, i.e., gyroscope and accelerometer sensors with a threeaxis sensing unit, are placed within the helmet and controlled via ARDUINO based microcontroller for fall detection. The designed helmet is used for data acquisition in 28 trials, and twenty-two statistical features are extracted from the recorded data. A subset of discriminating features are selected using the wrapper method and four different classifiers, i.e., Naïve Bayes, k-nearest neighbor, random forest, and support vector machine are applied on selected features to classify the two states i.e., fall and non-fall. It is evident from results that the Naïve Bayes classifies the fall of riders with the highest accuracy of 98.21%. The proposed methodology outperforms the existing state-ofthe-art fall detection techniques in terms of classification accuracy.**

IndexTerms **- Accelerometer, Classification, Fall Detection, Feature Extraction, Feature Selection, Gyroscope, Smart Helmet**

I. INTRODUCTION

Safety and security are the most crucial topic in every aspect of our life. According to the World Health Organization (WHO) report 2018, each year 1.35 million people dies in roadside accidents [1]. In the present-day scenario, we encounter various cases of deaths due to two-wheeler road accidents. According to the research, fall is the second leading cause of death by accidents and injuries. Anually, more than 2.8 million injuries were treated under the emergency department, and more than 8 million hospitalizations and 27,000 deaths occurs due to accidental fall in the United States [1]. Fall is a critical problem for the bicyclists and motorcyclists. Around the globe, millions of people have lost their life due to fall when riding. Currently, if the person encounters an accident, we may not ensure the urgent first aid treatment because of lack of any fall detection mechanism as well as no information about the location of the accident and the person may die due to this delay. So that fall detection mechanism is essential in order to save the life of people. If it is possible to deal in time with the fall injuries, we can surely rescue thousands of lives. This paper proposed the mechanism to develop an efficient fall detection system to support the bicyclists. The main reason that draws the attention of researcher toward the fall detection is health care of young and elderly people and to provide them fast assistance after they meet an accident and fall on the ground. Our motivation is to rescue the bicyclist or motorcyclist immediately when the fall occurs. Kids used to fall from the bicycle and have injuries. They need to be rescued in time. There are many mechanisms already introduced for the fall detection of pedestrians and bicyclists [2], [3]. They include wearable devices [4], smartphone-based, wireless-based, ambient sensor-based [5], vision-based, and floor sensor/electric field sensor based fall detection systems [6]. In [3], a two units wireless-based system is developed. One is a helmet unit, and the other is a bike unit. Both the units communicate with the help of RF transmitter fitted in the helmet. Bike unit has an onboard accelerometer which senses the free fall of the bike. In [7], a vision-based fall detection system is proposed. A camera records the observer's activity and by the use of image processing techniques, a fall is detected. The proposed method is a computationally intensive method. Some researchers have used smartphone built-in accelerometer and gyroscope with other sensors to sense the fall and sending alert messages for emergency response in case of fall [8], [9]. The position of the smartphone or wearable sensors in these studies vary.

II. EXISTINGSYSTEM

In existing system a similar proposed work that has been put forward earlier which is based on the principle of pressure sensing that is wearing a helmet creates a pressure on the helmet and a data signal is passed to the transmitter which redirects the bike ignition control to turn on. However, the technology have certain drawbacks: Pressure can be created inside the helmet by putting any dummy material inside it. Thus the rider instead of wearing a helmet can create the required pressure by putting any dummy material inside the helmet. Hence the basic purpose of starting the bike by wearing the helmet can be easily bypassed.

III. PROSED SYSTEM

The aim of our smart helmet is to provide the safety to the bike rider and give information location of the accident to the ambulance and family member. This is done by using the GSM module. But sending the message of that accident is not enough. We have to send the location of the accident. So we are using the GPS module. When the accident has happened the MEMS sensor sense the accident and give signal to the Arduino. Then Arduino will take location from the GPS and it will send the location of accident in the form of the latitude and longitude but normal user can't understand how get location from the latitude and longitude. Here we are using IR sensor which are for helmet detection.

