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A SMART MICROCONTROLLER BASED AUTOMATED VOICE REMINDER AGAINST ITEMS MISPLACEMENT IN A PUBLIC TRANSPORT

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ABSTRACT

Hypoxia is a condition characterized by a deficiency of oxygen in the body or a specific organ or tissue, leading to Misplacing invaluable items like phones, wallets, office keys, etc in a public transport is a hurting experience. Most times, passengers misplace or forget their precious items while alighting from a bus. In most cases, other passengers would pick those items and go away with them. Most times the drivers of such vehicles no nothing about the incident but gets to know after the act is over. This is very hurting and most time not easy to bear the loss. Currently in our public transports in Ebonyi State, there is no system installed in a public transport that reminds the passengers to ensure they pick up their items before leaving the bus. Therefore, this work proposes a smart microcontroller based automated voice reminder against mobile phone misplacement in a bus. The system is made up of a touch sensor which is mounted next to each passenger. The passenger will place his hand on the touch sensor once he is seated. As long as he places his hand on that sensor, the microcontroller receives signal to maintain the off state of the voice module. But once the passenger wants to leave the bus and eventually removes his hand from the sensor, the microcontroller receives the signal to turn on the voice module to play a recorded voice. By this, the passenger is reminded to pick up his items. Object Oriented Programming (OOP) method has been adopted in the implementation of this system as it ensures post-maintenance easiness.

Keywords: *Smart Microcontroller; Automated Voice Reminder; Touch Sensor; Public Vehicle; Neural Networks.*

INTRODUCTION

The need for people to travel from place to place arose from the need for exchange of good and services in different geographical zones in Nigeria and beyond. It also became more needful as the population of countries began to increase. Due to this increase people began to migrate from one location to

another in search of food, goods and services, clothing and shelter. The movement was done through several means of transportations.

According to Staff (2020), the common modes of transportation in Nigeria include cars, buses, taxis, bicycles (for road transport), trains (rail), airplanes (air), and boats (water). In Abuja, the nation's capital, traffic congestion is a major challenge, prompting many residents to rely on bicycles and motorbikes, which offer greater flexibility than cars, buses, or taxis. Nigeria's transportation system shares many similarities with those of other countries.

Conventional means such as cars, trains, buses, and bicycles dominate daily travel, and gridlocks in large cities are comparable to those experienced in other major urban centers across the globe. Within city limits, individuals can move around using public buses or hire private taxis. Although taxis provide faster and more direct routes than buses, they are not always considered the safest option. Owing to the frequent traffic gridlocks in metropolitan areas such as Lagos and Abuja, many locals prefer using bicycles, motorcycles, and mopeds as convenient alternatives for urban mobility.

There have been records of passengers who alighted from commercial buses and forgot some of their valuable items like keys, wallets, money, etc. Most times, the drivers may not be able to trace the owners of the items or some passengers in the same bus may do away with the items for good. This has truly inconvenience some people in life.

Misplacing or forgetting invaluable items in a public transport can be very frustrating and causing unnecessary expenses. Human beings can be distracted by external or internal factors and have tendencies to forget items anywhere. Thus there is need for our public transporters to help remind the passengers of their items.

This work proposes a smart microcontroller based automated voice reminder against mobile phone misplacement in a bus.

It advocates the use a touch sensor to ensure that passengers place their fingers rightly and be reminded when necessary. It integrate a voice module for voice reminder. The touch sensor must be kept at the position where human finger can be easily placed on it.

Once the passenger wants to leave the bus and eventually removes his hand from the sensor, the microcontroller receives the signal to turn on the voice module to play a recorded voice. By this, the passenger is reminded to pick up his items. The use of devices like microcontrollers, sensor technologies, voice recorders and neural networks has made it possible to come up with multiple embedded systems including the item reminder system.

This work is aimed at the design of a smart microcontroller based automated voice reminder against mobile phone misplacement in a bus. This system is significant to all those who board public transport while embarking on a journey. It is also significant to the drivers as there would be less cases of item misplacements in their buses. It is also significant to other researchers as they can review this work for further improvement.

REVIEW OF RELATED LITERATURE

When moving between cities across Nigeria, travelers typically rely on trains and buses. Although the national railway network is not as advanced as those found in many Western nations, it still serves several key routes. Buses, on the other hand, provide wider coverage and remain a more affordable means of intercity travel. However, passengers should anticipate crowded vehicles and limited comfort, as most public transportation options in Nigeria offer minimal amenities.

