Robotic Walk Along Cart

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Abstract*: Many people all around are having problems by carrying heavy weights on their shoulders and travelling around with trolleys. In busy airports, shopping malls and many other places people often face difficulty with this issue. Housekeeping robots that localize on walking person and follow the path of the user can stand as an advantage to the posed problem. The robotic cart proposed here focuses on reducing the load the user carries. It develops a platform for sending and receiving a signal that would provide a simple and practical means for the robot to determine a path by following the user and avoiding obstacles using ultrasonic sensors and also the ability to self-localize. This reduces the tiring experience faced by people and makes them tension free. The key of the design is to use the Wi-Fi technology to transmit the location of the user to the cart and LoRa technology to give the location of the cart. Meanwhile, together with both the technologies, the proposed design achieves the high feasibility and flexibility of the controllable distance as it follows the user. As a result, the proposed system shows efficiency up to 88%. A follower robot application can be extended to a wide range of fields as in the case of porters at railway stations, loading and unloading goods at factories (civil and industrial fields) and as a helping hand for elderly people thus allowing them to avoid the goods they have to carry along.

***Keywords*: Arduino UNO, LoRa transceiver, Node MCU Wireless communication**

I. INTRODUCTION

Traditionally, most of the robots are being used for heavy industrial errands such as assembling industrial parts, material handling with the least human involvement. Sensor technology has given the robots a more intelligent phase thereby supporting the humans effectively and well efficiently. Human following robots are being developed about by many researchers each day because of their useful applications in service sector activities like load carrying, monitoring the movements of elderly people, etc. This brings up an opportunity in creating user-friendly robots that can coexist with humans and support them [1].

Smartphones are getting really well popular and have contributed a 55% share in the telecommunication gadget market all round the world as of 2013 and is estimated to rise further more into the worldwide market. Nowadays smartphones come with a wide range of sensors like magnetometers, accelerometers, gyroscopes, Inertial Measurement Units (IMU), pressure and temperature sensors, GPS etc. and modules like Bluetooth and Wi-Fi. Better processing capabilities are nowadays available on smartphone and keep getting faster and efficient with each year that passes. The work depicted here provides a platform capable of sending and receiving signals to a smartphone thereby providing a simple and practical way for the robot to logically determine a path and constantly follow the user that barely requires the use of any internal maps and is capable of self-localizing. The robotic cart also uses a sensor to center itself behind the user. User can control the cart via the smartphone customized application allowing the user to hold the cart stand still when loading and also unloading. The capability of avoiding obstacles and its target following nature by the use of a location device based on a signal emitter (on the mobile) and a directional sensor. With a few more modifications, the robot is capable of acting as a human companion as well. They mainly aim at assisting the elderly people, children and others in carrying their loads along hospitals, libraries, airports, etc. It can also help people out at shopping centers, outdoors being a main factor or public areas.

A. Research problem

The work aims to develop a robot capable of maneuvering through outdoors, from school gangs to old age people, behind its owner while hauling his or her luggage. In order to follow a human, a mobile robot needs to know the position of the person and must be able to determine its own path in order to follow his target.

B. Sub-problem

Every research problem may be divided into sub-problems to make it easier to solve the research problem. The sub-problems identified are stated below:

- We had to go through the issues a trolley or shopping bags come up with on all ages of people.

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The issues included manual handling of trolleys always and carrying around of bags. Kids could not reach out to trolleys and elder ones found it difficult to carry bags. Not only in the malls, but many other fields can benefit from this like no longer labors have to carry heavy weights in industrial sites and so on.

- We have to come up with a solution that could eliminate most of the problems and make life easier. For that the main thing to be considered is to make an automatic cart thus not requiring the person to carry it around.

Also it should follow or walk along with the user.

- To make this practical, we have to make the cart follow a device on the user here we go with the smartphone which all of us always do carry along. The coordinates of the smartphone should go with that of the cart. Also we have to keep track of the location of the cart in case it is abandoned after use. The cart should also avoid obstacles to an extent.