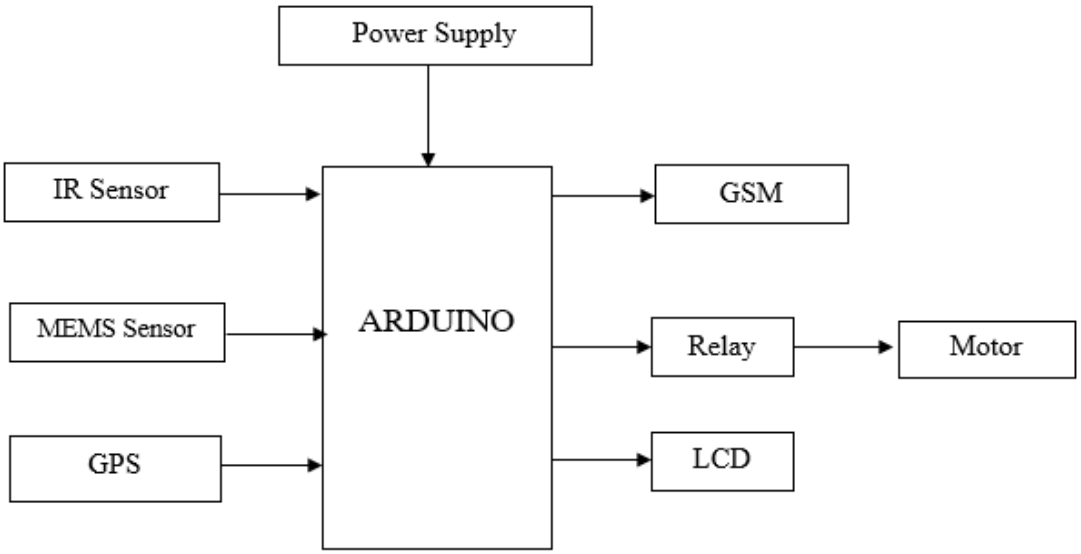

Fig1.Block diagram of proposed system

III(A)HARDWARE REQUIREMENTS

Arduino:

Arduino Uno is a very valuable addition in the electronics that consists of USB interface, 14 digital I/O pins, 6 analog pins, and Atmega328 microcontroller. It also supports serial communication using Tx and Rx pins. There are many versions of Arduino boards introduced in the market like Arduino Uno, Arduino Due, Arduino Leonardo, Arduino Mega, however, most common versions are Arduino Uno and Arduino Mega. If you are planning to create a project relating to digital electronics, embedded system, robotics, or IoT, then using Arduino Uno would be the best, easy and most economical option.

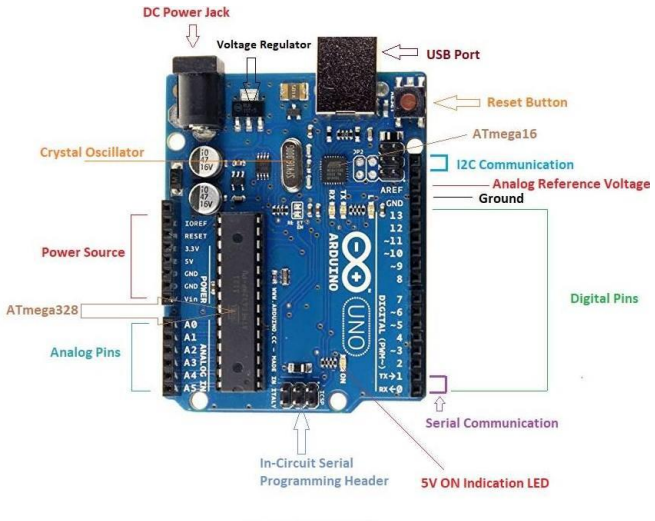

Fig 2 Arduino uno

- This board comes with all the features required to run the controller and can be directly connected to the computer through USB cable that is used to transfer the code to the controller using IDE (Integrated Development Environment) software, mainly developed to program Arduino. IDE is equally compatible with Windows, MAC or Linux Systems, however, Windows is preferable to use. Programming languages like C and C++ are used in IDE.
- Apart from USB, battery or AC to DC adopter can also be used to power the board.
- Arduino Uno boards are quite similar to other boards in Arduino family in terms of use and functionality, however, Uno boards don't come with FTDI USB to Serial driver chip.
- There are many versions of Uno boards available, however, Arduino Nano V3 and Arduino Uno are the most official versions that come with Atmega328 8-bit AVR Atmel microcontroller where RAM memory is 32KB.
- When nature and functionality of the task go complex, Mirco SD card can be added in the boards to make them store more information.

Applications:

Arduino Uno comes with a wide range of applications. A larger number of people are using Arduino boards for developing sensors and instruments that are used in scientific research. Following are some main applications of the board.

- Embedded System
- Security and Defense System
- Digital Electronics and Robotics
- Parking Lot Counter
- Weighing Machines
- Traffic Light Count Down Timer
- Medical Instrument
- Emergency Light for Railways
- Home Automation
- Industrial Automation

IR sensor:

An infrared sensor is an electronic device, which emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, which can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and these output voltages, change in proportion to the magnitude of the IR light received.

