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PASSIVE SAFETY SYSTEM FOR MORDERN ELECTRONIC GADGETS USING AIRBAG TECHNOLOGY

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***Abstract*--Most of us would have felt the pain of dropping a mobile phone or tablet, only to find the screen is shattered beyond recognition or use. The pain is further heightened when we receive the huge repair bill to fix or replace the screen of our smart phone. But there are those happy moments when we retrieve our dropped mobiles from the floor to find that the screen has remained intact. The main objective of our project is to prevent the front screen of our phone from breakage when it slips from our hand or falls down accidentally. This can effectively be overcome by designing a case that contains an airbag which prevents the gadget's front screen from touching the ground. The freefall is sensed by an inbuilt accelerometer which measures the acceleration due to gravity in all the three directions and predict the fall instantly in prior. Whenever the freefall is detected the case protects the front panel of the mobile phone by popping small air balloons at all the four corners of the gadget.**

Keywords: Free Fall, Accelerometer, Airbag.

I. INTRODUCTION

In automobiles, a central Airbag control unit monitors a number of related sensors within the vehicle, including accelerometers, wheel speed sensors etc. The crash is detected with the help of an accelerometer in modern cars by measuring the change of speed [1]. If the deceleration is great enough, the accelerometer triggers the airbag circuit. Normal breaking does not generate enough force to do this. A similar concept to the above is used to detect the crash in modern electronic gadgets like mobile phones, tablets, iPod etc but the only difference is to detect the fall prior to the crash. The mechanism of depletion of an air bag in automobile involves ignition of harmless gas [2] like nitrogen or argon which is packed behind the steering wheel whereas in mobile airbag compressed air is made to push through small tubes thus blowing small pop up bags at all the four corners of the mobile case. Table 1 summarizes the main difference between the car and mobile airbag.

AIRBAG IN AUTOMOBILES.	AIRBAG IN MOBILE PHONES.
1. This takes place due to chemical reactions in automobile system. 2. Airbag is deployed after the accident. 3. Cost is high. 4. Crash is to be detected.	1. This is done with the help of a mechanical system. 2. Airbag is deployed just before the accident. 3. Cost is low. 4. Freefall should be detected.

Table 1.difference in car and mobile airbag

New glass such as Corning Gorilla Glass has been introduced to avoid the breakage of front panel. Tests show that it could withstand around 100,000 pounds of pressure per square inch. It can withstand, without shattering or cracking, a 535g ball being dropped on it from 1.8m above. The screen technology has already made its way into the Samsung Galaxy S3 smart phone onwards [3]. How the phone or tablet falls to the ground is the key to the shattering question. If it falls face down it might escape without too much damage because the stress of impact is spread across the entire surface. It would almost certainly undergo damage, which cannot be visualized with the naked eye. But if it is dropped onto one of the corners, the uneven surface means the point of contact between the glass and ground is small and focused, directing the entire force of the impact onto one small point [4] and this is where months or years of little bangs and bumps can become relevant. With every drop the invisible cracks become greater, until a major spillage will cause it to shatter. The following table gives the cost based justification for the project on the grounds of considering three different mobile brands like the iphone 6s of the apple [5], s6 edge of Samsung[6] and Nexus-5 of the Google [7]

PHONE NAME	COST OF BUYING	COST OF REPLACEMENT
IPHONE 6S	RS 70000	RS 50000
SAMSUNG S6 EDGE	RS 55000	RS 20000
NEXUS -6P	RS 40000	RS 18000