Assumptions are done saying:

The weight the cart can hold is 15 kg but with the battery weight this reduces. Many other assumptions can also be considered.

II. MATERIALS REQUIRED

A brief description on the essentials required for the functioning of the cart is discussed.

A. Sensor Platform – Ultrasonic sensor

The ultrasonic sensors are low voltage and current devices. They work by emitting sound waves at a frequency too high for humans to hear. They then wait for the sound to be reflected back, calculating distance based on the time required. The sensors do not require a transmitter and receiver for transmission and reception of the signal. The sensors are connected to the ADC. The ultrasonic sensor transmits the ultrasonic waves from its sensor head and again receives the ultrasonic waves reflected from an object. ADC converts the data into digital form and gives it to Arduino board, powered using battery. Arduino compares the data from the 2 sensors and decides the movement of certain system. The sensors are used to detect the presence of obstacles and to measure the distance to targets in many robotized processing plants and process plants. Ultrasonic obstacle sensor consists of a set of ultrasonic receiver and transmitter which operate at the same frequency [5].

Fig.1 Ultrasonic sensor Hc-Sr04

If the object is very close to the sensor, the sound waves returns quickly, but if the object is far away from the sensor, the sound waves takes longer to return. But if objects are too far away from the sensor, the signal takes so long to come back that the receiver cannot detect it.

B. Motor driver Module-L298N

The L298N is a high voltage, high current dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A. It is designed to accept standard TTL logic level drive inductive loads such as relays, solenoids, DC and stepping motors.

Two enable inputs are provided to enable or disable the device independently of the input signals. Emitters of the lower transistors of each bridge are connected together. Additional supply input is provided to make the logic be able to work at lower voltages.

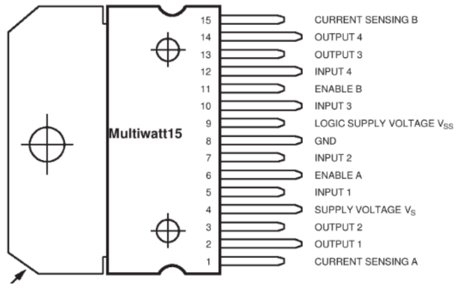

Fig.2 L298N Pin Description

The direction that the motors turn is controlled using the IN1, IN2, IN3 and IN4 input pins on the motor driver board. Connect these pins to digital outputs on your robots microcontroller. To make Motor A go forward, set IN1=HIGH and IN2=LOW. To make Motor A go backward set IN1=LOW and IN2=HIGH. The same method is used to control Motor B: set IN3=HIGH and IN4=LOW to move forward and set IN3=LOW and IN4=HIGH to go backwards. Note that "forward" and "backwards" refer to the direction of the motors themselves.

ENA	IN1	IN2	Description
0	N/A	N/A	Motor A is off
1	0	0	Motor A is stopped (brakes)
1	0	1	Motor A is on and turning backwards
1	1	0	Motor A is on and turning forwards
1	1	1	Motor A is stopped (brakes)

Fig.3 Motor driver truth table

C. Node MCU Module - ESP826

Node MCU is based on the Esperessif ESP8266-12E Wi-Fi System-On-Chip, loaded with an open-source, Lua-based firmware. It’s perfect for IoT applications and other situations where wireless connectivity is required. This chip has a great deal in common with the Arduino – they’re both microcontroller-equipped prototyping boards which can be programmed using the Arduino IDE.

The ESP8266 Integrates 802.11b/g/n HT40 Wi-Fi transceiver, so it can not only connect to a Wi Fi network and interact with the Internet, but it can also set up a network of its own, allowing other devices to connect directly to it. This makes the ESP8266 NodeMCU more versatile. Hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The ESP8266 works with 3.3 volts rather than the 5 used on most Arduino units. To save space, there's no independent socket for a power supply; rather, the unit is powered via a micro USB cable and provides 3.3 volts to other components via 3 pins evenly spaced around the edge of the unit. There are also 4 pins going ground.

