External mechanism to prevent irreversible damage to hardware components of a cellular phone

(Mobile White Knight)

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Abstract - a low cost external (case-like) air bag mechanism is proposed for protection of expensive fragile smartphones from severe hardware damage. This external helping mechanism is constructed by utilizing inbuilt accelerometer of a mobile phone interfaced with its internal microcontroller. A critical acceleration will be detected by the internal gyroscope of a phone, detecting free fall. Micro sharp sensors (External to the mobile, connected via Bluetooth to the internal microcontroller) are used to confirm the free fall of the device by calculating distance from the surface. This in turn will send an interrupt to the microcontroller and the cartridge (also external to the phone connected via Bluetooth) containing NaN3 (Sodium Nitrite), KNO3 (Potassium Nitrate) and SiO2 (Silicon Dioxide) will get stimulated and there is a chemical reaction between the three constituents. Inflating the external air bag present in the case-like structure and thus preventing direct contact of the mobile phone with hard surface. Fast and reliable responses, low power consumption are other attractive features of the proposed mobile white knight. The device will be incorporated as a mobile cover.

Keywords- smartphone; airbag; accelerometer; NaN3; KN03; Microsharp sensors;

I. INTRODUCTION

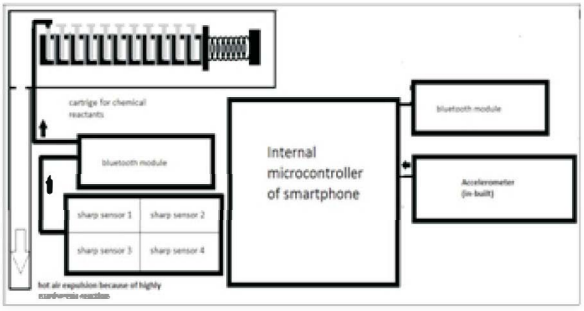

Fig.1 Block diagram of protection mechanism.

The mobile white knight is essentially a case-like external mechanism that protects mobile phones from hardware damage. As much as 10,000 potential fatalities have been prevented in the US alone since 1985 by the use of air bag for cars. The mobile white knight uses a similar approach to protect smartphones from fatal damage [8]. It uses the internal accelerometer of a mobile phone. Typically a three axis accelerometer is present in a mobile phone. A driver is installed in the internal microcontroller of a phone that utilizes the accelerometer readings for detecting any abrupt change in acceleration. The micro sharp sensors and a cartridge of minute explosives are connected to the internal microcontroller using Bluetooth module. In case of an abrupt change in acceleration AND detection of surface vicinity by micro sharp sensors, base current is supplied to the cartridge resulting in an exothermic reaction between NaN3 (Sodium Nitrite), KNO3 (Potassium Nitrate) and SiO2 (Silicon Dioxide), which inflates the air bag at the perimeter of the case. Mobile white knight can be used as a mobile cover barely making any change to the overall weight of a cellular phone. Simultaneously, preventing it from severe damage in case of free fall. The speculated cost of the completed product is 150 INR. The cost of a smartphone in current day and age may be anything varying from 2,000 INR to Rs2, 00, 000 INR.[1].

Going by the modern standards of design, the lighter the phone, mightier it is. This makes them more fragile and prone to damage in case of an accidental drop. The number of global smartphone users will surpass 2 billion in 2016, driven by rapid growth in developing countries. The number of smartphone users worldwide will surpass 2 billion in 2016, according to new figures from eMarketer, representing over a quarter of the global population [2]. According to a poll conducted by phonearena.com, 17.17% admitted that their phone had been damaged even whilst having a cover on. Mobile White knight addresses this market by providing a fool proof solution for mobile damage.

