Automatic Seatbelt Release System

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***Abstract*— An automatic seat belt release system is provided for installation in conjunction with the seat belt system of the vehicle so that, in the event of the vehicle is sustaining an impact of sufficient magnitude as to warrant emergency release of the seatbelt system, an electrically-operated actuator near the seat belt is actuated to release the seat belt system a short predetermined time interval after the vehicle comes to rest. The emergency release system includes an Accelerometer, a Gyroscope, a Developer board and a Solenoid actuator. Sensor Accelerometer is responsible of determining the collision of the vehicle, and Gyroscope sensor determines the orientation of the vehicle after the collision, if there is no change in orientation in the gyroscope it causes the predetermined time in the developer board to actuate. After the predetermined time expires, the Solenoid is actuated to release the seat belt.**

***Keywords*— Automation, Seatbelt, Release, Microprocessor, Roll Detection, MPU6050**

I. INTRODUCTION

In the modern era, the number of cars travelling in the asphalt has been increased many folds. As the number of cars increases the number of accidents also have increased thus causing severe injury or fatality to the occupants. The injury and the fatality are caused mainly due to the harmful movement that is caused due to the collision. To overcome this the 3-point seat belt system is introduced to greatly reduce the harmful movements that are caused due to the collision this minimizes the injury and the fatality of the occupant in the vehicle. When the vehicle is in motion, the occupants are traveling at the same speed as the car. If the vehicle tends to stop suddenly or crashes, due to inertial force the occupants continue to move at the same speed. To prevent this movement only the seatbelts are designed. The seatbelt restrains the occupant of the seat holding them preventing them from falling out or injure by making contact with the interior of the car.

In modern vehicles, the 3point seat belts are widely used. It generally consists of a buckle, latch plate, retractors, and webbing for the seatbelt. The seatbelt webbing is the flexible part that goes around the occupant it is generally made up of polyester that holds them to the seat during a collision. The retractor provides the occupant to move freely and tighten the webbing during a collision. The latch plate is the metal piece that is attached to the webbing for securing it to the buckle. The buckle is the part of the system where it secures and releases the latch plate it is designed in a way that it holds the latch plate firmly and to secure and release with little force.

The problem with the seatbelt is that during the collision the seatbelt retractors are locked and thus preventing the occupant from harmful motion this causes a high load on the latch plate and the buckle, due to this many times the latch plate and the buckle gets struck. Thus the occupant couldn't get out of the vehicle after the collision. This also causes delay to rescue the trapped occupant by the rescuers.

This system was designed to overcome this problem; the system automatically releases the seatbelt of the vehicle after the accident thus ensuring that the occupant can easily get out of the vehicle. The automatic seat belt release system is provided for installation in conjunction with the seat belt system of the vehicle so that, in the event of the vehicle is sustaining an impact of sufficient magnitude as to warrant emergency release of the seatbelt system, an electrically-operated actuator near the seat belt is actuated to release the seat belt system a short predetermined time interval after the has come to rest. The emergency release system includes an Accelerometer, a Gyroscope, a Developer board and a Solenoid actuator. Sensor Accelerometer is responsible of determining the collision of the vehicle, and Gyroscope sensor determines the orientation of the vehicle after the collision if there is no change in orientation in the gyroscope it causes the predetermined time in the developer board to actuate. After the predetermined time expires the Solenoid is actuated to release the seat belt.

The system first detects the sudden change in the inertia of the vehicle, this is done with the accelerometer sensor that detects the change in the acceleration. The sudden change in the inertia of the vehicle is caused due to collision thus the accelerometer detects the collision of the vehicle and sends an input signal to the controller. After the collision is detected the Gyroscope sensor measures the orientation of the vehicle. This process is implemented so that the system does not release the seatbelt when the vehicle is flipped upside down resulting injury to the occupant. The gyroscope measures the orientation of the car and if the orientation of the car is not flipped upside down and the orientation doesn't change the gyroscope sends the signal to the controller. This process is implemented to ensure that the vehicle is in a safe position to release the seatbelt. After the signal from the gyroscope is given to the controller a safe predetermined timer is started. The timer is provided to make sure that the vehicle inertial force comes into rest after the collision. After getting the signal from the sensors the predetermined timer is set and after the time expires, a signal is sent to the actuator to release the seatbelt. The actuating mechanism consists of a cutting blade that is attached to the end of the solenoid, the blade is set in a guillotine arrangement with side frame and a slot for the blade. The seatbelt webbing is passed through this arrangement. When the signal to release the seatbelt is received, the solenoid is actuated and the guillotine blade sets in linear motion thus cutting the seatbelt webbing releasing the seatbelt.