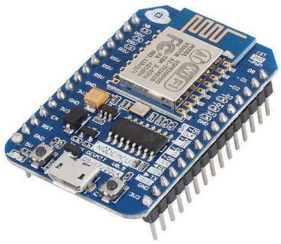

Fig.4 Node MCU ESP8266

D. GPS Module – NEO6MV2

The NEO-6MV2 is a module called GPS (Global Positioning System) and is used for navigation. The module simply checks its location on earth, and provides output data that is its position's longitude and latitude. It comes from a family of stand-alone GPS receivers with the high-performance u-blox 6 positioning unit. The revolutionary architecture provides excellent navigation efficiency even in the most challenging environments.

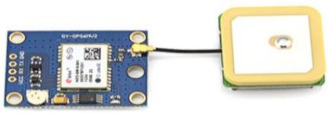

Fig.5 GPS module

E. Compass Module – HMC5883L

HMC5883L is a 3-axis digital compass used to measure the magnetization of a magnetic material like a ferromagnet, or to measure the strength and, in some cases, the direction of the magnetic field at a point in space. Communication with the HMC5883L is simple and all done through an I^2C interface. There is an on board regulator. By twisting or turning the device will provide the corresponding outputs. The voltage shift is the raw digital output value, which can then be used to sense magnetic fields coming from different directions.

Fig.6 HMC5883L

Fig.7 gives an idea about the following information:

i. When device rotate around its X-axis, X-axis remain the same while the other two axis changed.
ii. When device rotate around its Y-axis, Y-axis remain the same while the other two axis changed.
iii. When device rotate around its Z-axis, Z-axis remain the same while the other two axis changed.

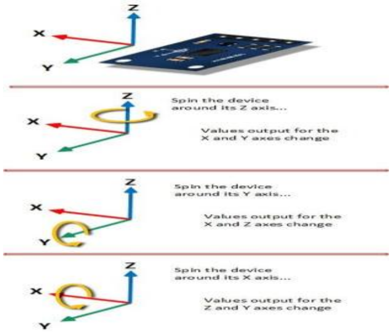

Fig.7 HMC5883L Corresponding output

F. LoRa Module – RA02

RA02 LoRa Module are Long Range low power Wireless Module 433Mhz IoT. This form of wireless communication results in a larger bandwidth, increasing interference resistance, minimizing current consumption, and increasing security. It is used for ultra-long distance spread spectrum communication. It provides high reliability connection mode. It helps in automatic meter reading.

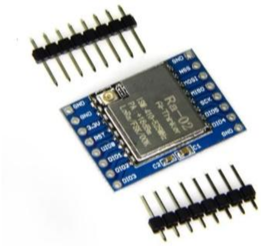

Fig.8 LoRa RA02 Module

G. Arduino Uno – ATmega328

Arduino Uno is a microcontroller board based on the ATmega328. It is an open source electronic platform based on easy to use hardware and software. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz crystal oscillator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button.

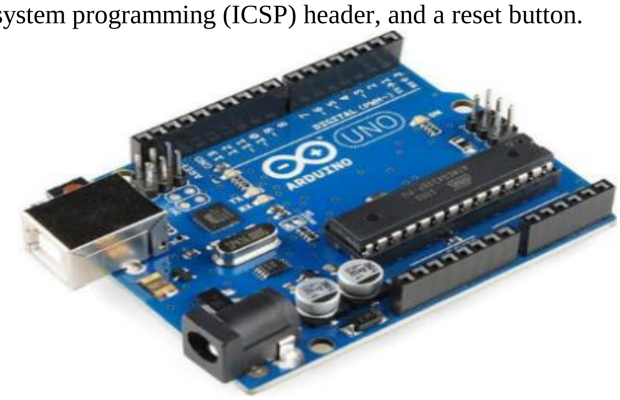

Fig.9 Arduino UNO Microcontroller

Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message and turn it into an output - activating a motor, turning on an LED, publishing something online. It also allows structuring the programs in segments of code to perform individual tasks. The typical case for creating a function is when one needs to perform the same action multiple times in a program. Functions help the programmer stay organized.

