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Department of Electrical-Electronic Engineering

QUARANTINE MONITORING BASED ON GEO-FENCING TECHNIQUE AND GPS-GSM TRACKING SYSTEM

Master Thesis

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Supervisor
Assoc. Prof. Dr. INDRIT MYDERRIZI

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Turkish Abstract	**:** Geniş akıllı telefon ve uydu ağı kapsama alanı, günlük hayatımızın konforunu artıran bir dizi yararlı uygulamaya katkıda bulunur. Uydu tarafından sağlanan Küresel Konumlandırma Sistemini (GPS) kullanarak, insanlar belirli bir konumda gerçek zamanlı olarak izlenebilir. GPS, bir dizi uydu ve onun tamamlayıcı teknolojilerinden oluşan bir uydu navigasyon sistemidir. Takip sistemleri, araçların, gemilerin, uçakların veya genel olarak kişilerin fiziksel konumlarını belirlemek için kullanılmaktadır. COVID-19 gibi bulaşıcı hastalıklar söz konusu olduğunda, yayılmasını azaltmak için en önemli önlem kontrol altına almaktır. Karantina genellikle bir çözümdür çünkü insanların 14 ila 20 günlük bir kuluçka süresi boyunca evlerinde tutulmasını gerektirir, böylece

enfekte olmuş kişilerin yerini belirlemek için izleme sistemi kullanılabilir. Oysa karantina, özel izleme merkezlerine kıyasla risk altındaki çok sayıda kişiyi ayırmanın çok daha uygun maliyetli ve uygun bir yoludur. Ancak, karantinaya alınan alanlar dünya çapında dağıldığından, konaklama yerlerinin içindeki sınırları doğru bir şekilde izlemek zordur. Hastanelerde kalmayı reddeden veya başka bölgelerden seyahat eden birçok insan var. Etkin bir sınır koruma sistemi benimseyen coğrafi çitli GPS sistemi önerilmektedir. Sistem, akıllı telefonların sınırlarına uyan bileklikler kullanılarak 2020 yılında bir ev karantina politikası uygulamak için bir uygulama olarak tanıtıldı. Sonuçlardan, önerilen sistemin çeşitli koşullarda doğru bir performansa ulaştığı sonucuna varılabilir.

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Istanbul – 2021

DECLARATION

I hereby declare that in the preparation of this thesis, scientific ethical rules have been followed, the works of other persons have been referenced in accordance with the scientific norms if used, there is no falsification in the used data, any part of the thesis has not been submitted to this university or any other university as another thesis.

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The thesis study of" Quarantine Monitoring Based on Geo-fencing Technique and Gps-Gsm Tracking System " has been accepted as MASTER THESIS in the department of Electrical and Electronics Engineering by out jury.

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SUMMARY

Broad smartphone and satellite network coverage contribute to a number of useful applications that improve the comfort of our everyday lives. Using the Global Positioning System (GPS) provided by the satellite, people can be tracked in real-time at a specific location. The Global Positioning System (GPS) is a satellite - based navigation system made up of several satellites and supporting technologies. Tracking systems are utilized to determine the physical location of vehicles, ships, aircraft, or persons in general. In the case of infectious diseases such as COVID 19, containment is the most important measure to reduce its spread. Quarantine is usually a solution because it requires people to be kept in their homes for an incubation period of 14 to 20 days thus that the tracking system can be employed to specify the location of the infected peoples. Whereas quarantine is a much more cost-effective and convenient way of separating a large number of individuals at risk compared to dedicated monitoring centers. However, it is difficult to accurately track confines inside their accommodations as the quarantined sites are dispersed across the world. Many people refuse to stay in hospitals or travel from other areas. The geo-fenced GPS system, which has adopted an efficient border protection system, is proposed. The system is introduced as an application to implement a home quarantine policy in 2020 using wristbands that match the confines of smartphones. It can be concluded from the results that the proposed system achieves an accurate performance at various conditions.

Key Words: GPS, GSM. Geo-Fencing, Tracking System, Quarantine

ÖZET

Geniş akıllı telefon ve uydu ağı kapsama alanı, günlük hayatımızın konforunu artıran bir dizi yararlı uygulamaya katkıda bulunur. Uydu tarafından sağlanan Küresel Konumlandırma Sistemini (GPS) kullanarak, insanlar belirli bir konumda gerçek zamanlı olarak izlenebilir. GPS, bir dizi uydu ve onun tamamlayıcı teknolojilerinden oluşan bir uydu navigasyon sistemidir. Takip sistemleri, araçların, gemilerin, uçakların veya genel olarak kişilerin fiziksel konumlarını belirlemek için kullanılmaktadır. COVID-19 gibi bulaşıcı hastalıklar söz konusu olduğunda, yayılmasını azaltmak için en önemli önlem kontrol altına almaktır. Karantina genellikle bir çözümdür çünkü insanların 14 ila 20 günlük bir kuluçka süresi boyunca evlerinde tutulmasını gerektirir, böylece enfekte olmuş kişilerin yerini belirlemek için izleme sistemi kullanılabilir. Oysa karantina, özel izleme merkezlerine kıyasla risk altındaki çok sayıda kişiyi ayırmanın çok daha uygun maliyetli ve uygun bir yoludur. Ancak, karantinaya alınan alanlar dünya çapında dağıldığından, konaklama yerlerinin içindeki sınırları doğru bir şekilde izlemek zordur. Hastanelerde kalmayı reddeden veya başka bölgelerden seyahat eden birçok insan var. Etkin bir sınır koruma sistemi benimseyen coğrafi çitli GPS sistemi önerilmektedir. Sistem, akıllı telefonların sınırlarına uyan bileklikler kullanılarak 2020 yılında bir ev karantina politikası uygulamak için bir uygulama olarak tanıtıldı. Sonuçlardan, önerilen sistemin çeşitli koşullarda doğru bir performansa ulaştığı sonucuna varılabilir.

Anahtar kelimeler: GPS, GSM. Geo-Çitleme, İzleme Sistemi, Karantin

TABLE OF CONTENTS

SUMMARY i
ÖZET ii
TABLE OF CONTENTS iii
ABBREDIVATION v
LIST OF TABLES vi
LIST OF GRAPHICS vii
LIST OF FIGURES viii
PREFACE viii
INTRODUCTION 1

CHAPTER ONE

PURPOSE OF THE THESIS

1.1. Litrature Survey 3
1.2. Problem Statement 4
1.3. Aim Of The Thesis 5
1.4. Mechanism Of Work Performed 5
1.5. Thesis Organization 5

CHAPTER TWO

SYSTEM OVERVIEW

2.1. The Tracking Instrument 6
2.2. Arduino Uno 6
  2.2.1. An Overview 6
  2.2.2. The Shield 7
  2.2.3. Atmega328p 8
2.3. Global Position System (Gps) 9
  2.3.1. GPS locating 10
2.4. Global System For Mobile Communication (Gsm) 15
  2.4.1. Gsm Modem 15
  2.4.2. At Commands 16
2.5. General Packet Radio Service (Gprs) 17
2.6. Geo-Fencing 17
  2.6.1. Geo-Fence Area Identification 18
  2.6.2. Types Of Geo-Fencing 19
  2.6.3. Geo-Fencing Work Flow 19

2.7. App Inventor 20
2.7.1. The Architecture Of App Inventor 21
2.7.2. App Inventor Modification 21
2.8. Different Technologies Used In Tracking Systems 22
2.8.1. Active And Passive Tracking 22
2.8.2. Types Of Tracking System 23

CHAPTER THREE

SYSTEM METHODOLOGY

3.1. Introduction 24
3.2. System Design 24
3.3. Working Principle Of The Proposed System 25
3.4. The Server (Adafruit.Io) 30
3.4.1. Adafruit Library In Arduino Ide 30
3.5. Geo-Fencing Application 31
3.6. System Working Principle 32
3.7. Bracelet Circuit Design 34
3.8. Bracelet Block Design 46

CHAPTER FOUR

TRACKING SYSTEM RESULTS

4.1. Real-Time Tracking System 39
4.2. Web Server And Database 40
4.3. Geo Fencing By Using Smart Phone. 41

CHAPTER FIVE

CONCLUSION

5.1. Conclusion 45
5.2. Future Work 46

REFERENCE........47

RESUME........51

ABBREDIVATION

GPS	Global Positioning System
GSM	Global System for Mobile Communication
VLR	Visitor Location Register
GPRS	General Packet Radio Service
EIR	Equipment Identity Register
RTO	Real-Time Online
NAVSTAR	Navigation System with Timing and Ranging Global
OSS	Operation and Support System
MCU	Micro-Controller Unit
RFID	Radio-frequency identification
MSC	Mobile Services Switching Center
SMS	Short Message Service
3G	Third Generation
AUC	Authentication Center
SS	Switching System
BTSs	Base Transceiver Station
SIM	Subscriber Identity Module
BSCs	Base Station Controller
MQTT	Message Queuing Telemetry Transport

LIST OF TABLES

Table 1. list of GPxxx sentences 14
Table 2. AT commands of modem..16
Table 3. The person location information in real time 41

LIST OF FIGURES

Figure 1. The Arduino UNO Board 7
Figure 2. ATMEGA328P Microcontroller 8
Figure 3. Segments Of GPS 10
Figure 4. Distance Between The Person And The Satellite 12
Figure 5. The Point At The Intersection Displays The Position Of The GPS Receiver 12
Figure 6. GSM Module 15
Figure 7. Polygon Region 18
Figure 8. Point Of Interest 18
Figure 9. Route Geo-Fencing 19
Figure 10. Sample AI2 Blocks Program 20
Figure 11. Interfacing GSM And GPS Module Using Arduino 25
Figure 12. Flowchart Of The GPS Model 26
Figure 13. Flowchart Of GSM Model 28
Figure 14. Flowchart Of Sending And Receiving Data 29
Figure 15. Adafruit Server Code Inside The Arduino IDE 30
Figure 16. Geo-Fencing System. 31
Figure 17. The Schematic Diagram Of The Proposed System Module 32
Figure 18. Operation Flowchart Of The Proposed System Module 33
Figure 19. Bracelet Circuit Design 35
Figure 20. Block Diagrams of The Proposed Bracelet. 36
Figure 21. Printed Circuit Board Of The Designed Bracelet (Top Side) 37
Figure 22. Printed Circuit Board Of The Designed Bracelet (Bottom Side) 38
Figure 23. The Block Diagram Of The Proposed Tracking System. 39
Figure 24. The Web Server Program 40
Figure 25. Patient Location Within The Boundaries Of Geofencing 42
Figure 26. Patient Location Outside The Boundaries Of Geofencing 42
Figure 27. The Patient Location With The Geographical Fence 43
Figure 28. The Final Version Of The Designed Bracelet. 44
Figure 29. Implemented System (Bracelet And Mobile Application) 44

PREFACE

During the preparation and writing process of this thesis, I would like to thank my esteemed professor Assoc. Prof. Dr. Indrit MYDERRİZİ.

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INTRODUCTION

The highly infectious disease of Coronavirus Disease 2019 (COVID-19) has been a pandemic that has had a profound impact on our lives and our economy (Silva, 2020). Whereas the prevention of infection by COVID-19 is the first step to effectively curb its spread. Individuals who have traveled from significant risk areas, those who have physical contact with infected cases, are expected to be isolated and placed in specific quarantine areas for a period of between (14-20) days in some countries. For example, since 2020, a mandatory quarantine order has been issued in many countries for people coming from abroad, whether at homes or security centers. (Lawrence Ka-Ki et al,2020). Some of the quarantine cases permit the citizens to stay in their residences or rent rooms compared to quarantine in dedicated buildings as "unified quarantines". It is an effective and inexpensive option for low-risk individuals, significantly reducing the attempt to maintain the facilities and the safety of the track. In addition, when they reside in the places of their choice, they also feel more relaxed and at ease at home. Any infringement of home quarantine (i.e., during the quarantine period when the person in custody leaves home) may pose a major risk and expense to public health. Various technologies have been proposed to detect the location of any object. There are differences between these technologies, including the cost, precision, functionality, coverage, and coverage areas needed to operate them, but the selection of the correct technique depends on the application or task required. Tracking infected individuals effectively and continuously is a challenge.

One of the successful solutions has been the provision of periodic satellite remote control reports on the location of infected persons. Such reports can be provided on a daily basis by sending them to remote control devices based on satellite systems such as Global Positioning System (GPS) (F. Reclus and K. Drouard, 2009), (R. R. Oliveira et al., 2013). In order to ensure that the infected person within the home boundary, a further approach is to make surprise visits by special medical teams. Nevertheless, this approach could not be regularly carried out owing to privacy issues. Hence, there is a possibility that the infected person may leave the boundaries of the quarantine site. In addition, with the spread of the Internet of Things (IoT) technology, analysts and programmers use smartphones to perform transparent, automatic, and digital geographic isolation processes for isolated people over time. A typical technique is to approximate when using a global tracking system, and then check if the infected person is within a bounded area. Although this approach is accurate, it requires considerable effort to pre-calibrate within and without the quarantine region. This is expensive and not flexible for more widespread quarantine sites. (Tan, J et al, 2020).