Mobile white knight is a unique way of saving smartphones from irreparable damage, utilizing its own resources. It addresses the need of approximately 2.03 billion smartphone users in 2015.[5]

WORKING ALGORITHM

1. Calculate relative linear accele ration between (x1,y1,z1) and (x2,y2,z2).
   D=((x1^2+y1^2+z1^2)^1/2)-((x2^2+y2^2+z2^2)^1/2).
2. If value exceeds 2.64 (acceleration stability limit as calculated), initiate isr to check values of IR sensors else go to step 1.
3. If IR already in surface contact goto step 1 else step 4.
4. If any IR sensor detects surface goto step 5 else goto 1.
5. Deploy protection command routine
   (send alert or HIGH signal via bluetooth, gate current provided to cartridge via bluetooth module RN52).
6. Go back to step1.

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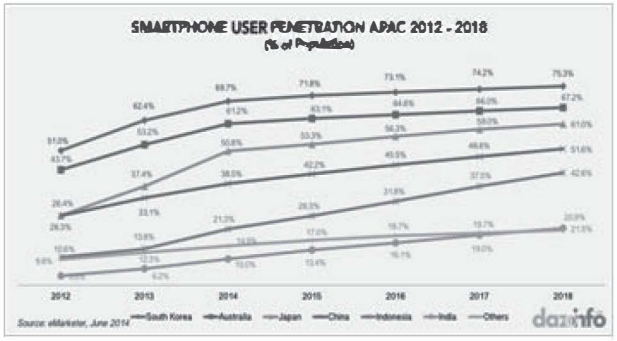


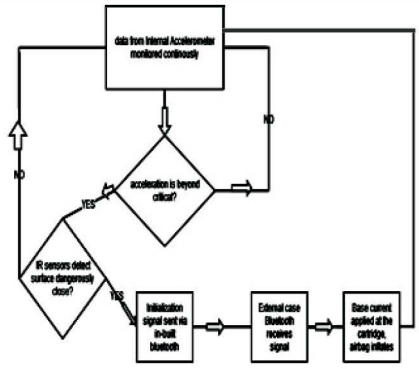
Fig.2 Smartphone user penetration. [4]

II. EASE OF USE

A. Understanding the basic software and harware requirements

The source code that programs the internal microcontroller of the phone to monitor the values of accelerometer and IR is uploaded to the phone using a driver software which is designed for popular operating systems like android, iOS, Windows. Through the app the phone establishes connection between the phone (also the in-built accelerometer) and the external IR and cartridge of minute explosives. The app uses Bluetooth as a communication medium to interact with the cartridge and the IR sensors. Hence, the user has to switch on Bluetooth on their smartphones.

The mobile white knight is available in various sizes for all popular models of smartphones, and can be customized to fit the needs of the user.



B. Using the mobile white knight as a back cover

Mobile white knight is very user friendly. These are the basic steps involved:

1. The back cover of the smartphone is to be taken off. The mobile white knight is put on at the back.
2. The device driver with the source code for programming has to be activated. The Bluetooth module of the cell phone is switched on.
3. Now, in case of any incident like an accidental drop, abrupt change in internal accelerometer is detected also, also IR detects if the surface is dangerously close.
4. A signal is sent via Bluetooth and base current of about 1 mA is applied to cartridge resulting in a minute explosion. And hence, air bag is inflated before the smartphone hits the ground protecting it from severe damage.

5. In order to use the airbag again, air is let out through a manual opening provided and airbag is fit back into the case. The cartridges are replaceable and the chemicals used as explosives are very economical and easily available.

III. CONSTRUCTION

The main hardware components of the mobile white knight are IR sensors, Bluetooth module, explosive cartridge and the airbag.