The system will not actuate the release of the seatbelt unless the orientation of the vehicle is in a safe position (flipped upside down) or change in orientation (rolling vehicle crash) which may cause neck or severe injury to the occupant if it releases during that stage. The release of the seatbelt is actuated only after the predetermined time expires and the orientation of the vehicle is in a safe condition. This system ensures that the passenger wouldn't get stranded inside the vehicle due to jamming of the seatbelt and it will be easy to rescue the passenger from the vehicle after the collision.

II. MOTIVATION OF THE PROJECT

The seatbelt secures the occupant with the seat to reduce the harmful movements that are caused due to the collision. This greatly reduces the injuries and fatalities due to the accident but in many cases, after the collision the occupants are unable to release the buckle to release the seatbelt. This causes the occupants to stuck inside the collided vehicle which very dangerous.

The cause of the locking of the seatbelt is that due to the high forces that cause the latch plate in the buckle to deform. Since the latch plate is deformed and the buckle mechanism jams, the seatbelt cannot be released properly. Thus the passengers are at risk of being stuck in the vehicle after the accident. This failure to release the seatbelt can be fatal due to which the occupants could not release themselves or by the rescue team. This system was developed to eliminate the risk of being stuck in the vehicle due to the seatbelt after an accident and to enable the rescuers to easily rescue the victim after an accident.

III. METHODOLOGY

Through literature reviews, we have studied some of the existing methodologies and designed our system to overcome the limitations of the existing system.

A. Existing Methodology

There are two major methods for releasing the seatbelt they are

1. Manual method.
2. Automated seatbelt release system without roll detection.

The block diagram of existing methodology is shown below Fig.1

Fig.1 Block diagram of Existing system

This system automatically releases the seatbelt under emergency situation using a PYRO pressure generator actuating a cutter to release the seatbelt.

Limitations

- The system senses only the sudden change in inertia for detecting the collision and releasing the seatbelt.
- Thus if the vehicle is in motion after an accident like rolling from a hill or by any means, the occupant will severely injure if the seatbelt is released.
- This system will compromise the safety of the occupant in such scenario.
- The system is relatively high cost.

B. Proposed System

The proposed system consists of various sensors that are integrated to the microprocessor. It consists of an accelerometer, a gyroscope sensor and a solenoid actuated release mechanism. The block diagram is given below. The accelerometer constantly monitors to changes in the inertia of the moving vehicle. It detects the collision by measuring the sudden changes in the inertia of the vehicle. After detecting the collision, it sends a signal to the microprocessor.

The gyroscope constantly monitors the orientation of the vehicle. After the collision is detected by the microprocessor by the accelerometer it checks the orientation of the vehicle. The microprocessor actuates the release mechanism only when the orientation of the vehicle is stationary and at a safe angle. The release mechanism consists of a solenoid actuated guillotine blade. When the microprocessor sends the signal to the release mechanism, the solenoid will release the guillotine blade which releases the seatbelt.

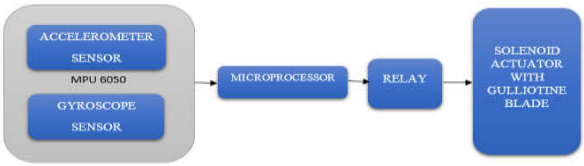

Fig.2 Block diagram of Proposed system

C. Procedure Flow

The system follows three steps in automatic seatbelt release in the vehicle. They are

1. Sensing
2. Monitoring and controlling
3. Actuating

Fig.3 Procedure Flow

The sensor is the starting point of the process. The sensor detects the changes the inertia and the orientation of the vehicle. The microprocessor monitors and controls the system. The actuating mechanism releases the seatbelt. At the start, the system constantly checks for the collision of the vehicle through the accelerometer. If there is a collision there will be a sudden decrease in the inertia, this sudden change in the inertia is detected by the accelerometer and the microprocessor checks the orientation of the vehicle through the gyroscope. The gyroscope measures the orientation of the vehicle, if the vehicle is in stationary and in a safe orientation an on-board timer is triggered for 5 seconds. After the timer delay, the microprocessor actuates the release mechanism. The Algorithm is shown in the below Fig.4

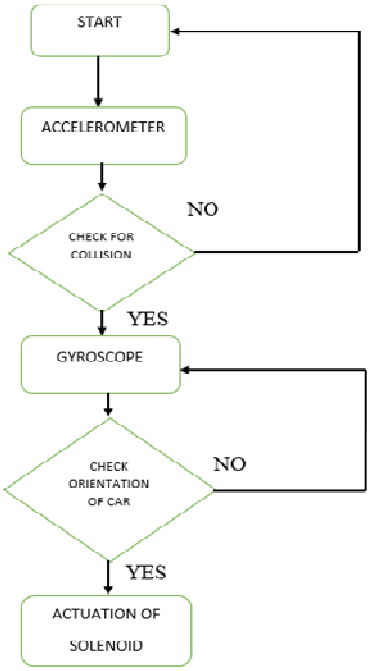

Fig.4 Algorithm used in Proposed system

IV. COMPONENTS

The selection of the components involves the study of their advantages, characteristics, cost, availability, ease of use. In our project, we select each and every component of study thoroughly about them. By the study only, we have done our selection. The components used are shown in the below Fig.5