GPS technology can provide three-dimensional location information. Information on latitude, longitude, and altitude can be provided using four GPS satellite signals. The Global System for Mobile Communications (GSM) modules can be used to find the exact location of the coordinates from GPS satellites. (Bharavi, U.& Sukesh, R. M.,2017).

In general, a tracking device is used to detect the movements of people or objects. In order to be able to represent the motion on the tracking system, the relevant position information shall be concatenated in a timely manner. There is a multitude of tracking systems, some based on the lag time index after a clause has been reached, while others are in real-time and close to real-time systems. For instance, GPS depends on how often the data is refreshed (Adwan, E. Z. ,2015).

The Real-Time Online (RTO) system collects the satellite's real-time location and continually rotates the data to the server. The data provided to the server in the typical online RTO system is based on GPS/GPRS/2G. This type of online monitoring is most commonly used for procedures that require constant location updates, such as logistics information systems, traffic systems, taxi systems, etc. The merits of online tracking lie in the appropriateness of use (Namkhun, S., & Hormdee, D., 2011).

Cell phone tracking system is more reliable in the urban areas. This is due to antenna towers which are wide propagated in urban areas. However, cell phone tracking could be not accurate in village areas or areas with few residents. This is attributed to antenna towers which are few in these areas. A mobile phone might be existing within an area of around 149 feet for urban areas, while a mile range is required for village areas (Adwan, E. Z. 2015).

CHAPTER ONE

PURPOSE OF THE THESIS

1.1. Literature Survey

Since 2010, real-time tracking systems have been received great attention. Many efforts have been done to improve and develop human tracking systems. For the time being, a number of tracking units, such as vehicle theft protection, aircraft tracking, ship tracking, and other traceable objects, using global tracking systems and with the help of the mobile phone network, are being developed along with customer detection and real-time control monitoring. Some of the previous studies are listed as follows.

The authors (Guang-Hui et al, 2012) used the GPS/GSM modules to implement an automotive (anti-theft) tracking system to protect the cars against theft. The device was made up based on the high-speed single chip (C8051F120), vibration sensors, GSM modules, GPS receiver modules, microcontroller board, and wireless remote control. The GPS module was employed to specify the location of cars to be accessed. From a cell phone, the user was able to obtain data about the location of his car and monitor the alarm system.

The framework for the tracking system has been adopted and Twitter has been used as a value-added service for the traditional tracking system. There are profiles available on any computer that users can easily access. As a result, the computer was constantly receiving tweets, linking to a map showing the location of the object in real-time. The system detects the current position, speed, and flicker of the object on/off (e.g. car engine). The system then sends all this information over the Internet to the monitoring server (ElMenshawi, Saeed, et al, 2013).

A GPS-GSM tracking device with Google map-based monitoring has been designed and implemented by (Verma, et al, 2013). By providing all the information needed to accurately determine the location through the web application, tracking and providing the information is carried out in any weather condition.

The authors (Al-Omary and El-Medany et al, 2014) presented a real-time tracking system that provides accurate location information of tracked people with low manufacturing costs.

The authors (Mohite et al, 2016) used the sentiment analysis tool to track the user's position. The smartphone was employed to place itself in a geo-fence as a small client. In addition to regarding the position of the user, the system also informs the user of the tasks that should be carried out at a given location.

The principles and methods for the construction and implementation of tracking systems using geofencing technologies were proposed by the authors (suganthi et al, 2018). The approach used to detect vehicle deviations beyond the prescribed safety zone was based on GPS. The vehicles were marked by using a digital stamp.

The authors (Zeynep Ozdemir, 2019) designed and implemented geofencing technology based on the GPS in practical time by monitoring the screen of the maps through the computer or mobile phone. The authors improved the accuracy of data which is received from the GPS.

The authors (Lalitha, R et al 2020) designed and implemented a tracking system for the COVID-19 infected peoples, that reside in quarantine areas by using geofencing technology through monitoring stations.

1.2. Problem Statement

Many factors cause the spread of major epidemic diseases, such as COVID19. The containment of an epidemic is the most effective measure to prevent the spread of diseases. Quarantine is usually one of the containment steps used to detain people in their homes for an incubation period of 14 days. A geographically fenced tracking system is proposed to prevent people from violating quarantine. The proposed system consists of a bracelet, GPS, GSM, and Arduino.

1.3. Aim Of The Thesis

The aim of this work is the development of a surveillance system that depends on a geofencing and positioning system. The primary application of this work is for tracking purposes. The proposed tracking system is constructed based on the 3G device kit for GSM mobile communications. It can be used for the following applications:

- Monitoring the prisoners,
- Tracking pregnant women and children,
- Tracking vehicles, ships, and planes within geographical boundaries
- Monitoring infected individuals in quarantine

1.4. Mechanism Of Work Performed

A) Designing a mobile application to display the results obtained from the tracking system by "Ai2.invertor".

B) Determine the location using GPS technology through the mobile application.

C) Designing the bracelet (tracking device) by using Arduino, GPS, GSM, and the simulation software (EasyEDA).

D) Testing and evaluating the proposed device to ensure the optimal application for monitoring.

1.5. Thesis Organization

The organization of this thesis can be summarized as follows:

- **Chapter One** presents related work, the problem statement, the aim of the thesis, Mechanism of work performed, and Thesis Organization
- **Chapter Two** provides System Overview, Arduino Uno, Global Position System (GPS). Global system for mobile communication (GSM), Geo-fencing and App inventor
- **Chapter Three** presents system methodology, system design, the server (adafruit.io), geofencing application, and bracelet block diagram
- **Chapter Four** presents the final design of the bracelet and experimental results.
- **Chapter Five** presents the conclusion and future work.

CHAPTER TWO

SYSTEM OVERVIEW

2.1. The Tracking Instrument

A tracking system is a device using an electronic tag to observe the location throughout the radio or satellite signals. The architecture of the tracking equipment is dependent on various variables, which are the type of tracked object, the budget of the tracker, and the data required by the tracker. Different technologies are used for indoor tracking systems such as ultrasonic, infrared, and inertial technologies. On the other hand, the Global Positioning System (GPS) can be considered the most reliable outdoor tracking system, due to the high precision monitoring (Adwan, E. Z. ,2015).

GPS has been used for a global tracking device, while the local tracking is based on the local system such as Radio-frequency identification (RFID), Bluetooth, and Wi-Fi. Usually, satellites are needed to use for the positioning system globally in order to achieve the correct information. (Adwan, E. Z. ,2015). In addition, the tracking system can be divided into passive and active units. The passive unit sends out a signal only when the user demands the data. However, the active unit continuously sends out a signal.

2.2. Arduino Uno

2.2.1. An Overview

Arduino UNO is a small board open-source microcontroller from the AVR family, based on the ATMEGA328P microcontroller. As shown in figure 1, Arduino UNO has 14 digital input/output pins (of which six can be used as PWM outputs) labeled with a tilde (~), six for analog inputs (A0-A5 pins), a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button (Khatri Chhetri, J. R. ,2020). The USB connector is attached to the device, either power it, upload graphs or transfer data. Although it is accepted voltages between 7-20 V, the recommended input voltage is 7-12 V. The operating voltage is 5 V. The board has a special power socket for the external power supply.

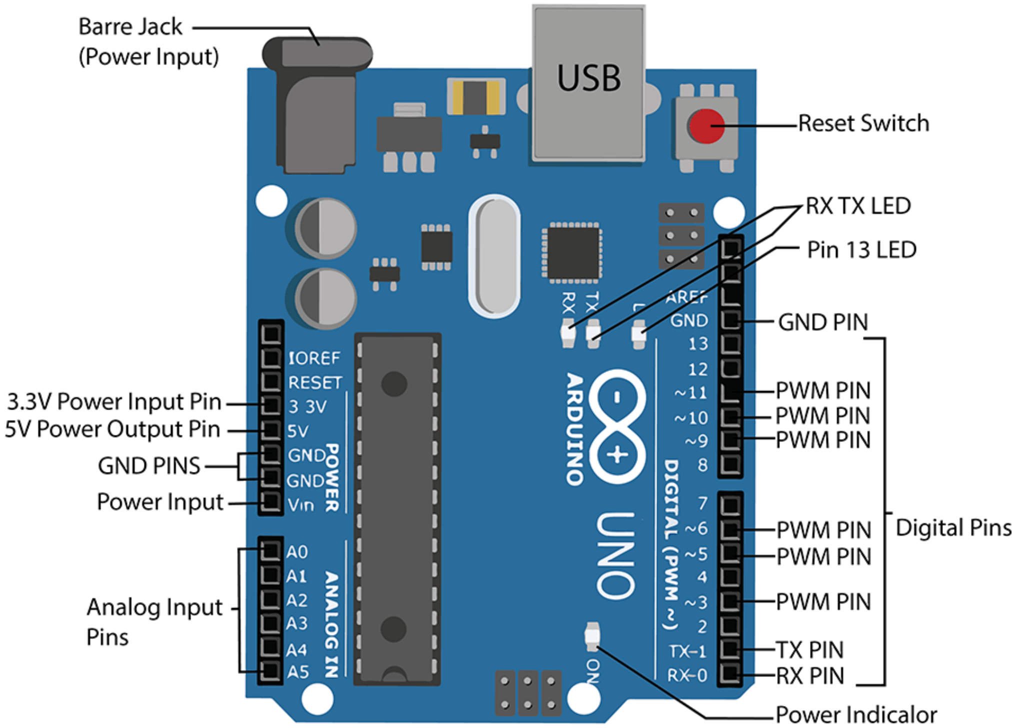


Figure 1. The Arduino UNO Board

As illustrated in figure 1, the TX RX LEDs are referred to light up when the data is transmitted and received between the Arduino board and other devices, which are connected by serial port or USB. Digital pin 13 is connected to the LED indicated with L connector. The tiny microcontroller, next to the LEDs; is controlled the USB interface between Arduino and the device during the transmission of data. The UART serial port of the Arduino UNO is used to connect to a computer via USB or other external serial systems for serial communication. Pin 0 and Pin 1 referred to RX and TX, which are used to collect and send data, respectively. The ATmega328P microcontroller is used serial connectivity with 5V TTL (Khatri Chhetri, J. R. ,2020).

2.2.2. The Shield

A shield is a modular circuit board which is connected through pins to the Arduino PCB to expand its functionality and features (Khatri Chhetri, J. R. ,2020). There are several shields such as GPS receiver shield, Ethernet shield, SIM808 shield, and MicroSD shielded, etc. In architecture, the Arduino shield is a stack. It facilitates connectivity through the sockets on its sides to the external board or another device.

2.2.3. ATMEGA328P

ATMEGA328P is a single-chip microcontroller from the AVR family. It has an 8-bit microprocessor with good performance and minimal power consumption, based on the reduced instruction set computer (RISC) architecture that has 32 KB directly linked to the Arithmetic Logic Unit (ALU). Furthermore, there are 23 general-purpose I/O lines and 32 general-purpose working registers (Dutta, S et al,2020). The ATMEGA328P has three large sizes of memories, which are:

- SRAM 2 Kb (volatile memory)
- Memory flash 32 Kb (nonvolatile memory)
- EEPROM 1 Kb (nonvolatile memory)

The ATMEGA328P microprocessor has various characteristics, including: Two-wire serial controller, 16-bit timer/counter, real-time counter with independent oscillator, six- or eight-channel 10-bit ADC, six PWM channels, two 8-bit programmable serial USARTs, watchdog timer, etc. as shown in figure 2.

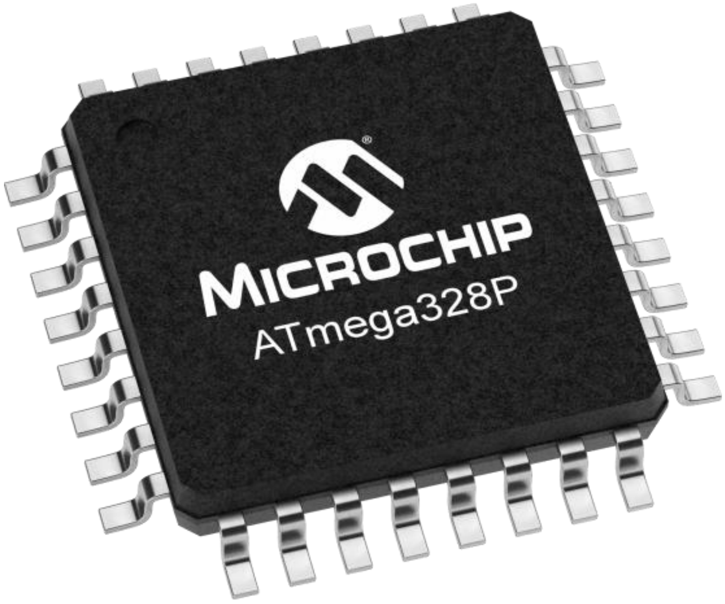


Figure 2. ATMEGA328P Microcontroller.