An Infrared (IR) sensor is used to detect obstacles in front of the robot or to differentiate between colors depending on the configuration of the sensor. The sensor emits IR light and gives a signal when it detects the reflected light. An IR sensor consists of an emitter, detector and associated circuitry. The IR sensor is used to confirm that the smartphone is in free falling condition, by calculating distance from the ground. In the Explosive cartridge there is a reaction between NaN_3 (Sodium Nitrite), KNO_3 (Potassium Nitrate) and SiO_2 (Silicon Dioxide) which is stimulated by heat generated due to base current. This is the initial reaction that forms sodium and hot nitrogen gas which inflates the air bag.

$$2\ NaN3 \longrightarrow 2\ Na + 3\ N2$$

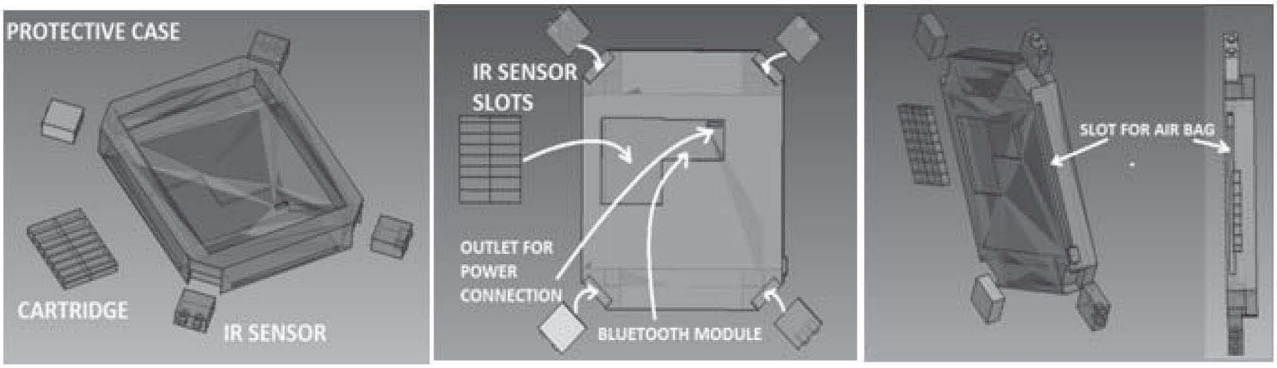


Fig.3 3D model of external protection mechanism.

And finally the previous two reactions leave potassium oxide and sodium oxide to react with the third component of the mixture, silicon dioxide, forming alkaline silicate "glass".

$K_2O + Na_2O + SiO_2 \longrightarrow$ alkaline silicate

The reactions in steps 1 and 2 release a great deal of nitrogen gas. It is this hot nitrogen gas that fills the airbag. The potentially harmful sodium created in step 1 combines with potassium nitrate in step 2 to produce more nitrogen, potassium oxide, and sodium oxide. The final result is nitrogen gas and alkaline silicate powder. The sodium produced in step 1 may also react with moisture, temporarily forming sodium hydroxide. Because these reactions occur so rapidly, the multiple steps in the reaction are in reality occurring simultaneously. [7]

With the exception of a small number of old designs that are being phased out of production, all airbag cushions manufactured world-wide are constructed with fabric made from nylon 6,6 yarn.[9] Therefore considering its superior properties like low density (1140 kg/m^3) and high specific heat capacity (1.67 kJ/kg/K) also its economic cost make it ideal to use as the primary material for air bag in Mobile White knight.

IV. WORKING

The simulation is created using Atmega 16. The basic working model is simulated and tested.

In case of an accidental fall the smartphone will detect an abrupt rise in the acceleration

The figure above shows a reaction time of 228 millisecond which is more than sufficient for the airbag of the mobile white knight to get inflated.