III. PROPOSED SYSTEM

The walk along cart work develops a platform that could send and receive a signal to a smartphone providing simple and practical means for the robot to determine a path and follow the user without requiring the use of internal maps. The cart uses a sensor to mainly avoid obstacles and also walk beside the person. The user controls the cart via Blynk application through which the data is send to the server.

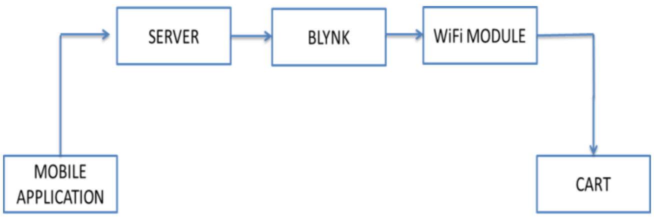

Fig.10 Simplified block diagram

Fig.10 shows the simplified block diagram giving an idea about the path of data transmission [1]. From the server to Blynk, an open source netty based server which is responsible for forwarding messages between blynk mobile application and the microcontroller boards i.e. arduino is used here. The connectivity required to transmit and receive the information is hence gained from LoRa module which is a networking protocol used to have a long distance transmission which connect things to internet as well as a bidirectional communication is accessed.

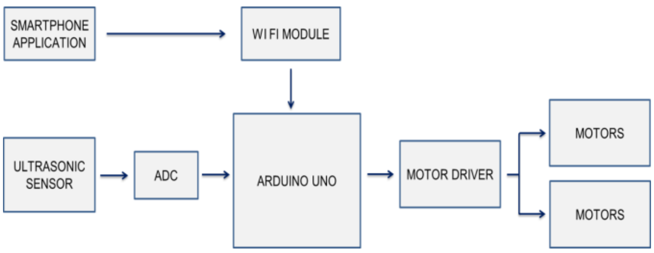

Fig.11 Detailed block diagram of communication between user's smartphone and motor drivers

The working of the robotic cart is that there are ultrasonic sensors which are used to detect the obstacles and once the obstacles are detected, the arduino does the decision making to either take a left or right. We get the coordinates from the smartphone via connectivity from node MCU thereby giving the position of the user to the arduino. If the smartphone needs to communicate to the cart it is via Wi-Fi that provides the connectivity to the arduino. The sensors are connected to the ADC where in, it converts analog to digital signal. This signal is then given to the arduino board where in it is able to read inputs, and light on sensors, activates the motors and turns on/off led. The motor drivers drive the motors and these motors allow the wheels to rotate from the commands provided from the arduino.

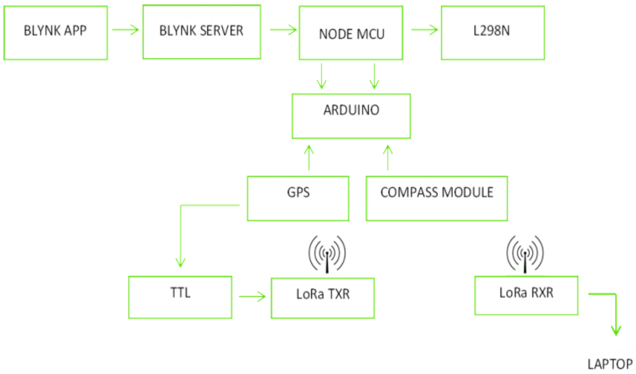

Fig.12 System block diagram

The Fig.12 shows the actual system block diagram. Communication from the server to the node MCU is using Wi Fi and from node MCU to the microcontroller is using serial peripheral interface. The main component constitutes LoRa as the module, providing the connectivity with which the cart is allowed to send its location and make it receive to particularly broad ranges. It creates the ability to monitor around the devices that are difficult to access from Wi-Fi. The information received by the server from the Blynk application is extracted by the node MCU. Here, the server is to store, retrieve and send files. It has more processing power, memory and storage. In the case of Blynk, it can store the data received and visualize it. It is responsible for all the communications between the application and hardware.