2.3. Global Position System (GPS)

The GPS is proper for utilizing in the tracking system due to its ability to run 24 hours a day in any environment, anywhere in the world, without subscription fees or set-up fees (Mouly, M et al, 1991). The GPS has three-dimensional positioning that provides the ability to track the user position with high precision.

The GPS satellite sends signals that only go one direction to the earth where the GPS receiver apparatus is placed. The data of the location and the time are sent by each satellite where determining the time data is significant to obtain the location of the Earth's users. The GPS satellites have an atomic clock to give a reliable reference to time data (Adwan, E. Z. ,2015).

At the receiving equipment, the GPS device provides a user with three-dimensional location and movement information. The GPS signal is received by an unlimited number of users through the receivers. The Time of arrival (TOA) is the absolute time instant during an RF signal exhale from the transmitter (i.e., satellite) toward the GPS receiver at the known position.

Onboard the satellites, the GPS time base is matched with the high precision of atomic frequency norms. In the satellites, a system called code division multiple access (CDMA) is used to broadcast ranging codes and navigation data. The GPS satellite transmits data on two frequencies, L1 (1575.42 Mhz) and L2 (1227.60 MHz), which are modulated by two codes. A shortcode is created as a course/acquisition (C/A) code and precision/secure code or (P/Y) code and these codes are used by the satellite to get accurate information. For this reason, four satellites are needed to yield four determining latitude, longitude, and time

GPS is used in many fields, including civil and military. The Precise Positioning Service (PPS) is used to have a predictable precision of at least 22 m, while the Standard Positioning Service (SPS) is used to have a precision of more than 13 m for all consumers worldwide (Kaplan Elliott et al,2006).

The GPS contains three significant segments, as illustrated in figure 3

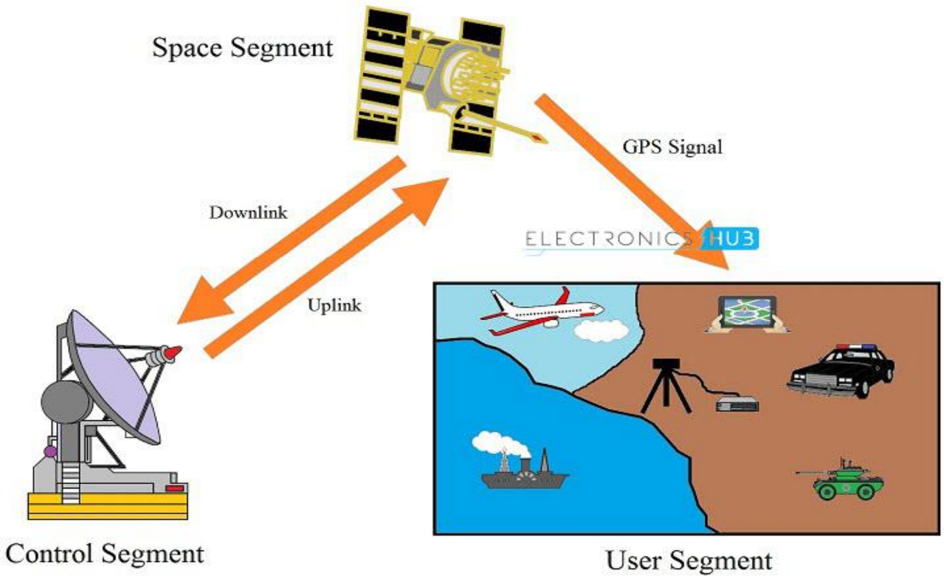


Figure 3. Segment of GPS (Bates, R. J. 2001)

- **The space segment** is the shape of satellites that rotate around the Earth in multiple space orbits, piling up to six or more space orbits.
- **The control segment** is the ground equipment that performs the Control task in the space segment, telemetry, tracking satellites and maintaining the configuration of the satellite orbit.
- **The user segment** is generated from satellite receivers and is used based on the received signals to receive signals and identify sites.

2.3.1. GPS locating

The GPS satellite sends signals in one direction to the receiver of GPS on the earth. The satellite determines the location of the receiver and the time at which the signal was sent, as the timing information is crucial for determining the location of the user. Therefore, the GPS contains an atomic clock to provide a time reference accurately (Bajaj, R. et al 2002).

Calculating the travel time of a signal from the satellite to the receiver, as illustrated in figure 4 (A), may be used to compute the distance between the satellite and the GPS receiver.

$$T_t = \mathrm{T}_{SR} - T_{ST} \quad (1)$$

$$\mathrm{r} = T_t \times \mathrm{S} \quad (2)$$

where:

T_t : Travel time.

T_{SR} : Signal reception time.

T_{ST} : Signal transmission time.

r : Distance.

S : Speed of light.

orbital velocity and orbital period of the satellite can be given in figure 4 (B) by:

$$\frac{Gm\,M_E}{r^2} = ma_c = \frac{mv_{orbit}^2}{r} \tag{3}$$

$$v_{orbit} = \sqrt[2]{\frac{G\,M_E}{r}} \tag{4}$$

$$v_{orbit} = 2\pi r/T \tag{5}$$

$$T = 2\pi\sqrt{\frac{r^3}{G\,M_E}} \tag{6}$$

Where:

r= distance from the center of Earth

m= mass of satellite

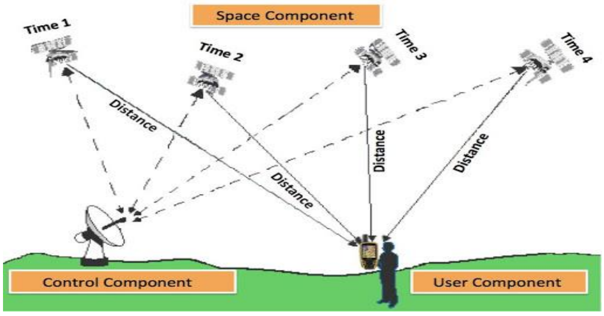
v_{orbit} = orbital velocity

M_E= mass of earth

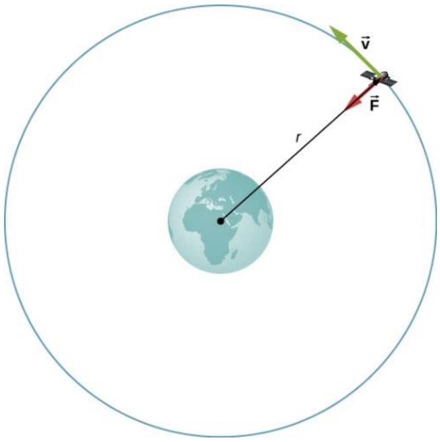
T= circular orbit period

G= gravitational constant

a_c= acceleration



(A)



(B)

Figure 4. Distance Between the Satellite and (A) The Person (B) the center of Earth (Adwan, E. Z. ,2015). ((Urone, P. P., & Hinrichs, R. (2012))

The GPS receiver's real position is determined by the transit time of the GPS signal from three satellites and their precise space coordinates, trilateration (triangulation). However, four satellites are required rather than three, to locate one's location in three-dimensional space. The intersection point demonstrates the GPS receiver position as shown in figure 5.

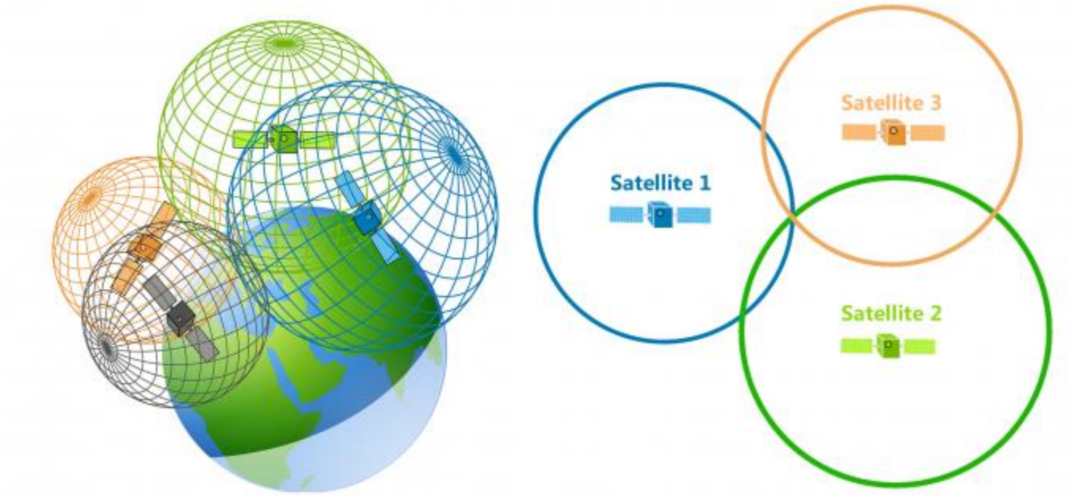


Figure.5 The Point at The Intersection Displays the Position of The GPS Receiver (Lee, B., et al ,2014)

A standard used is created by NMEA (National Marine Electronics Association) in order to describe the interface between various of electronic devices involving contact with the Receiver for GPS.

Each sort of gadget has its own standard clause, with two-letter prefixes on each of these phrases. The GPS receiver's prefix is GP. Three more characters are needed, which are used to classify the content of the words added to the prefix. The default sentence starts with a $ sign, Trace by $ with a 'talker ID' (two characters), a 'message ID' (three characters), separate data fields (each character), comma-separated information, optional checksum (starts with a * sign) and ends. (El-Rabbany, A. ,2002). Table 1 illustrates the sequence of GPxxx sentences.

Table 1. List of GPxxx sentences (Han, G. et al,2013)

CODE	The meaning
$GPBOD	Bearing, origin to destination
$GPBWC	Bearing and distance to waypoint great circle
$GPGGA	Global positioning system fix data
$GPZDA	Data & time
$GPGLL	Geographic position, latitude/longitude
$GPGSA	GPS DOP and active satellites
$GPGSV	GPS satellites in view
$GPHDT	Heading, True
$GPROO	List of waypoints in the currently active route
$GPRMA	Recommended minimum specific Loran-C data
$GPRMB	Recommended minimum navigation info
$GPRMC	Recommended minimum specific GPS/transit data
$GPRTE	Routs
$GPTRF	Transit fix data
$GPSTN	Multiple data ID
$GPVBW	Dual Ground / Water speed
$GPVTG	Track made good and ground speed
$GPWPL	Waypoint location
$GPXTE	Cross-track error, measured

2.4. Global System For Mobile Communication (GSM)

GSM is a contact mechanism that originated in Finland and evolved through digital technologies (Xu, G., & Xu, Y.2007). GSM is a 2G technology that is utilized for low volume digital voice and data transmission. An example of a low-size digital data service is a SMS message and MMS. There are four frequencies for GSM which are 850, 900, 1800, and 1900 MHz

2.4.1. GSM Modem

A GSM modem is a type of wireless modem with a SIM card. GSM modem uses the radio wave in order to transmit and receive the messages. SMS technology is commonly used because it is an economical, quick, and functional method of transmission and reception of data with good reliability (Adwan, E. Z., 2015). the operating voltage for the SIM800c (GSM) is 5.0V as shown in figure 6 (Zeyad, M et.al.,2018). GSM modem is utilized for sending SMS messages from a computer or mobile phone, as well as it is used with GPS for tracking.

There are three distinct GSM modem types, which are:

- A GSM modem with a SIM card is an external modem unit that connects to the PC by USB, serial port, Bluetooth, or infrared.
- A PC card or PCMCIA card that has been mounted on a laptop computer could be a GSM modem.
- A standard GSM cell telephone can also be a GSM modem.

Figure 6. GSM Module

2.4.2. AT Commands

AT command, commonly known as Hayes Smart modem commands, control all popular modems. (by Hayes Microcomputer Devices.), via a set of instructions for different operations. The AT commands perform various modem service actions such as phone dialing, SMS sending, module powering, GSM quality inquiry, fax, SIM information, module, and so on as shown in Table 2, the command line is beginning with an AT prefix that informs the modem at the beginning of the 15th command or code. The system uses these commands in order to connect with the computer (Khatri Chhetri, J. R. ,2020).