Travelers often carry some of their items like hand bags, mobile phones, house keys, purchased goods, laptops, money, sunglasses, umbrella, wallets, documents, car keys, etc while on transit. These items are very essential especially the ones for communication purposes like the mobile phones, laptops, etc. However, often these items are misplaced and the traveler gets trapped and frustrated. Human beings actually work with their minds. Sometimes, they can pre-occupy their minds with others things that might make them forget to pick up their valuable items from buses or other places. Some travelers who misplace their phones are left without electronic communication for some days. They face the challenge of losing their sim cards and lose of contacts. In some cases, the persons how pick these items make away with them and use them to cause further havoc like emptying the victim's account.

According to Katie, (2021) there is panic when one misplaces one's items anywhere. However, that there are ways to prevent and recover them. The author says that keeping records, using digital trackers, locking of items, and hiding them are some of the ways to prevent items from getting lost or stolen. According to the findings of the Prey Project (2018), approximately 69.12% of respondents reported misplacing their mobile phones, whereas 30.88% indicated that their devices were stolen within the same period. The study, which involved a sample of over 800 participants, further identified residential areas, public streets, workplaces, and public transportation systems as the most common locations where such incidents occurred. Katie also says that using a locator app, sending of text, taking precautions and calling the police could help one recover a misplaced phone.

Most researchers have provided some measures to be taken to prevent the loss of items in the first place. Others have also provided a means of recovering items if misplaced. Most of these traditonal ways of approaching misplaced items have not completely solved the problem of misplacing items especially in the bus. The is a need for an automated system which will remind the user of the items to pick them up when ever they want to leave a location. That is what this research work is designed to do.

Reasons why people forget items

According to Daniels (2021), occasional memory lapses can be frustrating, aggravating, and even concerning. When such occurrences become frequent, they may raise fears of the onset of dementia or Alzheimer's disease. However, several reversible or treatable factors can contribute to forgetfulness. Daniels identified six common causes as follows:

i. Lack of Sleep:

Insufficient or poor-quality sleep is one of the most underestimated contributors to forgetfulness.

A lack of restorative sleep can lead to irritability, mood fluctuations, and anxiety, all of which negatively affect concentration and memory retention.

ii. Medications:

Certain drugs—such as tranquilizers, antidepressants, antihypertensives, and other sedatives—may impair memory by inducing drowsiness or confusion. These effects make it difficult for individuals to focus and retain new information. It is therefore advisable to consult a healthcare professional if a prescribed medication appears to diminish cognitive alertness.

iii. Underactive Thyroid:

An underperforming thyroid gland can contribute to forgetfulness by disrupting hormonal balance, which may also cause sleep disturbances and depressive symptoms—both of which are associated with impaired memory. A simple blood test can confirm thyroid functionality.

iv. Alcohol Consumption:

Excessive alcohol intake has been shown to interfere with short-term memory even after intoxication has subsided. While tolerance levels differ among individuals, recommended limits are no more than two drinks per day for men and one drink per day for women. One standard drink typically equates to 1.5 ounces of distilled spirits, five ounces of wine, or twelve ounces of beer.

v. Stress and Anxiety:

Both stress and anxiety can hinder concentration and the ability to encode or retrieve information. High levels of psychological distress can obstruct the formation of new memories and the recall of existing ones.

vi. Depression:

Depression is often characterized by persistent sadness, loss of motivation, and diminished interest in pleasurable activities. Cognitive symptoms such as forgetfulness frequently accompany depression and may be both a symptom and a consequence of the condition.

Curejoy, (2017) also stated that smoking, dementia, excessive alcohol use, Vitamin B12 Deficiency and aging are other common causes of forgetfulness.

Conceptual Terms

Microcontrollers

Most embedded systems, including the proposed item reminder device, utilize microcontrollers as their primary control unit. These units are programmable using various programming languages to execute specific functions across different environments such as homes, offices, and industrial settings. Microcontrollers operate in conjunction with sensors that detect and respond to changes in the surrounding environment.

According to Ligo (2021), a microcontroller (MCU) is a compact, low-cost, and self-contained integrated circuit (IC) designed to perform dedicated tasks within embedded systems. Essentially, it functions as a small computer embedded on a single silicon chip. It is a programmable, clock-driven, and register-based device that accepts input, processes data according to preloaded instructions, and produces corresponding

output. Microcontrollers are typically employed in applications requiring dedicated control, such as in washing machines, air conditioners, and other automated systems.