Table 2: cost based justification of the project

II. BLOCK DIAGRAM

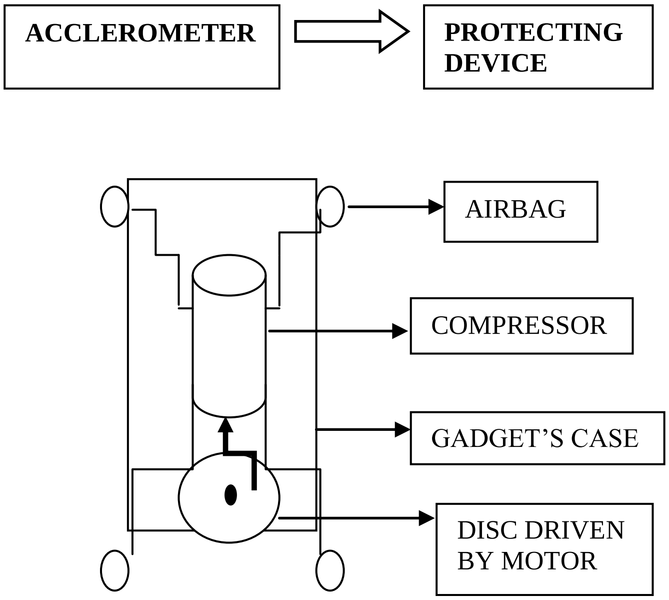


Fig 1. Block diagram

The block diagram shows how the signal from the accelerometer drives the protecting device. The components of the device include a motor, a compressor and four airbags at the corners. The signal from the accelerometer drives the motor which in turn forces the movement of piston that pumps air into the four small airbag structures through small tubes. Once the accelerometer senses the freefall it sends its acceleration due to gravity values to the processor which gives the interrupt to the motor based on looping mechanism. The value is checked in a loop for more than three times before it gives a phase shift to the motors. Once the value exceeds the threshold value the motor is driven at a step angle of 3.6 degree until the piston is pushed upwards. The piston contains compressed air and on pushing it with force it will cause the compressed air to blow in all the four tubes and thus deploying the air balloon at all the four corners of the gadget. The reason for keeping the airbag at the corners is that the centre of mass is concentrated at the corners. Hence according to Newton's second law, force is directly proportional to mass and so the force for hitting the ground is more at corners due to the centre of mass being concentrated there.

III. AXES READINGS USING INBUILT ACCELEROMETER

Any object that is being acted upon only by the force of gravity is said to be in a state of free fall [8]. When we are having the accelerometer inside the mobile phone, it eliminates to access it by using an additional hardware accelerometer. The only constraint in accessing the inbuilt accelerometer is that it cannot be used when the mobile is in off state but to view in a broader sense during the times of active, the inbuilt accelerometer is way better as it minimizes space and human calibration times. Nowadays most of smart phones carry an acceleration sensor. It is based on three mutually perpendicular silicon circuits, each one oscillating in one direction as a ball hanging on a spring whose movement is restricted to one direction [9]. The measurement of the acceleration sensor can be registered with a smart phone application.

```
# Accelerometer Values
# filename:  default__1.txt
# Saving start time: Fri Oct 25 19:12:46 GMT+02:00 2013

# sensor resolution: 0.01197m/s^2
#Sensorvendor: The AMI306 Android Open Source Project, name:
AMI306 3-axis Acceleration sensor, type: 1,version : 1, range
19.6

# X value, Y value, Z value, time diff in ms
  -0.032   -0.018   -0.051        22
   0.05     0.009   -0.037        22
   0.08     0.035   -0.042        21
   0.028    0.031   -0.064        21
  -0.053    0.019   -0.084        21
  -0.057    0.008   -0.093        21
   0.001    0.016   -0.075        22
   0.045   -0.002   -0.041        21
   0.005    0.015   -0.028        21
  -0.047    0.013   -0.043        22
  -0.052   -0.005   -0.039        21

   ...       ...      ...        ...
```

Fig 2.Accelerometer readings from android app

Here a briefly present the free Android application "Accelerometer Monitor ver.1.5.0" we have used in our experiments. This application takes 348 kB of SD card memory and can also be downloaded from Google play website [10]. This App shows the acceleration components ax, ay and az on x, y and z- axes at each time step. The resolution of the sensor in the measurement of the acceleration is $\delta a = 0.01197$ m/s² and the average sampling time is $\delta t=0.02$ s. This application also allows saving an output file, from which the data can be retrieved for further analysis. The output of the mobile application with the acceleration data is collected in an ASCII file as shown in figure-4. Probably, the simplest experiment we can perform with the mobile acceleration sensor is the study of a body which falls in the gravitational field of the Earth. This experiment was treated in reference [11]. Authors suspended a smartphone from a string. After cutting the string, the Smartphone fell freely for a period of time until getting to a soft surface which stops its motion. With the measurement of the fall time and the initial time and constant acceleration due to gravity during freefall, the height to deploy the airbag can be evaluated as follows by assuming a distance of 2 meters.