Table 2: AT commands of modem

AT COMMANDS	MEANING
AT	Match baud rate/Check interface
ATI	Recognition of shield
AT+CCID	SIM confirmation
AT+CREG	Check network registration
AT+CSQ	Provide signal quality
AT+CMGF	Text message format
AT+CNMI	To specify how to handle the newly arrived message
AT+CMGS	Send message
AT+CMGR	Read message
AT+CGNSTST	Send GNNS data to AT UART
AT+CGNSPWR	Power control of GNSS
AT+CGNSSEQ	Define the last NMEA sentences that parsed
AT+CGNSINF	Read NMEA sentences

The GSM network provides easy access to cell phones and satellite platforms. GSM network consists of three main systems as following:

- Switching system (SS): Doing call handling and subscriber-related activities are the core roles of this device. Authentication Center (AUC), Mobile Services Switching Center (MSC), Guest Location Register (VLR), Home

Location Register (HLR), and Equipment Identification Register (EIR) are the functional units under the switching framework (EIR).

- Base station system (BSS): Radio-dependent tasks, consisting of the base the base transceiver station, and station controller (BSCs) are the responsibilities of the base station system (BTSs). The base station controller uses to handle the al location of services. The mobile station's radio interfaces are managed by the base transceiver station, which is radio equipment.
- Operation and support system (OSS): It connects the switching system's and base station's equipment. OSS is utilized to provide a network overview and customer support which are necessary in a GSM network.

2.5. General Packet Radio Service (GPRS)

General Packet Radio Networks (GPRS) is an acronym that is available on virtually any mobile network which is included as an extension to the key features of GSM. Interworking and user-sharing of resources are supported by the GSM and GPRS systems. The GPRS for smartphones can be applied to map the location of the subscriber when connects to the network of mobile phones. The normal GSM network is not capable of transmitting data in packet-switched mode, therefore, GPRS support needs to be modified. Many features are obtained from this technology such as allowing people to connect all the time to the internet and communicate on a global scale (Fares, A. ,2005), (Heine, G., & Horrer, M. 1999).

2.6. Geo-Fencing

The Geo-fencing technique (Reclus, F et al ,2009) consists of a combination of two operations: constant monitoring of a mobile device's position and identification of a geographic of interest area. In this context, this field of concern is also referred to as geo-fence (geographic fence). If the mobile device position is outside the geo-fencing, the geo-fencing strategy triggers an alert. A valid timetable or calendar may also be linked to a geo-fencing zone to specify its temporal validity. Geo-fencing collects information of the actual position of the user with consideration if this user is close to places that may be in concern. In order to mark an actual location, it should assign its latitude and longitude. A geo-fence determines latitude, longitude, and radius, creating a circular area or fence around the whole monitoring site. This includes control and alignment of the mobile device location continuously with a collection of practical boundaries, i.e., geo-fences (Garzon, S et al ,2015). Geo-fencing is commonly used by the GPS satellite networks and/or local radio frequency identifiers (RFIDs) such as Bluetooth or Wi-Fi nodes to define geofences around a spot on a map (Garzon, S et al ,2015).

2.6.1. Geo-Fence Area Identification

The geofence area can be determined by:

- Polygon region: The geo-fence can be defined as a polygon where the coordinates are determined at the vertices of the polygon, as illustrated in Figure 7.

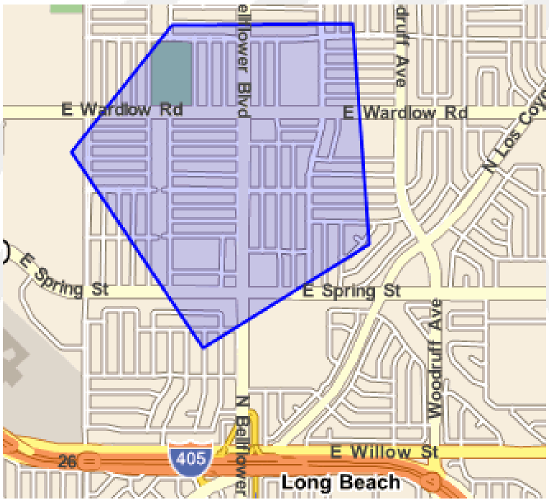


Figure 7. Polygon regions

- Point of interest (POI) – As shown in figure 8, the geo-fencing is clearly defined by the center point and radius coordinates, defining a circular field.

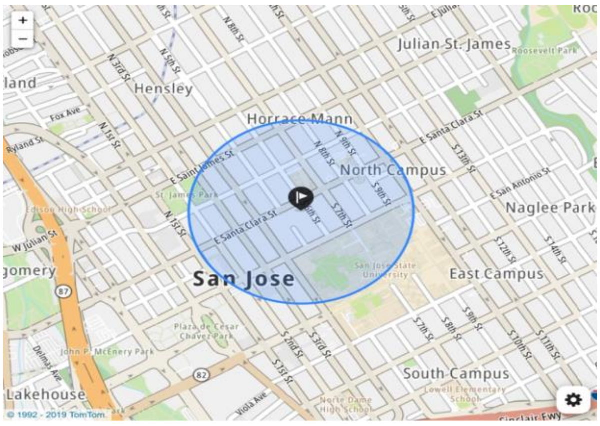


Figure 8. Point of Interest

- Route: Determining whether the user is inside the geofence or not is through the mobile application.as shown in figure 9.

Figure 9. Route Geo-Fencing

2.6.2. Types of Geo-Fencing

Static geo-notification: This relies on the spatial location of a mobile device with continuous field observation. When a special mobile reaches the geo-fence, a message is sent to the special mobile user. For instance, a message is sent to the user when a student entering a school campus (Rodriguez Garzon et al ,2014)

Dynamic geo-notification: this relies on the geographical location of a smartphone device followed by a moving source of information. For instance, the car parking sends a notification of free space. This notification is transmitted to local smartphone users who are driving.

Peer-to-Peer geo-notification: This is focused on the territorial position of a mobile observer relative to other applications. For instance, a shared mobile service which provides the location of nearby friends on some application like Twitter.

2.6.3. Geo-Fencing Work Flow

Place Accuracy: The location of the device must be accurate as compared to a geo-fence for the action in order to appear correctly (i.e., a message has been obtained from the right user) (Ververidis et al 2008).

Computer Speed- A device speed specifies the period during which updates the location by the system, in order to track and control the relevant incidents.

Device Direction: The device's route is followed around a geofenced area that affects the period for the updated location. For instance, if the unit follows the image of a circular geofence rather than moving through the good core, the time is much shorter (Rahate, S et al ,2016).

2.7. App Inventor

App Inventor is an online website that can be accessed by anyone using a visual drag-and-drop interface to build smartphone apps. This website offers a high-level abstraction that enables developers to create apps for their projects. The application can be built by the developers without previous awareness of conventional text-based programming languages and facets of architecture. The abstraction poses a smaller obstacle to the creation of smartphone apps that enable everyone to take advantage of the technology provided by mobile devices (Van Brummelen & et.al ,2019).

App Inventor's user interface is based on the concept of low-floor, higher production environments. (Papert, 1980). Furthermore, it comprises two basic components, which are the designer for application component collection, and the blocks Editor for application behavior setting. The App Inventor building blocks are typical user interface elements (buttons, icons, list pickers, images, etc.) coupled with mobile device functionality (texting, GPS, NFC, Bluetooth, etc.). Therefore, the rudimentary language is designed to assist the app developer in quickly controlling the functionality of these touch devices to allow lightweight, sensing devices. figure 10 shows the sample AI2 blocks the program.

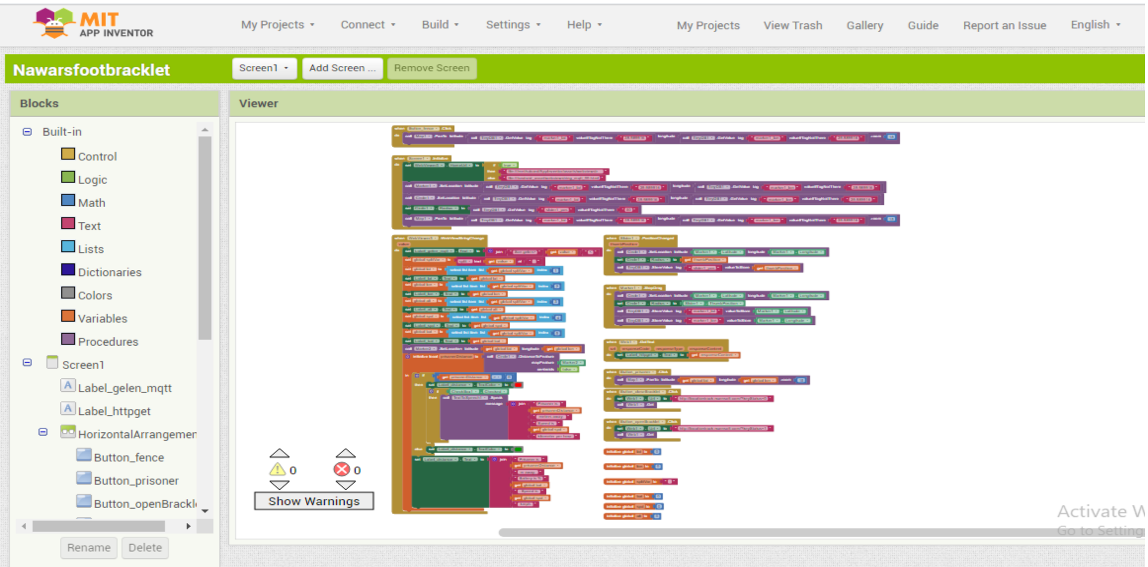


Figure 10. Sample AI2 Blocks Program

2.7.1. The Architecture of App Inventor

There are several common elements of the App Inventor that are introduced in different languages. The Companion software running on the phone is written in Kawa, a Java-implemented variant of Scheme that can access Java functionality, including the Android SDK. The Companion is connected to the Blocks Editor by Wi-Fi or a USB cable and runs the software that the user is programming and communicates data back to the block's editor. The blocks editor is running in the browser and implemented in Java and JavaScript. App Inventor is deployed with the Google Software Engine, which is a framework that allows developers to upload and run their application maintenance products. Furthermore, the App Engine utilizes Google usernames to authenticate the deployed app, and it provides each user with the means to store data. This means that the App Engine for App Inventor projects is processed on the cloud by users. The App Inventor code is written in Java to deal with project loading and storage. (Van Brummelen & et al ,2019).

For storage purposes, a few text files are used to represent each project. In the block's editor, the XML representation indicates where the blocks are placed. The JSON representation of the components is selected by the consumer in the designer file, while the properties of those components are given in another file. App Inventor is deployed for individuals to use, however, it is also open-source, so anybody can get a copy of the source code, make changes, and run their version.

The source code for App Inventor is held on GitHub, a project hosting and distribution platform with revision control. It permits the users to upload their projects and offers a chance to the peoples around the world to develop the projects together (AlHumoud, et al, 2014).

2.7.2. App Inventor Modification

IoT Manager is an option that is used to orchestrate all the requisite activities between the smartphone application and the app inventor. This option describes all the actions which are performed when an IoT system is attached to a smartphone app, a new code upgraded, and variables updated (Turbak, et al,2014).

2.8. Different Technologies Used In Tracking Systems

2.8.1. Active and Passive Tracking

There are several kinds of tracking systems for individuals. In general, they are classified as "passive and active". Passive devices store GPS coordination such as longitude, latitude, speed, and time. A triggering event such as turning the switch on or off and opening or closing the system is stored by Passive devices. Passive systems have an automated method of download that transmits information through wireless download. On the other hand, active devices also gather the information, but they typically transmit the information to a server or database center for evaluation in real-time over cellular or satellite networks. To access the tracking information, the data contained within the passive tracker is needed to be uploaded to a computer. It is also possible to rely on the passive tracking system when gathering all the data from a passive tracker (Ahmed, S., et al ,2015).

GPS trackers allow individuals to display tracking information in real-time. If an activity tracker like a GPS is placed in the hands of an individual, it will then reveal the location, stop time, and speed of the person. GPS trackers are really useful for tracking individuals who frequently need to be watched. As GPS trackers are better than passive sensors, it is possible to track individuals with better speed and high performance. Any trackers with GPS are real-time trackers. For instance, if a real-time tracker is used for someone, then all this someone movement can be observed.