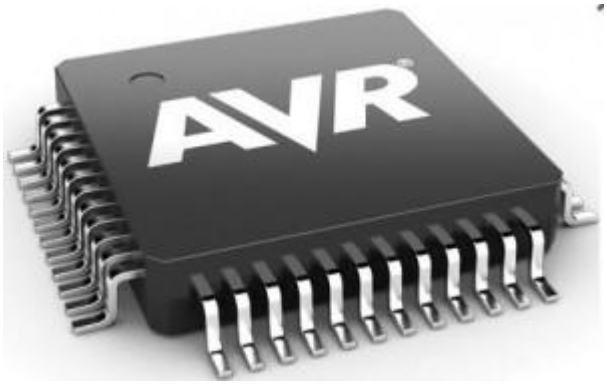


Figure 1: Atmel AVR Microcontroller

Sensors and Embedded Systems

Sensors are fundamental components of embedded systems. According to Embedded (2019), sensors and embedded systems function together to form one of the most critical aspects of the Internet of Things (IoT). Sensors play a key role in detecting environmental and object-related changes, thereby enabling intelligent responses within a system. In general, sensors are used to identify variations in the logical and physical relationships between objects and their surrounding environment.

Logical changes refer to the presence or absence of an electronically detectable condition—such as position or activity, while physical changes may involve measurable factors such as light, temperature, pressure, motion, or sound. Both physical and logical changes are vital within the IoT framework, as they collectively enable automated systems to interpret and interact with their environments effectively. Common categories of sensors applied in the Industrial Internet of Things (IIoT) include pressure or force sensors, humidity sensors, temperature sensors, ambient light or optical sensors, acoustic sensors, level, flow, or leakage sensors, as well as chemical, radiation, or gas sensors. Other important types include acceleration or motion sensors, touch or lock-status sensors, and magnetic or electrical sensors.

Touch Sensor Working and Its Applications

The human body relies on five sensory organs to perceive and interact with its environment. Similarly, machines require sensing elements to enable interaction with their surroundings, a need that led to the invention of sensors. The first man-made sensor, the thermostat, was developed in 1883, marking the beginning of artificial sensing technology. By the 1940s, infrared sensors had emerged, expanding the range of detectable environmental variables.

In modern times, sensors have evolved to detect a wide variety of parameters such as motion, light, humidity, temperature, and smoke. Both analog and digital sensors are now widely available, each serving specific applications depending on accuracy, cost, and signal processing needs. The development of sensor technology has significantly reduced the size and cost of control systems, making automation more accessible and efficient. Among these technologies is the touch sensor, a device designed to detect physical contact or proximity, thereby mimicking the human sense of touch in electronic systems.

Touch Sensors

Touch sensors are electronic devices designed to detect physical contact or proximity. Functioning similarly to a switch, they activate or deactivate a circuit when touched. These sensors are widely used in modern technologies such as **touch-sensitive lamps, mobile device touchscreens**, and various **interactive electronic interfaces**. Touch sensors provide an intuitive and user-friendly means of interaction between humans and machines, enhancing usability and responsiveness in electronic systems.

Figure 3: Touch Sensor

Touch sensors, also referred to as **tactile sensors**, are electronic devices designed to detect physical interaction through contact or pressure. They are relatively simple in design, cost-effective, and can be mass-produced, making them suitable for a wide range of commercial and industrial applications. With advancements in technology, touch sensors have increasingly replaced traditional **mechanical switches** due to their reliability, durability, and aesthetic advantages.

Touch sensors are broadly categorized into two main types based on their operating principles: **capacitive** and **resistive** sensors.

- **Capacitive touch sensors** operate by measuring changes in capacitance caused by the conductive properties of the human body. They are commonly used in portable electronic devices and are valued for their robustness, durability, and cost efficiency.
- **Resistive touch sensors**, on the other hand, function by measuring the pressure applied to their surface rather than relying on electrical conductivity. These sensors detect touch input through physical deformation of their layered structure, making them suitable for applications that require stylus or gloved operation.

Working Principle of touch sensor

Touch sensors work similar to how a switch works. They get activated when they are subjected to touch; pressure or force, then they act as a closed switch. They act as an open switch when the pressure or contact is removed. Examples of touch sensors available in the market are TTP22301, TTP229, etc.

Embedded systems

An embedded system is an electronic device that integrates both hardware and software components to perform a specific, pre-defined function. Such systems are designed to execute dedicated tasks efficiently, unlike general-purpose computers that handle a wide range of operations. Depending on the nature of the application, an embedded device may be either programmable or non-programmable.