A. Approximation according to orientation

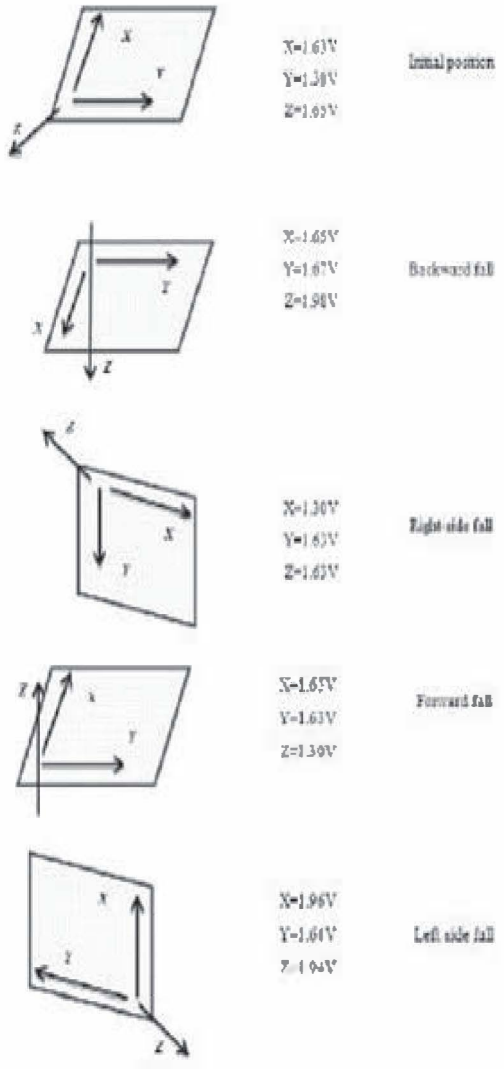


Fig.4 Accelerometer in different situations.

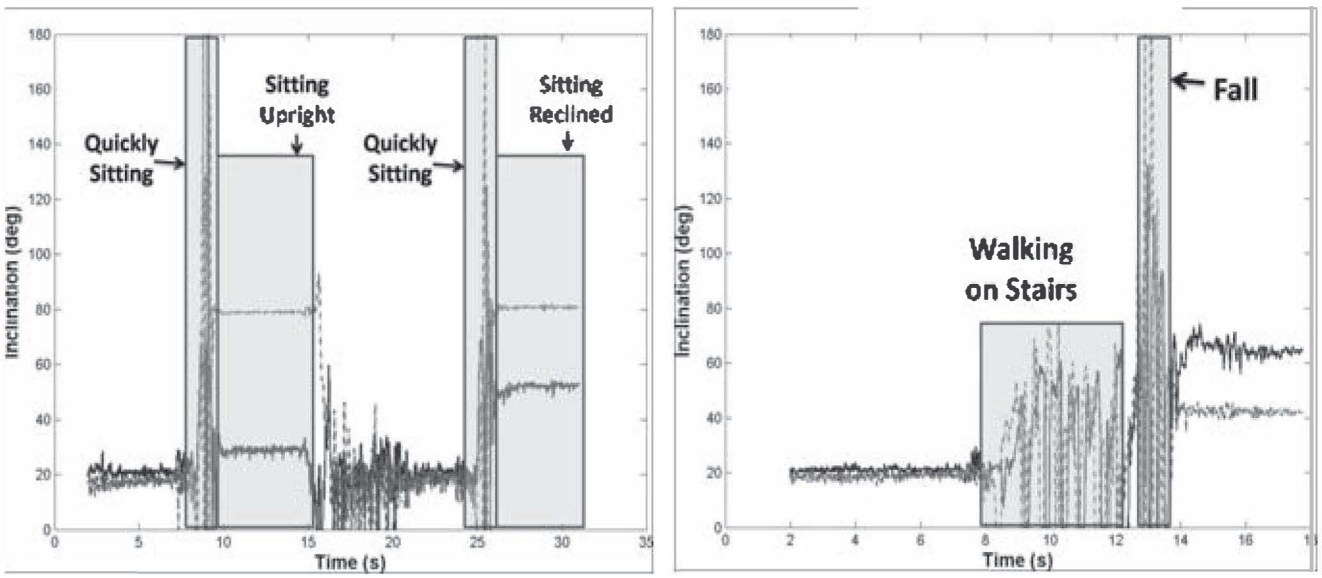


Fig.5 Graph of accelerometer in various situations.