The Global Positioning System (GPS) is an active real-time tracker, while other systems are passive real-time-dependent tracking devices. A real-time monitoring device has a lot of positive qualities. By remaining at the screen and watching, the movement of the person can simply be seen. Many current tracking systems for individuals incorporate the benefits of active and passive tracking. The Arduino microcontroller board saves data in an external SD memory card, and information in private memory, In the state of unavailability of the network connection, the stored data is transferred to the server once the network available again (Ahmed, S., et al ,2015).

2.8.2. Types of Tracking System

Assisted GPS (AGPS) - Terrestrial (RF) networks are used in AGPS systems to boost the efficiency of GPS receivers as they can directly supply satellite information to the GPS receivers. To collect detailed information for mapping locations, AGPS is used for both mobile phones and cell phone networks. AGPS is included to get rid of any GPS limitations. The GPS has been used to identify the location of satellites and to receive data without assistance.

The GPS receiver that the person carried is linked to four GPS satellites to detect individuals. Three of these satellites provide the longitude, latitude, and altitude. However, the fourth satellite offers the time data. Thus, there is no failure in locating the target (Ahmed, S., et al ,2015).

CHAPTER THREE
SYSTEM METHODOLOGY

3.1. Introduction

A geo-fenced GPS is proposed to realize an efficient border protection system. GPS is introduced as an application for a quarantine scheme which is appeared recently. The proposed system uses a wristband that matches the confines of smartphones. This chapter comprises many subsections that cover the proposed system design, utilized algorithm, Adafruit server, system working principle, and bracelet circuit design.

3.2. System Design

The proposed tracking system consists of a GPS L86 module, SIM800c GSM module, and AT mega 328P SMD microcontroller chip which is utilized as the processing unit for the tracking system. The location of the person (i.e., patient) is determined by the GPS receiver. Afterward, the obtained location data is sent to the server (adfruit.io) via GSM. Figure 11 shows the circuit diagram of the proposed tracking system.

A modified geofencing design is proposed and implemented to track the infected people with COVID-19. The infected people are tracked through a special application which is programmed by the MIT inventor platform. This application is compatible with smartphones running by the Android operating system. The people that carry the proposed tracking system can be tracked by using this application. Hence, a geofence technology is applied to allow the infected person to move within only the geofence. Besides, the programmed application controls the dimensions of the geofence, in other words, can enlarge or reduce it.

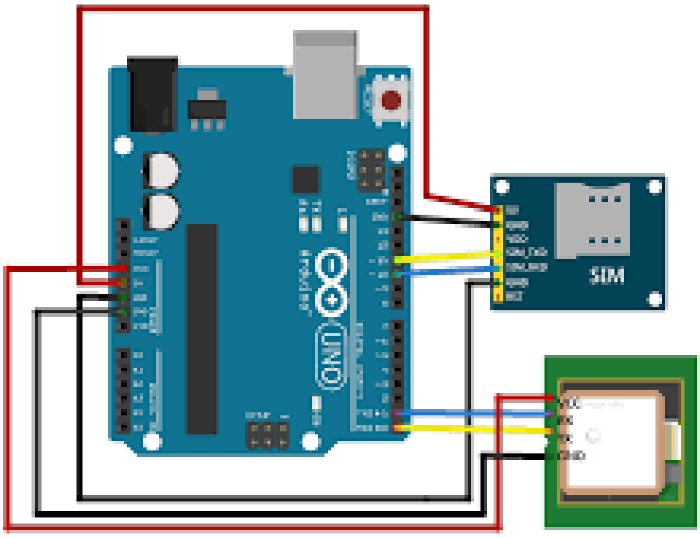


Figure 11. Interfacing GSM and GPS Module Using Arduino

3.3. Working Principle of The Proposed System

To acquire the longitude and latitude of the specific location, a practical test is initially applied, by using the GPS module which is linked to the ATmega328P SMD microcontroller chip. Two libraries of "SoftwareSerial.h" and "TinyGPS.h" are embedded with the Arduino IDE in programming the code. The flowchart of the GPS working principle is illustrated in figure 12. Longitude and latitude data are collected by the GPS receiver, after that, the serial monitor of the Arduino IDE displays the obtained location data.

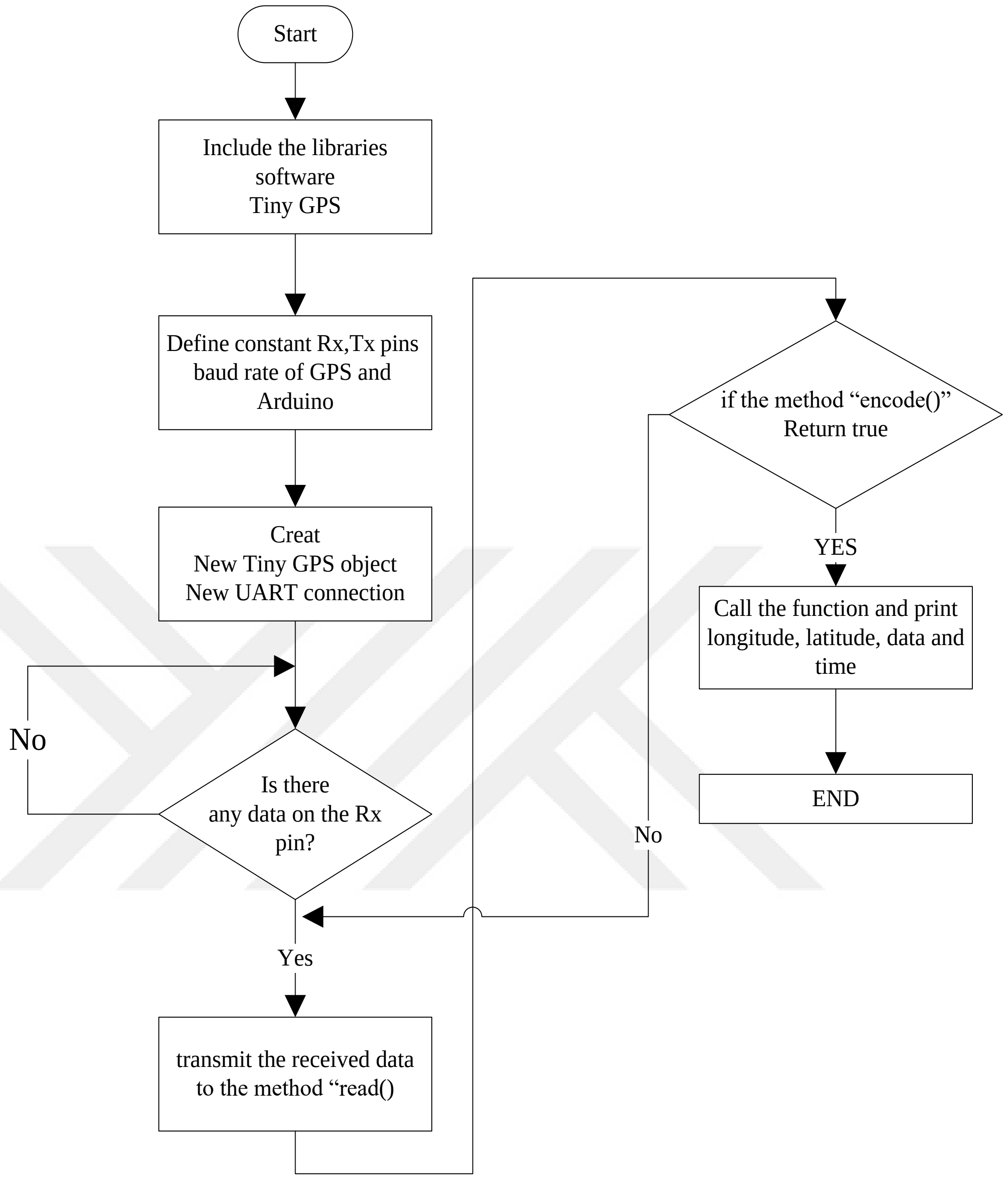


Figure 12. Flowchart of the GPS Model

In the GSM network, a kapadokya GSM (SIM800) and an ATmega328P microcontroller chip are used to transmit the data to the Adafruit server. This is done by the person holding the proposed tracking system (i.e., bracelet). In the programming of data transfer instructions, the AT command mode is used. The flowchart for GSM operation is illustrated in figure 13.

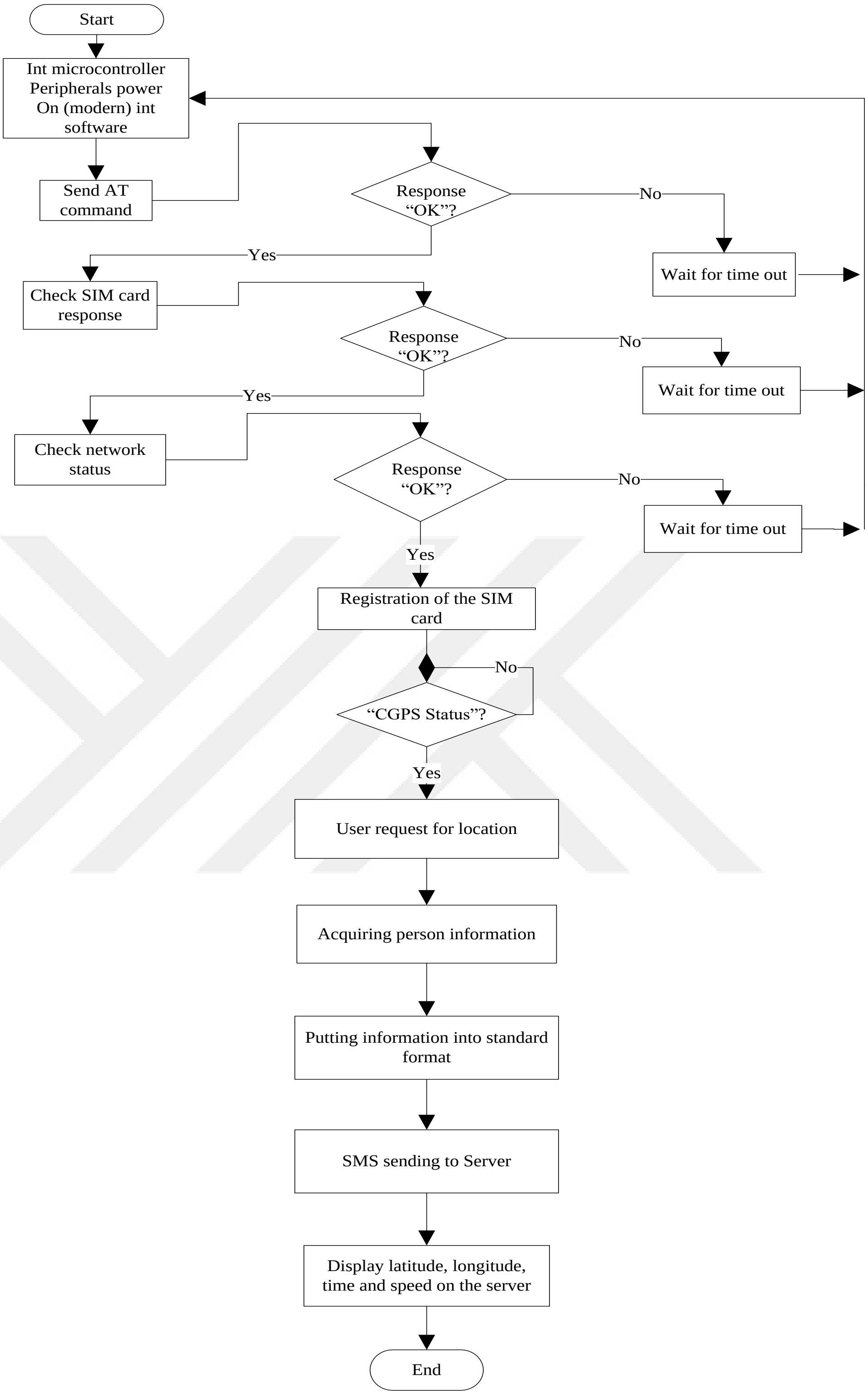


Figure 13. Flowchart of GSM Model

The AT commands can be used to test the connection between the GSM module operation and the cell phone base station. For geolocation data (latitude, longitude, time, and speed), the receiver receives the information of the GPS signal, and then sends this information to the server. Figure 14 illustrates the flowchart of transmitting and receiving data.