In everyday life, embedded systems are found in numerous devices such as mobile phones, smart home controllers, CD players, and microwave ovens. These systems rely on embedded boards supported by various types of microcontrollers developed using standardized hardware and software modules.

Among the many development platforms available, Arduino has emerged as one of the most widely adopted embedded system boards. Arduino facilitates the design, prototyping, and implementation of embedded solutions and plays a significant role in the advancement of the Internet of Things (IoT) by providing a simple yet powerful framework for sensor integration and device connectivity.

Voice Recording Techniques

The ability to record and play back voices has really added much values in embedded systems. One can actually record a voice and automatically play it when certain events take place in an environment. For instance, if one is about to cross a certain boundary, an embedded system can be programmed to detect the person and start playing the recorded voice immediately. This concept has found applications in many places. It is used in smart phones to play ringing tones when one has a call, etc.

Technology and Tools for Implementation

The hardware component of the reminder system is implemented using microcontrollers and sensor technologies, while the software component is developed through an Integrated Development Environment (IDE).

As discussed earlier, microcontrollers are compact computing units integrated on a single chip. They are programmed using high-level languages such as C++, Python, and others to execute specific control functions. A typical microcontroller comprises input and output units, memory for data storage, and a processing unit for executing instructions.

The software or intelligence aspect of the system is achieved using an IDE, which provides the environment for writing, compiling, and uploading code to the microcontroller. For example, the Arduino IDE is commonly employed to program Arduino-based microcontrollers. Within this framework, program code is developed and uploaded to the chip, where it governs the system's behavior and decision-making process. When a specified condition is met, the microcontroller activates connected actuators—such as buzzers, LEDs, or motors—to perform corresponding actions.

Sensors, as highlighted earlier, play a crucial role in any embedded system. They enable the system to detect environmental changes and transmit the sensed data to the microcontroller for analysis and response. In the case of a smart item reminder system, for instance, a touch sensor or push button can serve as the input device that triggers reminders or alerts based on user interaction.

Related Works

It is obvious that some researchers have made efforts to design an automated reminder system. The review of their literature is as below:

Marty (2020) developed an automatic vehicle location (AVL) system integrated with an automatic announcement module to enhance accessibility and efficiency in public transportation. The system enables operators to broadcast both internal and external announcements during transit and at each stop, in

compliance with the Americans with Disabilities Act (ADA), which mandates such provisions to improve transport services for passengers with disabilities. The integration of audio announcements and visual display systems plays a vital role in assisting individuals with disabilities, ensuring that they can navigate public transport systems more safely, independently, and efficiently. However, the system does not integrate a way to remind the passengers about their items in the vehicle before they alight.

Balachandra *et al* (2017) proposed a system that consists of an Internet of Things (IoT) enabled medicine box which sends prompt messages to the patients about their medication time and appropriate dosage. It alerts and encourages the patients to take medicines at the proper time. The medicine details can be recorded in the mobile application by the patient or by the nurse/caretaker of the patient. The system helps to preserve track of dosage, stock of medicine and so on.

Research gap

From the review so far, most of the vehicles in Nigeria do not integrate an automated system that reminds the passengers to pick up their items while they are leaving the bus or certain places. Some of the buses abroad have only integrated a system that reminds the passengers about their destinations but not their items like phone, wallets, etc. Most researchers have also tried to provide measures to be taken by item users in order not to misplace their items like keeping records, etc,

Others have also provided a means of recovering stolen or misplaced items like tracking, etc.

However, there is need to use audio method to remind users of their items especially while they are leaving that location at that time. This ensures that the user does not forget his item in the first place. It also spares the society the stress and risk of recovering misplaced items.

MATERIALS AND METHODS

Information Gathering

Information gathering refers to the systematic process of collecting relevant data from a sample or target group to support research objectives. The selection of appropriate data collection methods is typically influenced by factors such as cost, coverage of the target population, flexibility in questioning, participants' willingness to respond, and the accuracy of responses obtained. Common techniques include interviews, online surveys, system studies, facilitated questionnaires, and brainstorming sessions, among others.

For this research, the following methods were employed:

i. Study of Related Materials:Existing literature and documented resources relevant to the study were reviewed to gain a deeper understanding of the subject matter and guide the design of the proposed system. This method proved cost-effective and provided valuable theoretical grounding.
ii. Online Surveys: Internet-based searches and surveys were conducted to obtain supplementary information and insights from credible online sources related to the research topic.
iii. Interviews: Selected individuals were interviewed to obtain firsthand information and practical perspectives that contributed to refining the system design and functionality.

iv. Brainstorming: Collaborative brainstorming sessions were conducted with peers and colleagues to generate innovative ideas and possible solutions to challenges identified during the system development process.