- d= 1/2(g*t^2); Where d is the distance.

- T=√2d/g; where T is the threshold level.
- T=0.628.
- V=√2g*d ; where V is the velocity
- V=6.260.
- V=g*t. where t is threshold voltage.
- t=3.6 volts

The following table gives different velocity and time ranges for seven different heights and enables us to predict the time and place to deploy the airbag.

Table 3. Time calculation for different Distance and Velocity

DISTANCE(m)	TIME(s)	VELOCITY(m/s)
0.25	0.225	2.213
0.5	0.319	3.13
1	0.451	4.42
2	0.63	6.26
3	0.780	7.66
4	0.903	8.85
5	1.01	9.89

IV. AIRBAG APP TO DETECT THE MINIMUM ACCELERATION

The time to deploy the airbag is calculated with the help of the developed airbag android application. The purpose of the application is to estimate the minimum axes value along the z-direction faces during the fall of the mobile phone. This minimum value is compared with the value obtained from table-3 which justifies it is sufficient to open the airbag after a distance of ½ meters irrespective if the height as it unnecessary to deploy airbags for gadgets falling in heights less than ½ meters since the probability of breakage is very low. The app works on java platform via eclipse software. Eclipse is an integrated development environment (IDE) [12]. It contains a base workspace and an extensible plug-in system for customizing the environment. Eclipse is written mostly in Java and its primary use is for developing Java applications, but it may also be used to develop applications in other programming languages through the use of plug-in

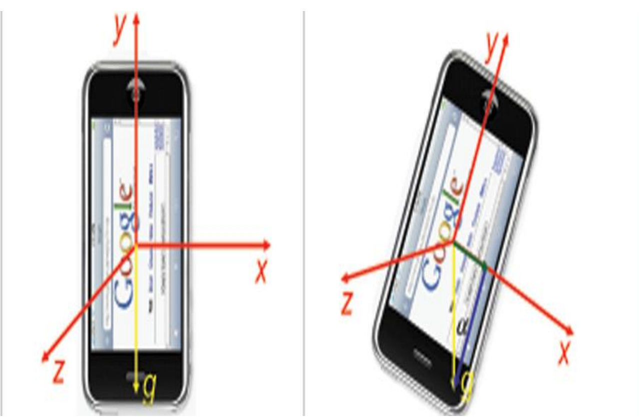


Fig 3. Accessing the inbuilt accelerometer

STEPS OF THE PROCESS

- Initially when the code is dumped into the android device, the app loads with three buttons like start /reset, stop and print.
- When the device in our hand after pressing the reset button the value is equal to 9.8 which is acceleration due to the gravity.
- When the phone is in free fall the value is decreased corresponding to the distance and the variation occurs in the Z direction.
- When the print button is pressed, all the value of accelerometer is printed in LOGCAT.

- We have derived using equation of motion that after a threshold value of 3.6the mobile is in free fall. So after this particular value of 3.6 something has to be indicated as a beep sound.
- The above threshold value is found using the LAWS OF MOTION. The following equations are further calculated.

STEP 1

Initially once the code is dumped into the android device the screen appears to be like the following. It will have three states START, STOP and PRINT. The start section starts counting the acceleration due to gravity values and the stop section stops counting the gravity values and meanwhile the print section displays all the counted values between start to stop in the eclipse working window.