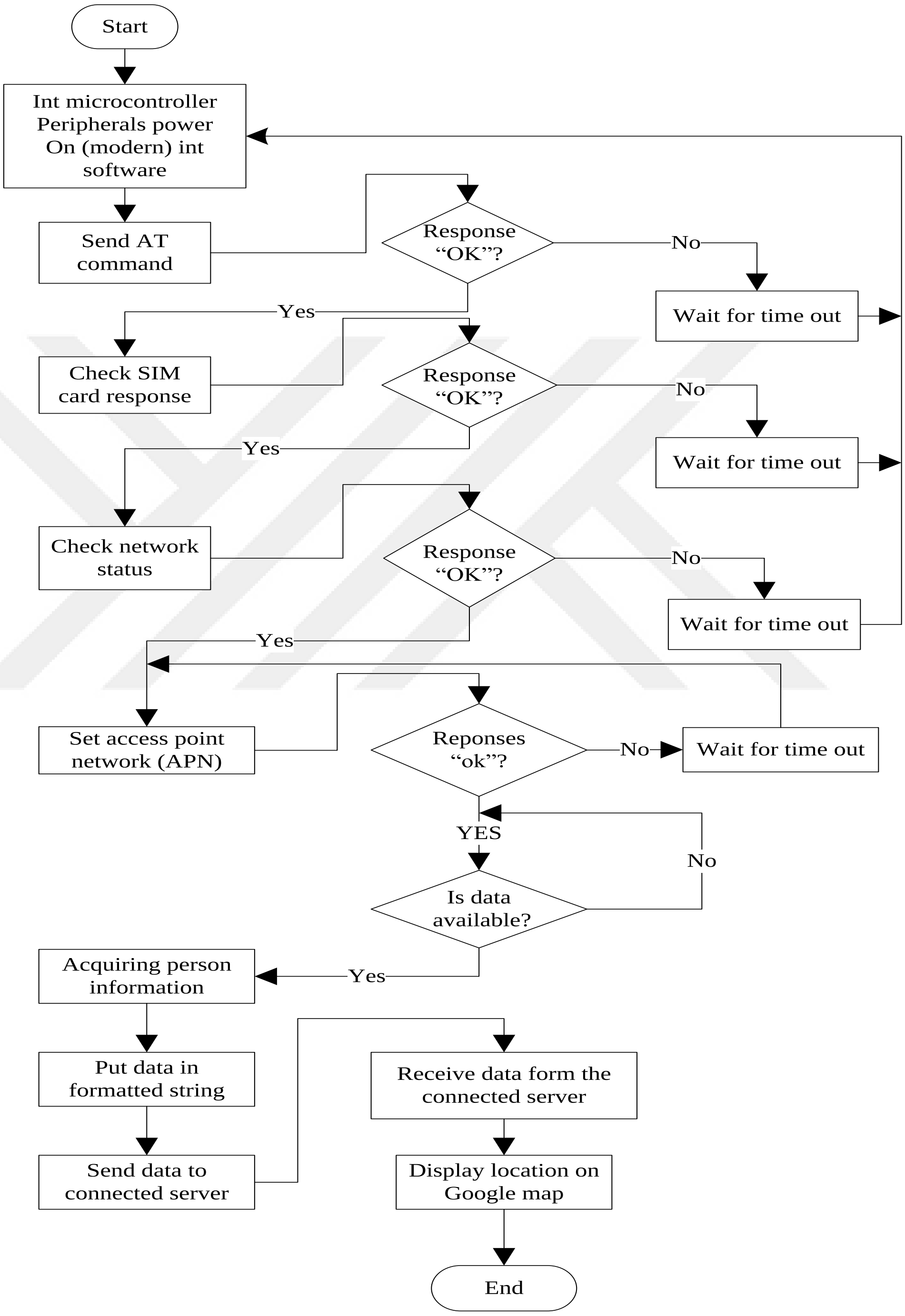


Figure 14. Flowchart of Sending and Receiving Data.

3.4. The Server (Adafruit.Io)

3.4.1. Adafruit Library in Arduino IDE

In Arduino IDE, the hostname is set at asio.adafruit.com, while the 1883 server port number is used. The code comprises the Adafruit account username, regenerable special AIO key, feed setup and feed name, SSID, and internet connection point password. The feed name is the subject name that can be subscribed or published for internet connectivity via the server. The code is compiled and submitted to the control to install properly. Figure 15 shows the relationship that binds Arduino and the server between each other. It also shows the definition of the server's name, the server port, and the key assigned to the server.

```
    #define AIO_SERVER     "io.adafruit.com"
    #define AIO_SERVERPORT  1883
    #define AIO_USERNAME    "nawar"
    #define AIO_KEY         "67b6416f24dd438bb69c99c8159195be"
Adafruit_MQTT_FONA mqtt(&fona, AIO_SERVER, AIO_SERVERPORT, AIO
_USERNAME, AIO_KEY);
  define halt(s){ Serial.println(F( s )); while(1); }boolean FONAconnect
(const __FlashStringHelper *apn, const __FlashStringHelper
          *username, const __FlashStringHelper *password);
Adafruit_MQTT_Publish LOCATION
          = Adafruit_MQTT_Publish(&mqtt, AIO_USERNAME "/feeds
          /locTrack");
 Adafruit_MQTT_Subscribe led
          = Adafruit_MQTT_Subscribe(&mqtt, AIO_USERNAME "/feeds
          /locGeo")
```

Figure 15. Adafruit Server Code Inside the Arduino IDE

3.5. Geo-Fencing Application

Geo-fencing incorporates the actual position of the user with an understanding of the closeness of the user to sites. The mark is placed on a distinguished area. Latitude and longitude are specified to determine the proximity to the location. Thus, the geo-fencing is in a circular shape, hence a radius is added to determine the longitude and latitude. It is a technique used to maintain safety and monitor people within certain limits.

There are many ideas and applications for creating a geo-fencing system. However, in this project, a unique and easy way to create geofencing is developed through the Android application (MIT invertor).

The proposed system is designed and implemented to meet the needs of locating, as well as the ability in controlling the geofencing technology within an Android application. Also, upon the exit or entry of the person carrying the device (tracking system), it gives an alert as shown in figure 16.

Figure 16. Geo-Fencing System.

3.6. System Working Principle

In a personal tracking device, a GPS receiver collects positioning data such as the longitude and latitude of a person and sends it to a web server via an HTTP request.The smartphone application is used to download a PHP website featuring Google Maps to display the individual location in real-time, by using geofencing technology. The SIM800c module is feeding by an external 12V DC source, the AT command in the Arduino program activates the GSM module. Initially, the AT + CREG network is registered, and then the Access Point Name (APN), username, and password are set.

Finally, the GPS power supply is powered with the CGPSPWR command. The latest GPS location information can be accessed with the AT + CGPSINF command. Figures 17,18 show the schematic diagram and the flowchart of the proposed system module, respectively.

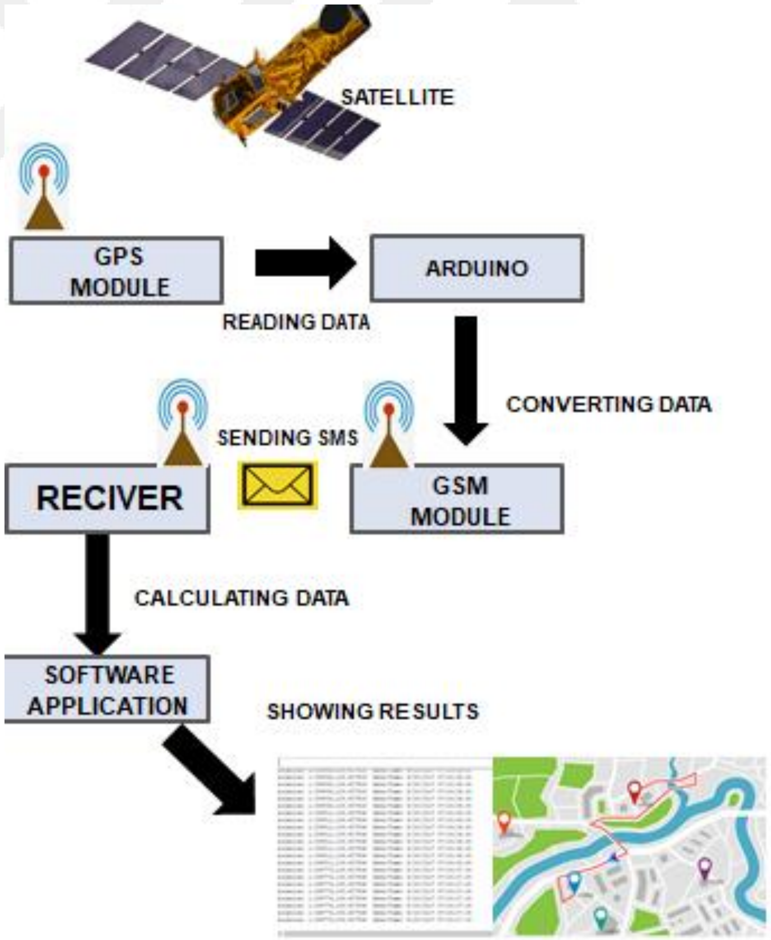


Figure 17. The Schematic Diagram of the Proposed System Module

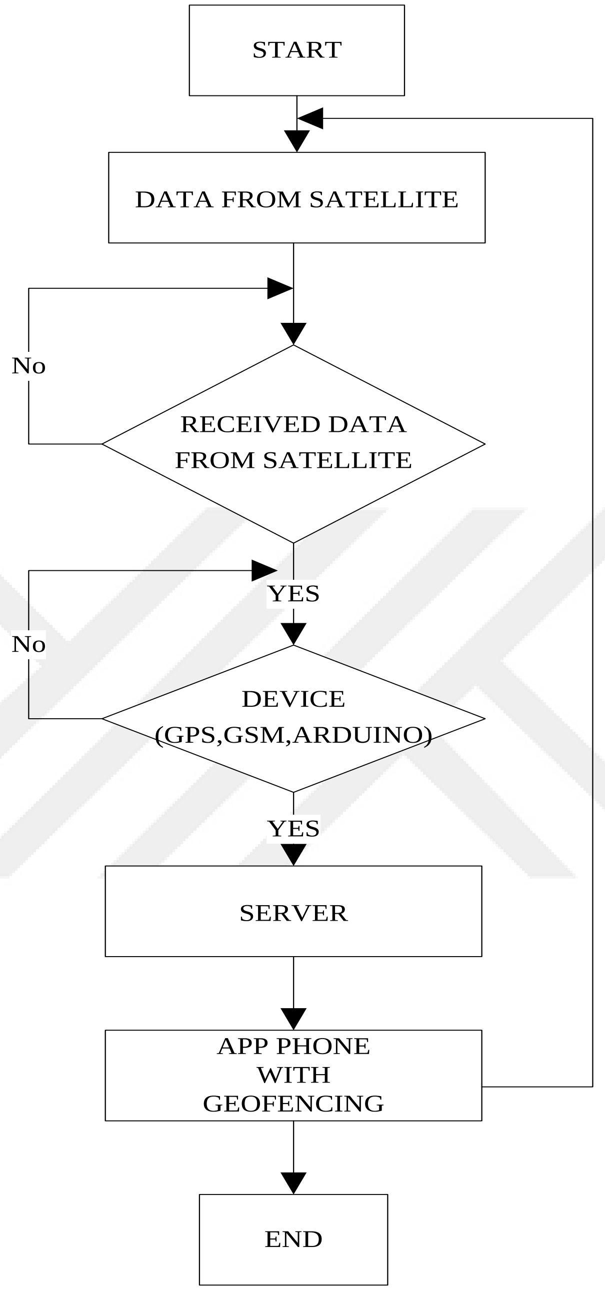


Figure 18. Operation Flowchart of The Proposed System Module.

The mechanism of the tracking system can be clarified by receiving the position data (longitude and latitude) from the satellites by the GPS receiver and then transferred to the ATmega328P microcontroller for processing purpose, after that this data is transmitted to the Adafruit server by the GSM module to be displayed in the mobile application.

3.7. Bracelet Circuit Design

The bracelet tracking circuit contains GPS&GSM (SIM800C), ATMEGA328P microcontrollers, Common Mode Filter (ZJYS51R5), Switcher (LM2596), voltage regulator (SPX3819), a set of Headers, GPS and GSM antenna (IPEX3), a set of LEDs, and an IC Charge (MCP73831) as shown in figure 19.

ATMEGA328P contains a set of output / input pins where Vin stands for the input voltage of the board. The 5v pin supplies 5 volts to the output board, where the microcontroller board is supplied of (7 - 12) volts and a current of 50 mA.

The SIM800c is designed with power-saving technology so that the consumption value is as low as 1 mA.

The GPS antenna gives 28 dB at a power consumption of 10mA. the operating frequency range is 1575.42 ± 1.023 MHz, the voltage range is from 2.0 volts to 5.5 volts, and the corresponding current range is from 5.9 to 17 mA.