SI.NO	COMPONENT	TYPE
1	ACCELEROMETER	MPU6050
2	GYROSCOPE	MPU6050 (GY-521)
3	SOLENOID	12V DC
4	RELAY	12V DC
5	MICROCONTROLLER	Arduino UNO 328P
6	CUTTING TOOL	GUILLOTINE BLADE

Fig.5 List of Components

The detailed description of the selected components is given below.

A. *Arduino*

The Arduino UNO is microcontroller board and it has 14 digital input/output pins (of which 6 can be used as PWM outputs),6 analogue inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. The UNO differ from the all other board in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Uno 16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

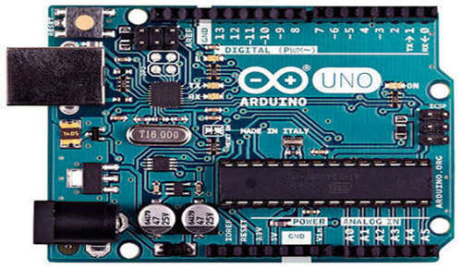

Fig.6 Arduino UNO (source [19] www.arduino.cc)

B. *MPU 6050 Accelerometer and Gyroscope Sensor*

The MPU 6050 sensor contains a MEMS accelerometer and a MEMS gyro in a single chip. It is very accurate, as it contains 16 –bits analogue to digital conversion hardware for each channel. Therefore, it captures the x, y, and z channel at the same time. The sensor uses the I2C-bus to interface with the Arduino. The MPU6050 is used for the detection of the collision and the orientation of the vehicle.

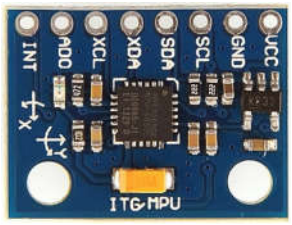

Fig.7 MPU 6050 Accelerometer and Gyroscope (source [19] www.arduino.cc)

1. MPU 6050 Working

The MPU 6050 is a 6 DOF (degree of freedom) or a six-axis IMU sensor, which means that it gives six values as output. Three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on MEMS (Micro Electro Mechanical Systems) technology. Both the accelerometer and the gyroscope are embedded inside a single chip. This chip uses I2C (Inter-Integrated circuit) protocol for communication.

Accelerometer			Gyroscope		
Ax	Ay	Az	Gx	Gy	Gz
12060	-3934	11096	1.69	-5.44	6.61
-3464	-12634	-12206	-56.23	-183.48	158.17
-6668	-10120	-11928	7.02	-102.38	121.8
-7226	-9668	-10610	18.29	9.94	-7.04
-5028	-11382	-9432	65.04	71.37	-98.44
1958	-14690	-9554	227.88	99.97	-141.71
4374	-15624	1472	223.37	9.56	-136.05
8936	-9324	6214	248.9	-37.08	-209.88
11968	-4426	9226	179.57	14.99	-191.77
15162	1976	11142	148.7	20.75	-251.1
5354	15062	8856	137.54	35.25	-286.64
4830	15772	9572	47.16	10.26	-91.56
10460	9600	13170	-16.37	-0.12	79.5
11736	15784	7546	-24.26	33.59	268.49

Fig.8 Accelerometer and Gyroscope Data sample

2. Accelerometer Working

An accelerometer works on the principle of the piezoelectric effect. Imagine a cuboidal box with a small ball inside it, like in the picture above. The walls of this box are made of piezoelectric crystals. Whenever you tilt the box, the ball is forced to move in the direction of the inclination, due to gravity. The wall that the ball collides with creates tiny piezoelectric currents. There are three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y, and Z axes. Depending on the current produced from the piezoelectric walls, we can determine the direction of inclination and its magnitude.

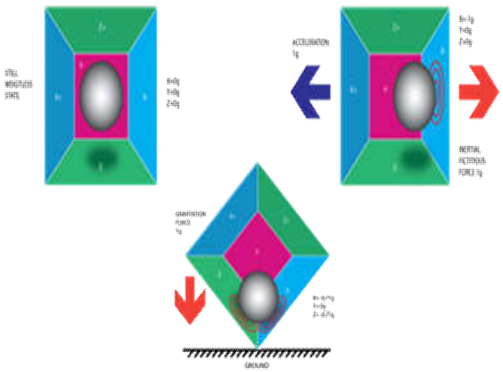

Fig.9 Accelerometer Working (source [17] www.classes.engineering.wustl.edu)

3. *Gyroscope Working*

Gyroscopes work on the principle of Coriolis acceleration. Imagine that there is a fork-like structure that is in a constant back and forth motion. It is held in place using piezoelectric crystals. Whenever you try to tilt this arrangement, the crystals experience a force in the direction of inclination. This is caused as a result of the inertia of the moving fork. The crystals thus produce a current in consensus with the piezoelectric effect, and this current is amplified. The values are then refined by the host microcontroller.