IV. METHODOLOGY

The project centers around a robotic cart focused on two effective wireless communication technologies. As discussed above, first the coordinates on the smartphone should almost match with the location of the cart. Also the location of the cart should be known to us. So, in order to deal with these problems Wi-Fi and LoRa are used.

i. Preparing of the Blynk App is to be considered first:

By modifying the Blynk App to our use we can get the present coordinates of the phone which includes the variables such as speed, altitude, latitude and longitude. Blynk system is responsible for most of the smartphone-hardware interactions. One could use the cloud in Blynk or operate the private server in Blynk remotely. The open source could accommodate hundreds of devices quickly. This information of the location of the phone is then available on the Blynk server. A server is a site-page archive that answers when someone queries a certain website. This query is simply a method of accessing the browser's website address then hitting back.

ii. Node MCU is used to establish a Wi-Fi connection:

The cart has its own GPS and compass module to give the location and direction of the cart. The coordinates from the phone should go with that of the cart, only then does the cart start to follow. Node MCU is a low-cost open source IOT platform with storage of 4 Mbytes.

iii. Locating the cart is the next barrier:

For this, we use LoRa transmitters and receivers. Since LoRa provides for long-range reliability it can cover a diameter of 2 km. LoRa has been the first low-cost industrial usage application [4]. Also LoRa does not require network dependency, so even if the cart is lost it can be located even without Wi-Fi or any other network source. For example when considering outside an airport Wi-Fi is not applicable to such long ranges. Later on a call back system can also be given to bring the cart to the given position.

iv. Next, ultrasonic sensor to prevent obstacles is chosen:

They detect the obstacles in the way by evaluating the distance between the robot and the obstacle. If the robot detects any obstacle, it changes its position either to the left or to the right and then keeps going forward. This design thus enables the robot to navigate in an uncertain place by avoiding obstacles, which really is a key requirement for any autonomous mobile robot.

The basic principle behind the operation of the ultrasonic sensor is to observe the time required by the sensor to transfer ultrasonic beams and to receive back the beams after the surface has been hit. The distance is then evaluated using the formula. The commonly accessible HC-SR04 Ultrasonic Sensor is used here.

Distance = (Time x Speed of Sound in Air)/2

v. Battery-powered motor driver are then considered:

They control the speed and direction of the two DC motors by means of common PWM signals.

PWM is indeed a technology in which the average value of the input voltage is modified by transmitting a series of on / off pulses; the average voltage is proportional to the width of the pulses known as the Duty Cycle. The larger the duty cycle, the higher the average voltage given to the dc motor, which in turn leads to the highest speed. L298N is a dual-channel H-Bridge motor driver capable of controlling 2 x DC motors. The Arduino UNO carries out the programming of all these components. It enables programs to be structured in code segments to perform individual tasks.

V. FIGURES

The figures below constitute the mechanical assembly of the cart and the programming of components, interfacing of components related to functions they provide and assembling them. The cart has been assembled out of plywood. Fig.13 shows the model of the cart which is foldable.

Fig.13 Horizontal and vertical position of cart

The Fig.14 shows foldable cart that makes user place the cart anywhere and requires less area. The cart includes two wheels attached with 12V DC motors and an ideal wheel. This type of modeling makes the cart easy to handle, change the path direction and feasible. A small room is given to place the components within.

Fig.14 Foldable cart

The Fig.15 shown below represents the Node MCU being connected to our laptop for programming it.