The SPX3819 is a positive voltage regulator with a low dropout voltage and low noise output. In addition, this device offers a very low ground current of 800µA at 100mA output. The SPX3819 has an initial tolerance of less than \1% max and a logic-compatible ON/OFF switch input. When disabled, power consumption drops to nearly zero. Other key features include reverse battery protection, current limit, and thermal shutdown. The SPX3819 includes a reference bypass pin for optimal low noise output performance. With its very low output temperature coefficient, this device also makes a superior low power voltage reference.

For the charging process, a MCP73831 IC charging is used with highly advanced controllers, where a constant current / constant voltage charging algorithm is used. The charging current is determined based on the temperature of the bracelet during high energy consumption. The 12V unregulated voltage is provided to pin 1 and the regulated voltage is obtained on pin 2, which is then passed through an LC filter of value 100uH and 470uF respectively to filter output switching noise. The output voltage can be set by using the resistors R30 and R29 forming the potential divider circuit and connected to feedback pin.

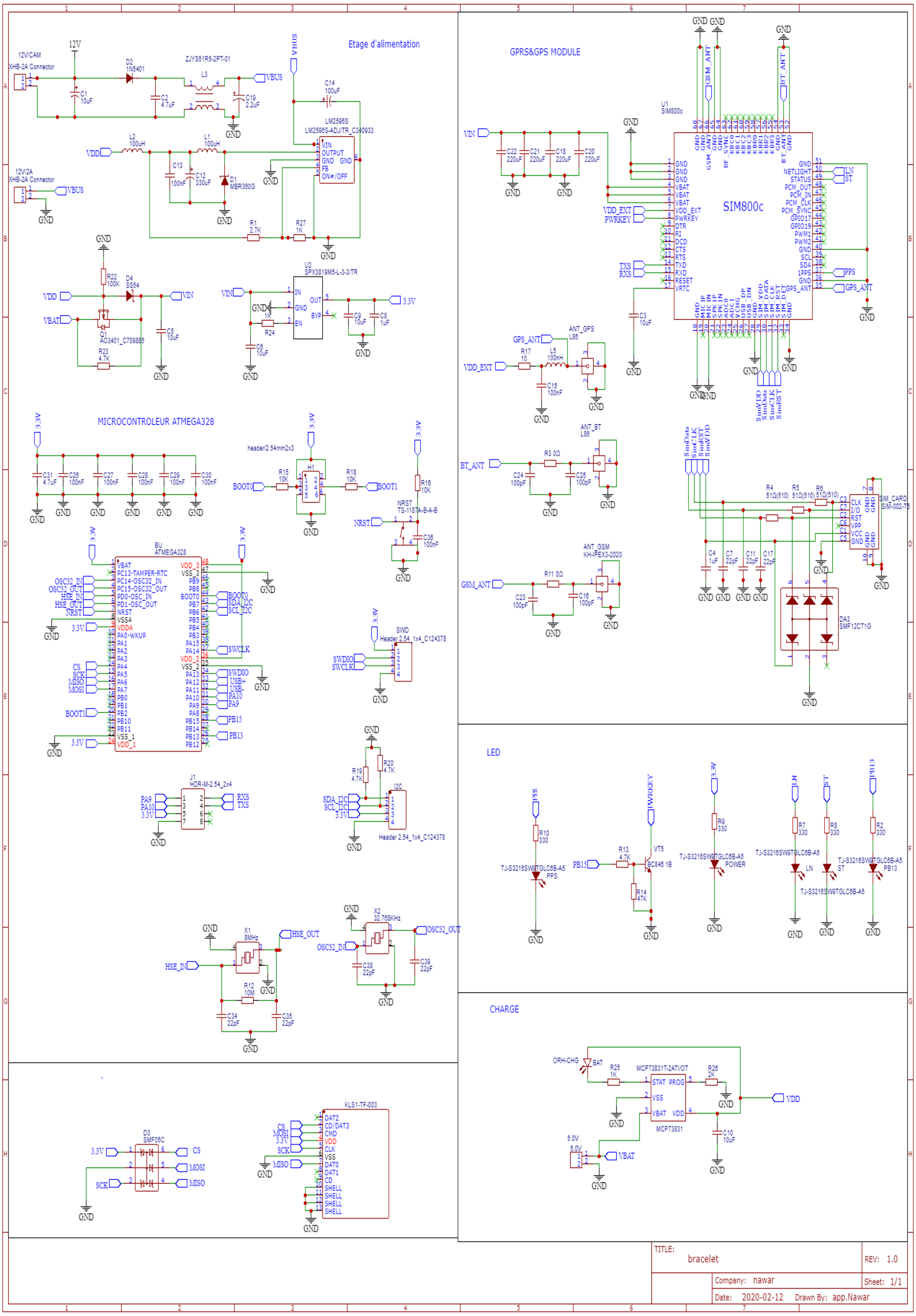


Figure 19. Bracelet Circuit Design

3.8. Bracelet Block Diagram

A GPS module is used to obtain a real-time location in any area over the world. This is done by providing lat. and long. The GEO-Satellite is responsible to provide the location information to the GPS module, which in turn gets 3-4 satellite signals to compare among them. A voltage of 3 - 5 V is required to supply the GPS module. A UART protocol with 9600 baud rates is utilized to achieve the connection with the microcontroller, Figure 20 illustrates the block diagram of the proposed bracelet design.

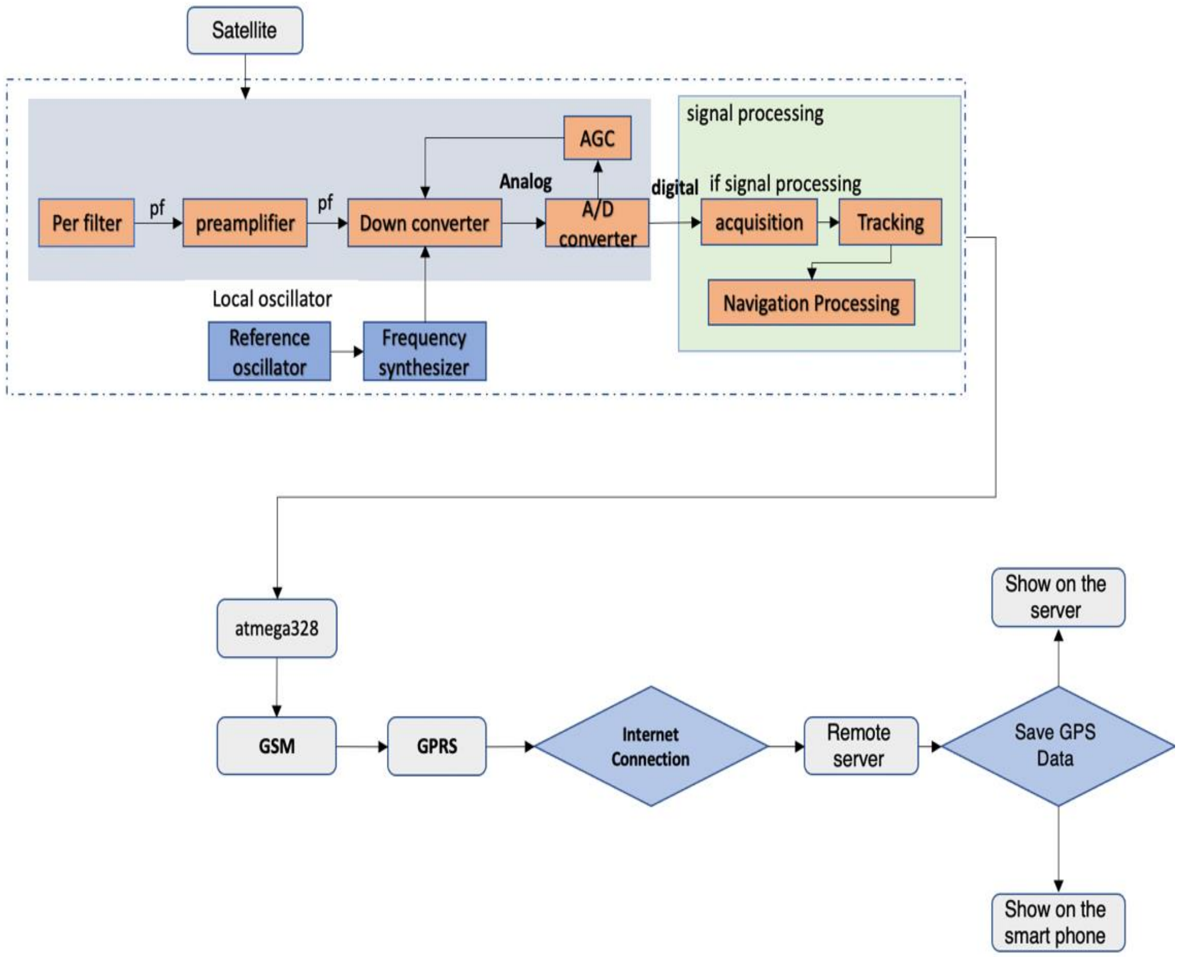


Figure 20. Block Diagrams of the Proposed Bracelet.

The RF signal is received by the antenna and LNA. After that, the front-end pre-filters have used to amplify and convert the received signal into a clean sampled signal (Dan, D. 2012). These signals then are received by the signal-processing block. The filtering process is important due to its ability to decline the other band signals, decrease the noise, and reduce the aliasing effect. The wide bandwidth controls the accuracy of the signal. However, the higher sampling rates require more power in the receiver (Thor, J., Normark et al, 2002). Hence, a filter is used to reduce the sampling rates by providing narrower band signals. The front-end pre-filters perform down-conversion to reduce the frequency of RF signal into an intermediate or direct frequency for the baseband (Kaplan Elliott, 2006).

A mixer is used in the down-conversion to multiply the received signal by a locally generated replica. Also, it filters the output signal to take off the double frequencies. Finally, the GPS signal is received by Arduino, which processes and transmits it to the server by the GSM. To get the location information, the smartphone application is used to access the server. Figures (21,22) show the main parts of the bracelet (GPS, GSM).

Figure 21. The Printed Circuit Board of the Designed Bracelet (Top Side).

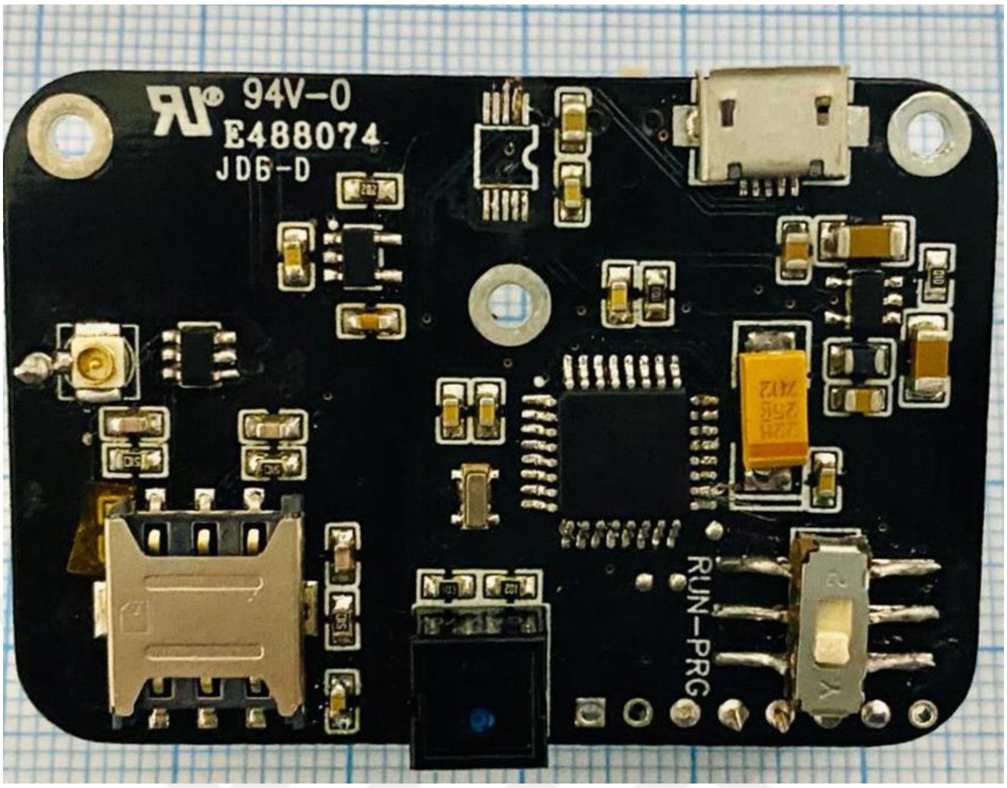


Figure 22. The Printed Circuit Board of The Designed Bracelet (Bottom Side).