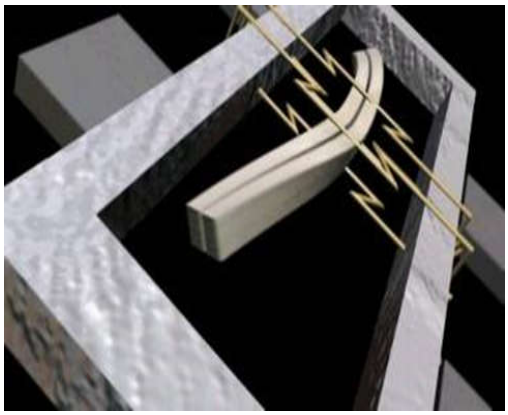

Fig.10 Gyroscope Working (source [17] www.classes.engineering.wustl.edu)

Whenever you try to tilt this arrangement, the crystals experience a force in the direction of inclination. This is caused as a result of the inertia of the moving fork. The crystals thus produce a current in consensus with the piezoelectric effect, and this current is amplified. The values are then refined by the host microcontroller.

C. *Solenoid Actuator*

The linear actuating solenoid is a type of electromagnetic actuator that converts an electric signal into a magnetic field producing a linear motion. The linear solenoid works on the basic principle of the electromechanical relay and just like relays that can also be switched and controlled using transistor or MOSFET. A "Linear solenoid" is an electromagnetic device that converts electrical energy into a mechanical pushing or pulling force or motion. Linear solenoid basically consists of an electrical coil wound around a cylindrical tube with a ferromagnetic actuator or "plunger" that is free to move or slide "IN" and "out" of the coils body.

Fig.11 Linear Actuation Solenoid (source [18] www.indiamart.com)

D, *Cutting Tool*

The cutting tool is attached to the end of the Solenoid actuator such that when the linear solenoid actuator is actuated the tool is propelled linearly. A GUILLOTINE blade is used as a cutting tool in this system. It is arranged in a frame setup with the guillotine blade such that the seatbelt webbing is inserted through the frame. When the solenoid is actuated the guillotine blade propels forward thus cutting the seatbelt webbing in the frame. Thus the seatbelt is released in this system.

V. PROGRAMMING

The programming is done in Arduino IDE software. A sample program for reading raw values from MPU6050 is given below.

```
#include<Wire.h>
const int MPU6050_addr=0x68;
int16_t AccX,AccY,AccZ,Temp,GyroX,GyroY,GyroZ;
void setup()
{
Wire.begin();
Wire.beginTransmission(MPU6050_addr);
Wire.write(0x6B);
Wire.write(0);
Wire.endTransmission(true);
Serial.begin(9600);
}
void loop(){
Wire.beginTransmission(MPU6050_addr);
Wire.write(0x3B);
Wire.endTransmission(false);
Wire.requestFrom(MPU6050_addr,14,true);
AccX=Wire.read()<<8|Wire.read();
AccY=Wire.read()<<8|Wire.read();
AccZ=Wire.read()<<8|Wire.read();
Temp=Wire.read()<<8|Wire.read();
GyroX=Wire.read()<<8|Wire.read();
GyroY=Wire.read()<<8|Wire.read();
GyroZ=Wire.read()<<8|Wire.read();
Serial.print("AccX = "); Serial.print(AccX);
Serial.print(" || AccY = "); Serial.print(AccY);
Serial.print(" || AccZ = "); Serial.print(AccZ);
Serial.print(" || Temp = "); Serial.print(Temp/340.00+36.53);
Serial.print(" || GyroX = "); Serial.print(GyroX);
Serial.print(" || GyroY = "); Serial.print(GyroY);
Serial.print(" || GyroZ = "); Serial.println(GyroZ);
delay(100);
}
```

VI. EXPECTED OUTCOME

In this modern day, as the number of vehicles in the roads increases the number of accidents also get increased. Thus there is a risk of seatbelt failure to release after a collision. The existing systems have limitations that may cause further injury to the occupants.

- This system checks both gyroscope and timer before releasing the seatbelt.
- The gyroscope monitors the orientation of the vehicle.
- The system will release only when the orientation of the vehicle is a safe condition.

• It will not release the seatbelt if the car is toppled over or rolling which will cause severe injury to the occupants.

Thus this system is expected to minimize the risks and overcome the limitations of the existing system.

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