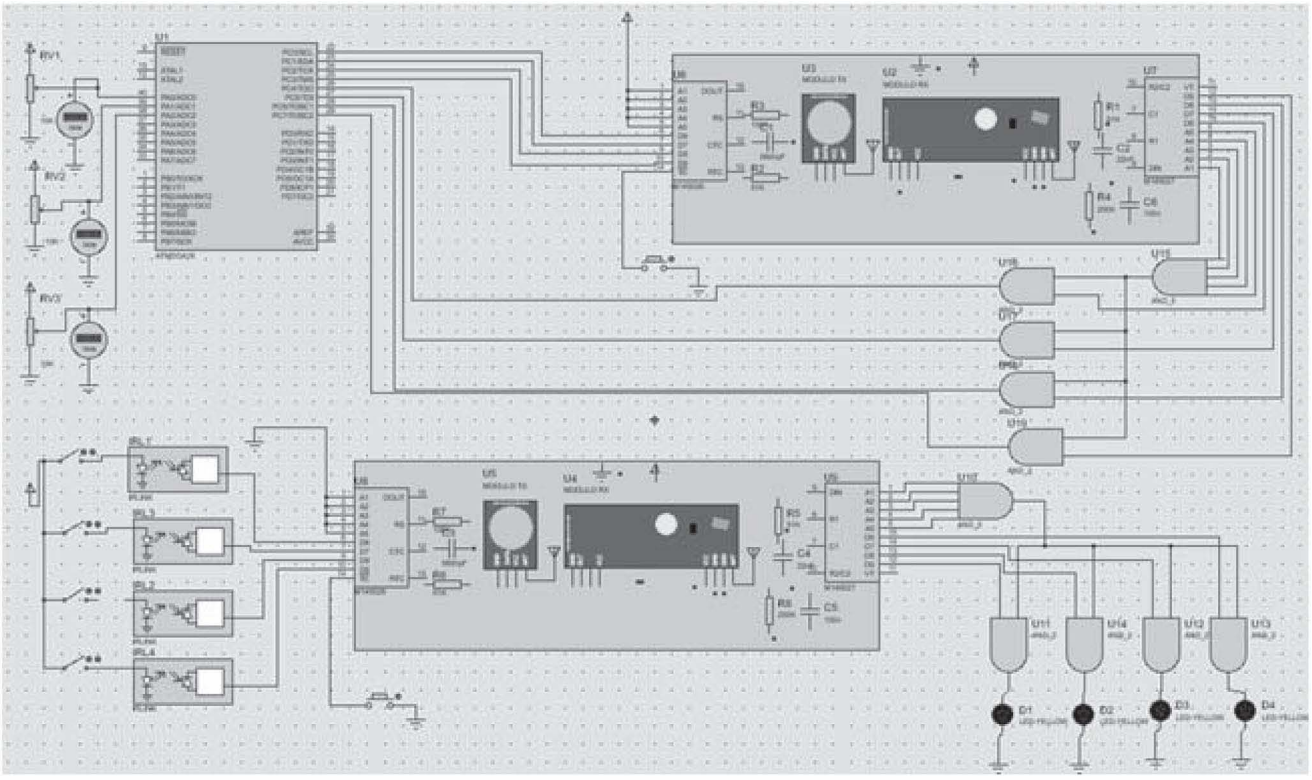


Fig.6 Simulation of the External mechanism.

V. CONCLUSION

The sensitivity of the internal accelerometer of a contemporary smartphone is capable of detecting sharp acceleration and sends timely interrupt to the operating microcontroller in no time. This makes the mobile white knight detect sharp change in velocity within fraction of a second.