CHAPTER FOUR
TRACKING SYSTEM RESULTS

4.1. Real-Time Tracking System

The proposed tracking system is based on GPS, GSM, Arduino, and the webserver. The microcontroller is connected to the SIM800 module of the GSM shield, to act as an SMS transceiver as shown in figure 23.

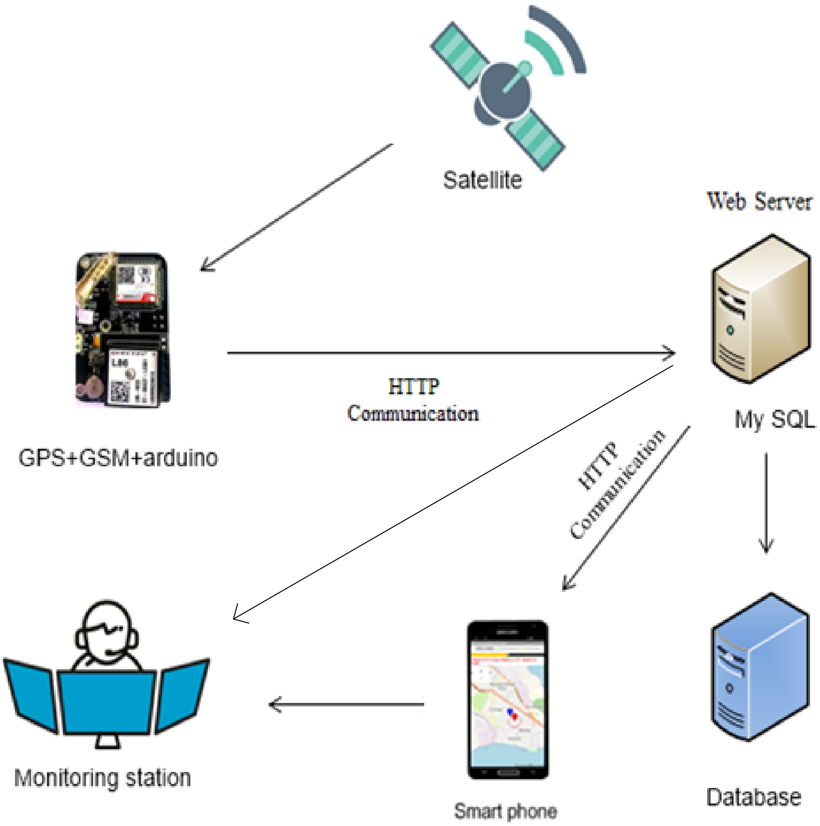


Figure 23. The Block Diagram of The Proposed Tracking System.

In general, the tracking device sends an SMS condition request constantly to the unit, at any time the central server wants to find the patient. The GPS inside the bracelet sends the received data continuously to the server via GSM. This data includes the coordinates (latitude and longitude, time, speed). After that, the GSM shield in the monitoring system receives the information and sends it via the microcontroller to the server (adafruit .io). In a smartphone application, the server derives the coordinates from the data, which is received by SMS. The position is shown on the map in a way that is comfortable for the observer. The web server program is developed with adafruit.io, as shown in figure 24. The location of the moving person (patient) is shown on the cell phone map, and then it is archived in the database for potential future use. The microcontroller works by configuring the received data from GPS and then send it to the server via GSM.

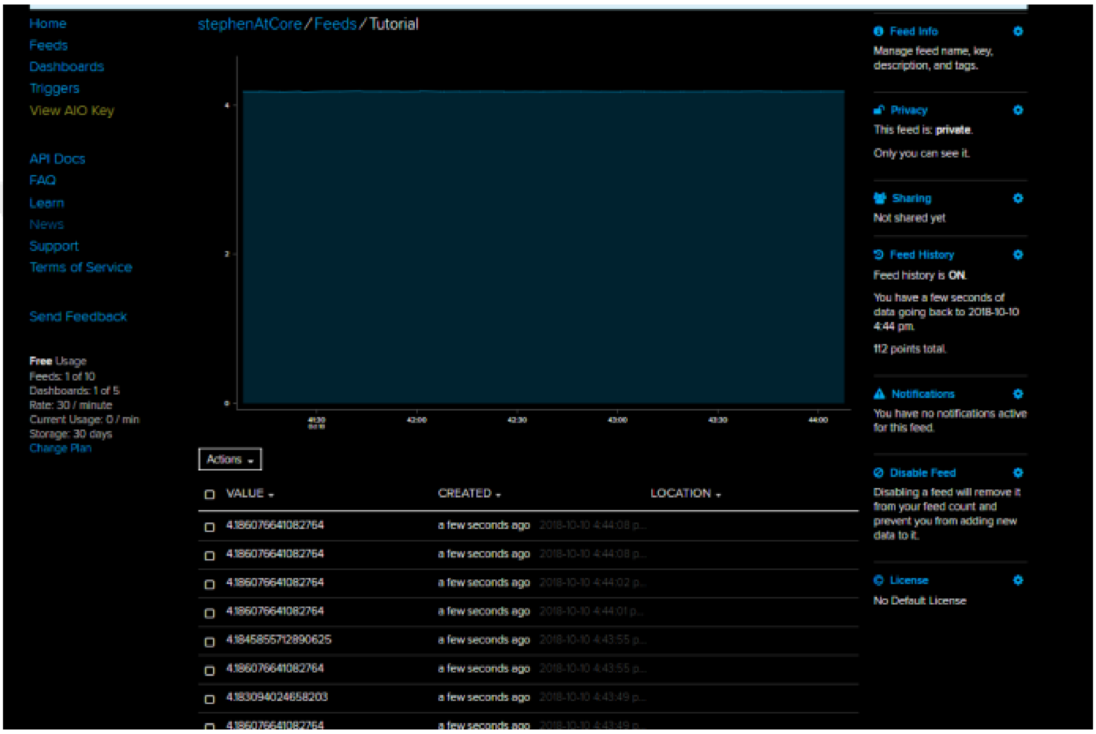


Figure 24. The Web Server Program.

4.2. Web Server and Database

The web server is linked to the database which contains information about the person's location. The experimental data of individual location information is listed in TABLE 3, which can be obtained from the database based on a test run. The experimental results display that the minimum time for updating the information of location is 2 - 4 seconds. This time is configurable according to the individual movement.

Table 3. The person location information in real time

TIME	DATA	LATITUDE	LONGTUDE	ALTITU
16:27:22	30-12-2020	40.986855	28.708899	98
16:27:24	30-12-2020	40.986865	28.708908	98
16:27:26	30-12-2020	40.986878	28.708914	98
16:27:28	30-12-2020	40.986886	28.708921	98
16:27:30	30-12-2020	40.986894	28.708928	98
16:27:32	30-12-2020	40.986907	28.708933	98
16:27:34	30-12-2020	40.986915	28.708941	98

4.3. Geo-Fencing by Using A Smartphone

Two types of commands are executed by using the established Smartphone program, which is namely fence and patient. The fence command indicates the geofence, while the patient command indicates the location of the bracelet holder. The distance and time between the patient and the geofence are displayed within the selected path. The tracking system automatically updates the patient's location every 3-5 seconds. All the results are displayed by the smartphone app. In this section, experiments are performed on several patients by using the proposed tracking system, as illustrated in cases 1, 2, and 3. The tracking system is represented by a bracelet, which the patient can wear on his hand or foot.

The first case: the blue pin represents the patient that carries the bracelet, while the red pin represents the geofence that the patient must stay within it. A green message indicates that the patient is in the safe zone. Figure 25 shows the patient's presence inside the geofence.

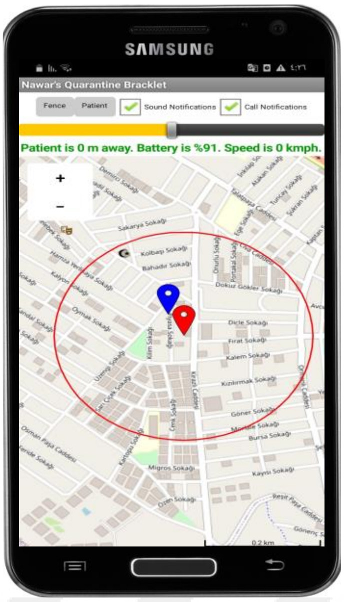


Figure 25. Patient Location Within the Boundaries of Geofencing.

The second case: when the patient crosses the boundaries of the geographical fence an alert is sent on the mobile phone, where the distance between the location of the patient and the geographical fence is calculated, a red message indicates that the patient is outside the safe area is appeared as shown in figure 26. The alert operates continuously until the distance between the patient and the geographical fence is equal to be zero, which means that the patient is within the safe zone.

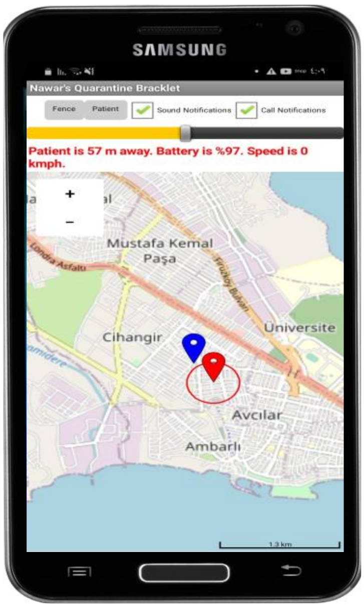


Figure 26. Patient Location Outside the Boundaries of Geofencing.

The diameter of the geographical fence can be controlled according to the required area for tracking. In the proposed tracking system, the bracelet is programmed with the maximum distance of one kilometer and with the smallest distance of 200 meters. Figure 27 shows the patient location within large boundaries of the geographical fence.

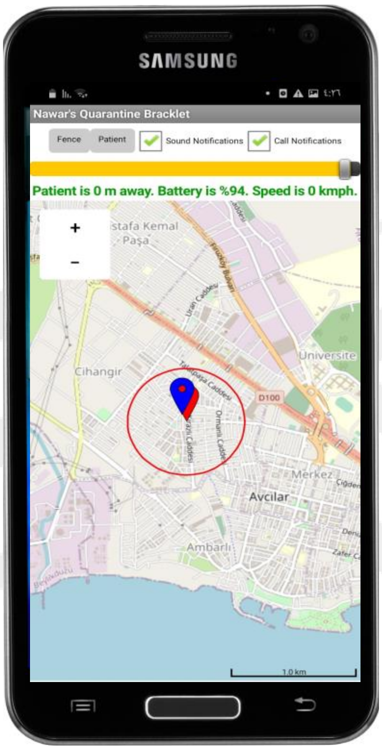


Figure 27. The Patient Location with The Geographical Fence

The bracelet installation includes two parts are; the main electronic circuit and two batteries on the sides. Also, the final design of the bracelet shows the possibility of wearing it in the hand or foot as shown in Figure 28. The bracelet has a solid design, therefore, can be used under different climatic conditions, and connects with the mobile using the cloud as shown in Figure 29. In the state of taking off the bracelet from a wear position, it sends a warning to the controlling mobile and makes a phone call to the adopted number in the application.

Figure. 28 The Final Version of The Designed Bracelet.

Figure 29. Implemented System (Bracelet and Mobile Application).

CHAPTER FIVE
CONCLUSION

5.1. Conclusion

A real-time tracking system is demonstrated and developed using the application of geofencing technology. The tracking system is suggested as a home quarantine application that has recently emerged. The proposed tracking system consists of a GPS L86 module, SIM800c GSM module, and AT mega 328P SMD microcontroller. A modified geofencing design is proposed and implemented to track the infected people with COVID-19. The infected people are tracked through a special application. This application is compatible with smartphones running by the Android operating system.

AT commands are used to test connectivity between the GSM module operation and the cell phone base station. For geolocation data (latitude, longitude, time, and speed), the receiver receives the information of the GPS signal, and then sends this information to the server. The geofencing technology provides accurate real-time information that allows the person in charge of monitoring, to quickly track the person who leaves the specified area. An alert is sent to the mobile phone when the patient crosses the boundaries of the geographical fence. It can be concluded that the proposed system can be used for tracking the stolen cars, monitoring children, tracking animals, or tracking prisoners. This work strengthens the interpretation of the Global Positioning System (GPS) and improves expertise in programming. Using the proposed tracking / monitoring system, efficient and reliable performance is obtained from experiments with several patients.

5.2. Future work

1- Artificial intelligence technology can be applied to design a smart and compact circuit based on geofencing technology.
2- Global Positioning System can be improved by using the fourth generation or fifth-generation communication technology
3- Privacy and protection of patient information remain some of the most important factors that must be provided, especially with the use of IoT technology. A cyber security-based encryption algorithm can be created to prevent possible cyber-attacks and protect patient information.

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RESUME

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