Fall Detector for the Elderly

Using GPS and Accelerometer and Body Sensors

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2017

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# Abstract

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# Chapter 1: Introduction

# Chapter 2: Global Positioning System

## 2.1 Introduction

GPS or Global Positioning System can be described as a constellation or a network of orbiting satellites that transmit accurate data of their position in space back to earth. These signals are gained by GPS revivers such as navigation devices (Mio Technology, 2011). The very first GPS satellite was launched in 1978. In 1980 the American Government made the first GPS available to the public. There are 24 NAVSTAR (NAVigation Satellite Timing And Ranging) satellites at a range of 12000 miles above earth. It took until 1994 to complete the 24 satellite constellation. It takes less than 24 hours for one satellite to orbit the earth twice. Each satellite is built to last about ten years, as result GPS satellites are constantly been built to be launched into space.

## 2.2 GPS Function

GPS is generated by a satellite ID called the Pseudo Random Code, every satellite has a unique code, which is simply on and off pulses GPS is sent by two frequencies, these are; L1 at 157.42MHz and L2 at 1227.60 MHz. There is also two-pseudo random code, the first is called ‘Coarse Acquisition’ code that modulates L1 carrier, repeats every 1023 bits at 1MHz. The second is called ‘Precise’ code it repeats on a seven-day cycle and modulates both L1 and L2 carriers at 10MHz. (Trimble Inc., 2016)

GPS receivers compute the position and time by using a number of satellites and ground stations. The information is transmitted back to earth over radio frequencies, ranging from 1.1GHz to 1.5GHz. WAAS (Wide Area Augmentation System) and DGPS (Differential Global Positioning System) are used to improve signal accuracy. WAAS is air navigation aid developed by Federal Aviation Administration and common on most GPS receivers improves accuracy to about 5 meters. DGPS on the other hand requires a specific type of GPS receiver. It gets accuracy up to centimeters. There expensive and require additional antennas. (A1RONZO, 2012).

## 2.3 Types of Data Transmitted

Satellites send out two types of data Almanac and Ephemeris. Almanac data is course orbital parameters; there are six parameters to specify the motion and position fully, however very precise but valid for several months. Ephemeris data by comparison is very precise orbital and clock correction for each SV and is necessary for precise positioning but valid for 30 minutes. The almanac enables the receiver to know which satellites to search for. A 2D position cannot be given until at least three satellites received the data from the ephemeris. This data is broadcasted every 30 seconds. (Mehaffey, 1998).

## 2.4 Space Race

Satellites have played a major part in GPS technology. During the Cold War the USA and USSR were in a competition to see who would come out on top in the Space Race. The Soviets launched Sputnik I on 4th October 1957. Sputnik I would become the very first artificial satellite into space. The satellites weighing 83.6 kg, 58 cm in diameter, orbited the earth every 98 minutes. As a result, this started the “Space Race” and accelerated science, technology and military developments especially in America. The Soviets now had ability to develop missiles that could hit main land America from Europe. The Soviets launched Sputnik II, with an animal passenger, a dog named Laika on November 3rd 1957. America responded with the launch of Explorer I on January 31st 1958. By July 1958 America set up NASA or National Aeronautics and Space Administration. (Garber, 2007).

## 2.5 First NASA Satellites

Echo 1 became the very first Communication Satellite launched into space on August 12 1960. The satellite or balloon was 30.48m in diameter and was constructed out of mylar polyester film 0.5 mil thick. The balloon was designed for sending telephone (voice), radio, and television signals for both transcontinental and intercontinental means. The balloon was constructed as a passive communication reflector; this means a satellite reflects communications signals between stations without a providing amplification. It transmitted on 107.9MHz beacon for telemetry measurements purpose. The reasons for the large area-to-ratio of the balloon were to allow for calculation of atmospheric density and solar pressure. For the transmitters to work the balloon was fitted with five nickel-cadmium batteries, that were charged by 70 solar cells. NASA continued to send satellites to space with the launch of TIROS 1 on April 1st 1960. The TIROS 1 was the very first meteorological satellite. Again on November 20th 1998 NASA launched The International Space Station. (Mackey, 2004).