The IR sensors present that the body of the cover cross check if the mobile is actually in free fall, by calculating distance to the nearest surface. Mobile white knight is addressing 30% of world population that uses smartphones on a daily basis and providing them with a service that has no other contemporary. Simplicity is the uniqueness of this project. All the data and the hardware components of a smartphone remain unscathed if mobile white

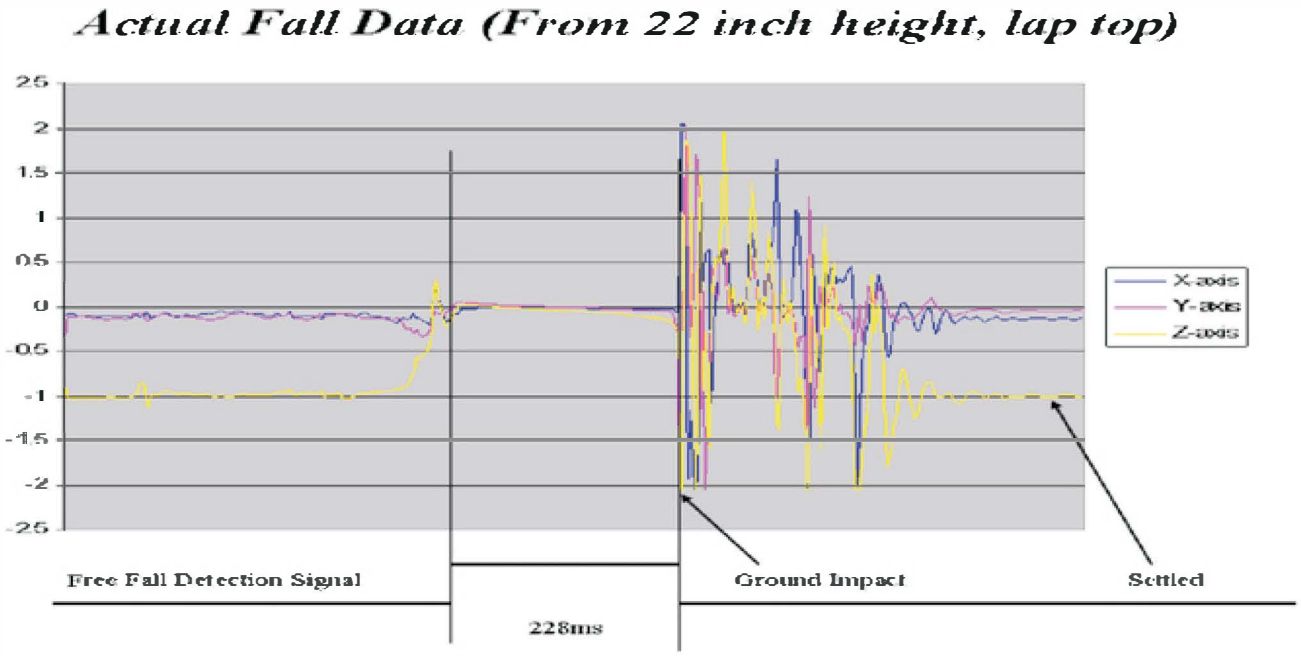


Fig.7 Fall data Graph.

knight is incorporated with the mobile.

The results follow a similar study published by SquareTrade last month that claimed Americans alone have spent $5.9 billion on damaged iPhones. That same survey noted that the main reason phones became damaged in the first place was falling out of user hands (at 30 percent of issues), followed by liquid damage at 18 percent[10] The most rampant cause of data loss is due to hardware damage and human error.[11]

TABLE 1: CAUSES AND EPISODES OF DATA LOSS	
PCs in use	76.2 million
CAUSES OF DATA LOSS	**EPISODES OF DATA LOSS**
HARDWARE FALIURE	1,849,800
HUMAN ERROR	1,345,300
SOFTWARE CORRUPTION	5888,600

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COMPUTER VIRUSES	249,300
HARDWARE DESTRUCTION	126,100
THEFT	403,0005
TOTAL	4,607,100

Hardware failure and Hardware destruction account for 42.8% cause of data loss. Therefore there is an undeniable need to protect smartphones from hardware damage. The mobile white knight is a major step towards achieving hardware protection for smartphones