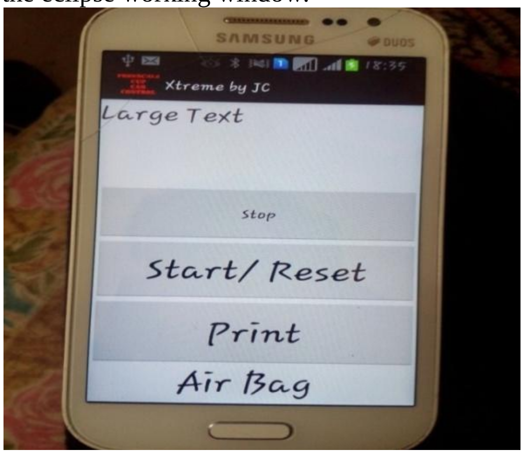


Fig 4. Initial stage of the APP

STEP 2

Once there is a movement in the device the acceleration due to gravity is sensed and displayed as follows. Until the stop button is pressed the value keeps on changing in the Z-direction. The values will be close to 9.8 which is the standardized value for the acceleration due to gravity

Fig 5. APP displaying the acceleration values

STEP 3

During the motion of the device towards the ground the different values are sensed and the threshold is calculated using the laws of motion. The value displayed on the screen is the minimum acceleration faced by the device during its freefall. This value allows us to justify our threshold for our device that any value below 3.5g in the S-factor denotes freefall

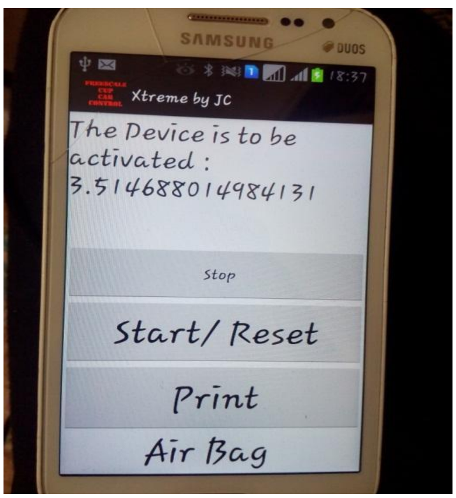
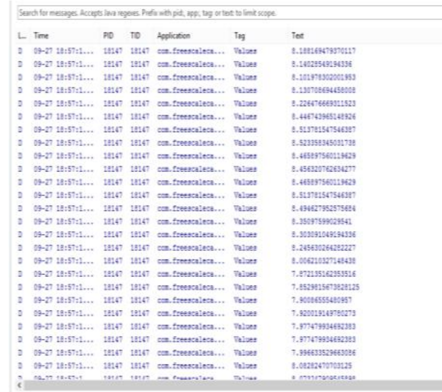


Fig 6 Minimum acceleration faced during freefall

STEP 4

This step of the project deals with the print button present in our APP, it is used to display the different acceleration due to gravity values faced by the gadget between the start and the stop sections


Search for messages. Accepts Java regexes. Prefix with pid:, app:, tag: or text: to limit scope.

L...	Time	PID	TID	Application	Tag	Text
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.188169479370117
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.14028549194336
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.101978302001953
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.130708694458008
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.226476669311523
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.446743965148926
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.513781547546387
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.523358345031738
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.465897560119629
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.456320762634277
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.465897560119629
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.513781547546387
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.494627952575684
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.35097599029541
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.303091049194336
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.245630264282227
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.006210327148438
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.872135162353516
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.8529815673828125
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.90086555480957
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.920019149780273
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.977479934692383
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.977479934692383
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	7.996633529663086
D	09-27 18:57:1...	18147	18147	com.freescaleca...	Values	8.08282470703125

Fig 7. Displaying all the acceleration faced during freefall

V. CONCLUSION

Freefall detection has number of application like monitoring baby, preventing elderly people from falling, protecting the electronic gadget from breakage etc. The fall detection is the major challenge here since the entire process of deploying an airbag must happen in micro seconds. Here we have implemented freefall considering only the Z-direction readings, but to have more accuracy the value should be obtained by taking the S-factor in to account. There are also cases where a gadget falls on a soft cushion and at the same time the airbag also gets deployed which proves to be unnecessary, these situations are unavoidable so we are trying to use replaceable airbags at the case which proves to be cost effective. The future developments of the project may include detecting the time and sending an interrupt via a processor to push the compressed air in to the tubes.

VI. ACKNOWLEDGEMENTS

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