## 2.6 Commercial Application of GPS

GPS systems are used in many areas of life today such as navigation in vehicles, aircraft and ships. Anyone one with a GPS receiver is allowed to pinpoint their speed position to incredible accuracy, whether they are on land, sea or air. Modern car GPS allow for drivers to find a route, detour and receive traffic alerts. GPS is also useful for hikers and athletic people, the GPS device can mark rendezvous points along their route or mark out a route for a certain distance. GPS devices can very important for scientific and engineering experiments and monitoring geological activities such as volcanic and seismic activities and climate change. GPS receivers are also built into many everyday commercial technologies. These range from mobile phones, watches, smartphones, tablets, cameras, road vehicles and agriculture machinery.

### 2.6.1 GPS in Commercial Technology

GPS in commercial technologies usetrilateration to calculate exact location. GPS receiver uses trilateration to determine its position on the earth’s surface by using timing signals from a least three GPS satellites. These signals transmit signal with precise details of location, time of day and the speed the device is moving. Each of the signals sends out a periodic signal. The GPS device calculates the distance between the device and each satellite, based on the time it was transmitted and the time the signal was received. The device can now calculate the trilateration’s. Trilateration’s are calculated like a 3D version compasses on a map. The positions were at least three circles meet this is the precise position of the GPS device. For this to happen the receiver needs to have a clear sight to the satellite, interference can come from dense tree cover and buildings. Some phones use wireless assisted GPS or enhanced GPS. This system can retrieve a user location quicker using this system. More so this system can work in buildings, poor transmission areas and in dense forests. Some phones have a complete GPS located in the phone or connect through a Bluetooth connection. These GPS enabled phones can understand programming languages like Java. These features allow tracking device. The phone must have a compatible receiver, and supports transmission of map GPS data, software that provides the actual maps and location.

GPS on phones have certain advantages such as trackers which allow business companies to pinpoint GPS coordinates of their employees and allow the user to dial an emergency number. Parents can locate the location of their children to see if they are in a safe area. Such technologies that are available in this market include a Japanese technology watchdog GPS watch phone. GPS technology on mobile phones is displayed on the screen, with indications of turning directions and also phone speakers. Unfortunately the data may not be up to date as this depends on data provided by the company. Such companies include TeleNav, ViaMotonand MapQuestFind.

# Chapter 3 Accelerometers

## 3.1 Introduction

“An accelerometer is an electromechanical device that will measure acceleration forces.” (Dimension Engineering LLC, 2016, p. 1). These forces can be dynamic or static movements. Dynamic and static acceleration give different results. Static acceleration displays what angle a device is tilted compared to the earth’s axis. Dynamic accelerometers displays the direction an object is moving. (Goodrich, Accelerometers: What They Are & How They Work, 2013).

There are many uses of accelerometers in smartphones from a compass knowing what direction the phone is pointing to turning the phone from portrait view to landscape and respond to a certain required action in video games such as turning a virtual car left or right. Motion sensors are capable of detecting earthquakes and used in bionic limbs. “Acceleration is the measurement of the change in velocity, or speed divided by time”, such as a car accelerating to a certain speed over a short period of time. (Goodrich, Accelerometers: What They Are & How They Work, 2013).

## 3.2 Accelerometer Function

Accelerometers are used in many areas of technologies such as in laptops. The accelerometers protect the hard drive from damage. The accelerometer turns off the hard drive to avoid hitting the reading heads into hard drive platter when the laptop is suddenly dropped in use. Otherwise the reading heads would scratch the platter causing extensive reading damage. Accelerometers can determine if an object is moving uphill or if an object will fall over. It can also determine if an object is flying horizontally or at an angle. (Goodrich, Accelerometers: What They Are & How They Work, 2013).

## 3.3 How they work

An accelerometers works in many ways the most common been piezoelectric effect and the capacitance sensor. Piezoelectric uses “microscopic crystals structures that become stressed due to accelerative forces”. (Goodrich, Accelerometers: What They Are & How They Work, 2013). The accelerometers interpret voltage from the stress to determine velocity and orientation. Capacitance accelerometer works by sensing changes between microstructures located next to the device. The accelerometer will translate any capacitance changes caused by forced movement to voltage for analysis. The components of a accelerometer can either be purchased individually but most components are integrated into the technology that access either operating systems or governing software. Accelerometers tend to have multiple axes either two to determine two dimensional movements, or a third axes for 3d positioning. Two dimensions are mainly used to determine the moment of impact of a car crash, while mobile phones tend to use 3 axes. Accelerometers tend to be very sensitive, the more sensitive an accelerometer is the more easily it can measure acceleration. (Goodrich, Accelerometers: What They Are & How They Work, 2013).

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