Fig.15 Node MCU

Here, first setting up of the Node MCU was done by doing the blink test with the led on the module. Only after this, was the programming done to get the coordinates shown in the Blynk app to the serial monitor screen. After programming, we got the same coordinates on the screen as that on the Blynk app. Blynk is used to obtain the current coordinates of the smartphone.

The coordinates obtained was entered into the Google Map so as to verify the location. This is a reverse geo system. Successfully, we ended up at the correct place or location whose coordinates were entered.

This Fig.16 shows the coordinates provided by the Blynk app.

Fig.16 Blynk coordinates

Reverse geocoding is done here. It is the process of back (reverse) coding of a point location (latitude, longitude) to a readable address or place name. This permits the identification of nearby street addresses, places and/or areal subdivisions such as nearby neighborhoods, state or country. Reverse geocoding is a critical component of mobile location based services to convert a coordinate obtained by GPS to a readable street address which is easier to understand by end user. Here, this system thus became helpful.

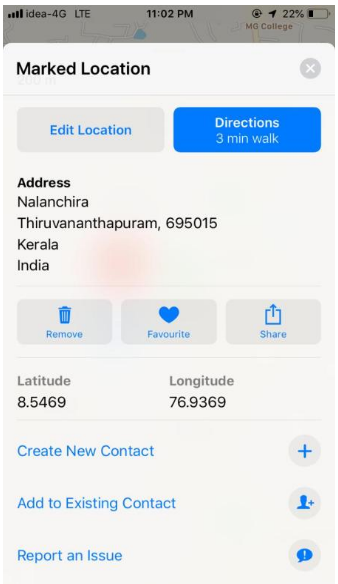

Fig.17 Reverse geo systems

Next, we started with the programming of the GPS Module. The GPS was setup to get the latitude, longitude, altitude and speed of the cart. Further on the satellite time was also obtained with this setup.

The Fig.18 below shows the program we used and the results obtained on the serial monitor screen. The coordinates obtained was exactly that of the current location the module was placed.

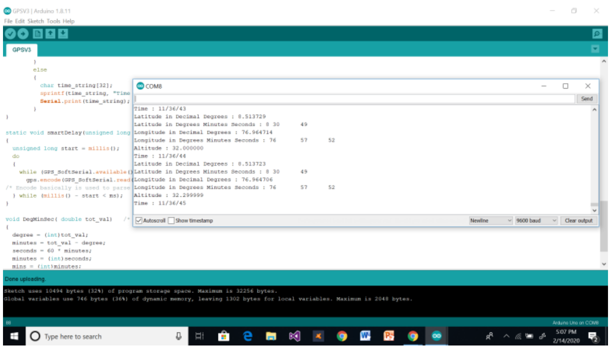

Fig.18 Program for GPS Module

VI. DISCUSSION

Human computer interaction technology is very well developed in this current era. Follow me cart is designed to automatically follow the user along with carrying the luggage. It develops a platform capable of sending and receiving signals that would provide a simple and practical means to follow the user and to avoid the obstacles. Arduino UNO is placed in the cart and all the other components are connected to it. An android platform is required to establish a connection between user and cart. So for that Blynk app is installed in the smartphone and through that data is given. Main component of the cart is the Wi-Fi module and through that information about the user's location is send to the cart. This information is received by the Blynk server through the Blynk app. While the cart moves obstacles may occur so the cart should detect the obstacles. Two ultrasonic sensors are placed in the cart for this purpose. These sensors are then connected to ADC to convert this analogue signal to digital so that Arduino can receive it [5]. Cart has four wheels connected to it where two wheels are motor controlled. The data from blynk server is given to L298N which gives this data to motors such that motor will make the wheels to move with respect to the data. GPS and compass module is placed in the cart to make the location and to fit the coordinates of this location to the location of the user. The technology used for the movement is LoRa. LoRa stands for long range communication that will connect up to 10-12 meters. LoRa is a spread spectrum modulation technique derived from spread spectrum technology. So a LoRa transmitter is placed in the cart to provide information about the location of the cart. And this is received by the LoRa receiver placed in the laptop. This will helps the cart for not getting lost [4].