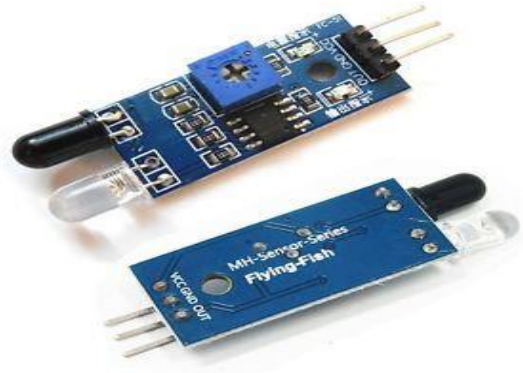

Fig 3 IR Sensor

MEMS Sensor:

The term MEMS stands for micro-electro-mechanical systems. These are a set of devices, and the characterization of these devices can be done by their tiny size & the designing mode. The designing of these sensors can be done with the 1- 100-micrometer components. These devices can differ from small structures to very difficult electromechanical systems with numerous moving elements beneath the control of incorporated micro-electronics. Usually, these sensors include mechanical micro-actuators, micro-structures, micro-electronics, and micro-sensors in one package. This article discusses what is a MEMS sensor, working principle, advantages and it's applications

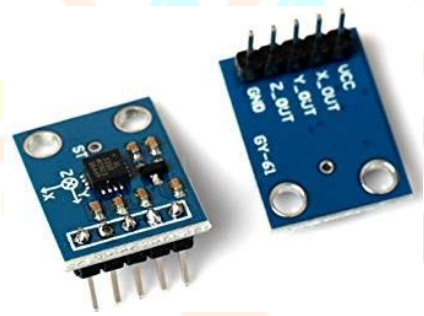

Fig 4 MEMS SENSOR

GPS:

Global Positioning System (GPS) is a satellite-based system that uses satellites and ground stations to measure and compute its position on Earth.

GPS is also known as Navigation System with Time and Ranging (NAVSTAR) GPS.

GPS receiver needs to receive data from at least 4 satellites for accuracy purpose. GPS receiver does not transmit any information to the satellites.This GPS receiver is used in many applications like smartphones, Cabs, Fleet management etc.

Fig 5 GPS MODULE

GSM

GSM is a mobile communication modem; it is stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. GSM system was developed as a digital system using time division multiple access (TDMA) technique for

communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates. There are various cell sizes in a GSM system such as macro, micro, pico and umbrella cells. Each cell varies as per the implementation domain. There are five different cell sizes in a GSM network macro, micro, pico and umbrella cells. The coverage area of each cell varies according to the implementation environment.

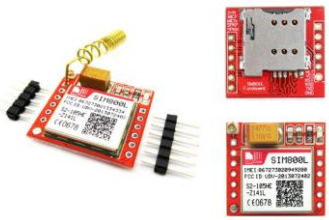

Fig 6 GSM MODEM

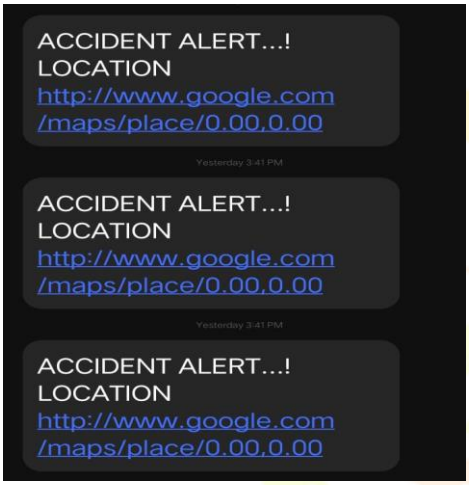

Fig 7 ACCIDENT ALERT LOCATION

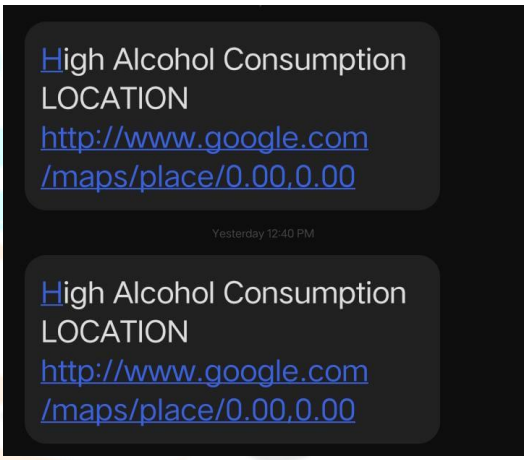

Fig 8 HIGH ALCOHOL CONSUMPTION

Conclusion

The outcomes of the project have showed that the bike ignition will start if the helmet is worn(using IR sensor). So, it will automatically decrease the effect from accident. Arduino is good in controlling all the system and the sensors.

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