VII. RESULT

The cart has been constructed according to the needs. Real life scenarios meet up reducing manual works. Output has been obtained. The design of the cart is such that it is of great benefit to the user as it meets the requirements of a robotic assistant device.

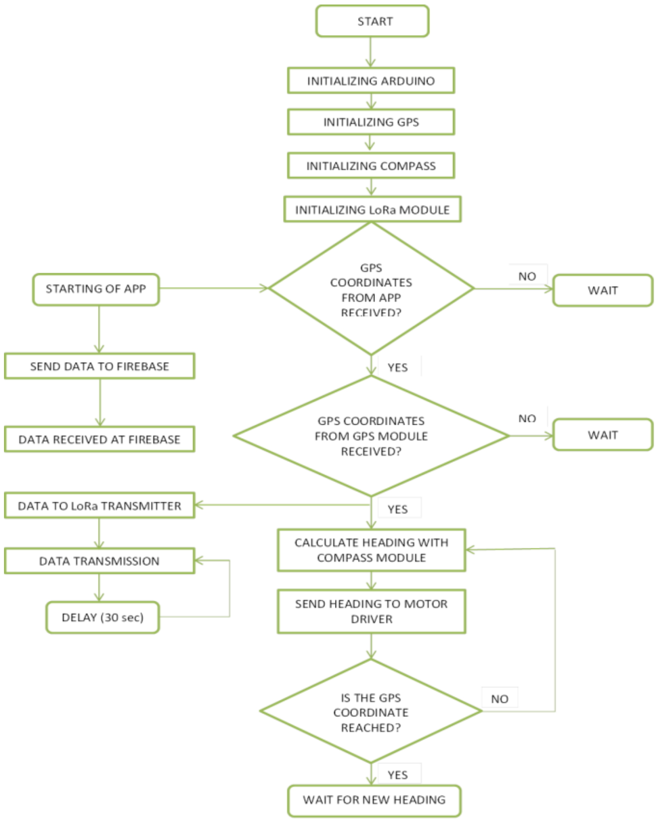

Fig.19 Flowchart of the proposed system

The approximate location and readings from the user's smartphone were obtained on the cart. The location of the cart is also read. Fig. 19 depicts the overall processes that take place within the system. Here, the heading used in the flowchart indicates the direction to which it heads.

VIII. CONCLUSION

In the current era, human machine interface technology is evolving very well.

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Here, a successful execution of a robotic cart capable of moving along is shown. This cart was designed to automatically trail along with the customer while holding their bags to reduce the risk of carrying it on their shoulders. Safeguarding the robot from contact with the target is another thing that needs to be addressed for which the cart utilizes sensors to do this. . The biggest hindrance in this kind of research is that target identification is a sensitive thing to do. To identify it and carry down the basic task, the target has to be special to the device. The clear tag or here the Wi-Fi coordinates solves this identity problem and makes the job fairly easy. The most significant factor for a robot that functions autonomously is coordination between the human and the device. This work thus invests trivially in the creation of such robots. There has been a lot of research in this field. This robot is able to follow the target person, connect and also engage with the human. Taking this into account, the robot should have the capabilities to obtain information from the environment when following. The cart will be of great benefit to various fields. This robotic cart has better scope in the near future[5].

IX. FUTURE SCOPE

Applications can be extended to a wide variety of fields in the vast robotic world. This may include medical, military, industrial fields and also airports. A call back system can be incorporated into this work. This can be of great use in airports or other large grounds. Even though, people use the cart to make full benefit of it, there are only a few cases where they return or place the cart back at its position. So in order to call back all the abandoned carts within few kilometers it turns out to be a great idea. In order to increase the security system of the cart, a face recognition system can be done. This would allow only the present user handling the cart or with whose phone the cart is at present being connected to unlock it. It can be used in military fields by mounting a real time video recorder [7].

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