Analysis of Existing system

From the analysis made in our public transports in Ebonyi State, there is no system installed in a public transport that reminds the passengers to ensure they pick up their items before leaving the bus. This therefore encourages the constant loss of items by the passengers as most of them usually forget to pick up their items especially mobile phones before alighting from the vehicle.

High Level Model of the Proposed System

The proposed system has been analyzed using a block diagram and OOP.

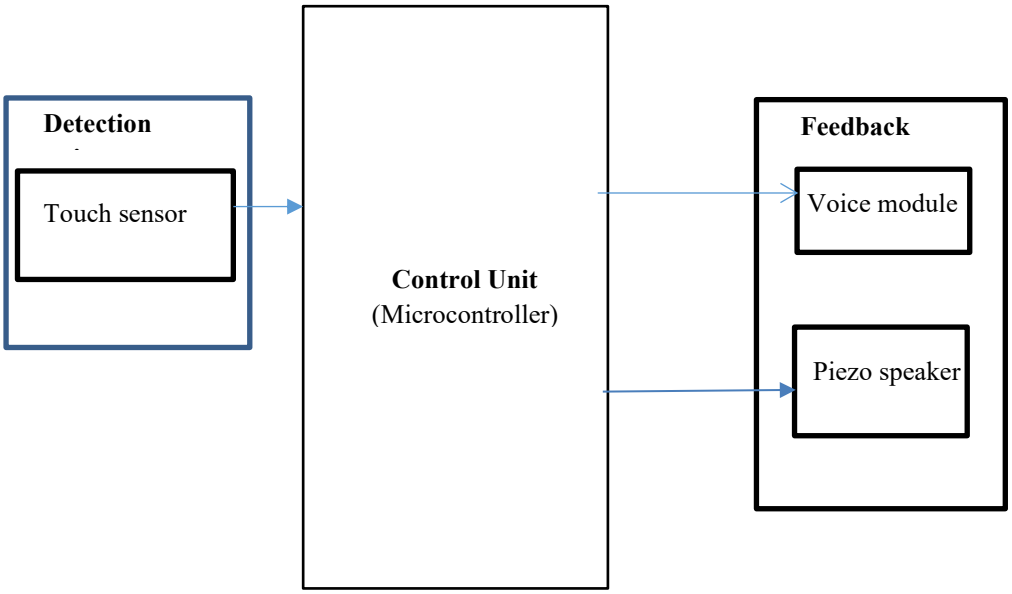


Fig. 4: The Block Diagram of the Proposed System

The block diagram above shows the different parts of the systems such as the detection unit, control unit and feedback units. The detection unit is the touch sensor which is responsible for detecting touch. The control unit is made up of the microcontroller (atmega328p) which is responsible for the signal control and execution. The feedback units is the voice module which has the piezo speaker attached to it. They are responsible for reminding the passenger of his items before leaving the vehicle.

Analysis of the Proposed System

Functional Requirement

Use case diagram was used to specify the functional requirements of the system. The use case of the entire system comes first, and then the various instances of the use cases followed.

Use case diagram of the system

This diagram shows the interaction between the Smart System and the outside world. Here, the smart system and the user are actors that perform actions. The work is housed in the outermost compartment while the individual use cases are housed in the inner rectangular boxes. The system is required to detect touch and give feedback to the passenger (user) by playing a recorded voice. The arrows show the flow of interaction and dependencies among the individual objects of the classes. The “play recorded voice” use cases occur

only when the "detect touch" use case takes place. The actor is represented as the object that looks like human being. It represents the proposed system itself.

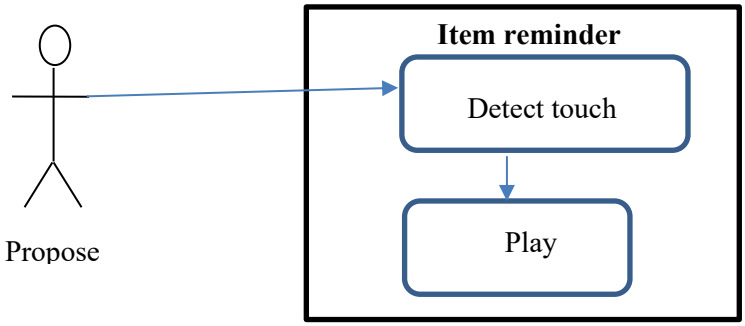
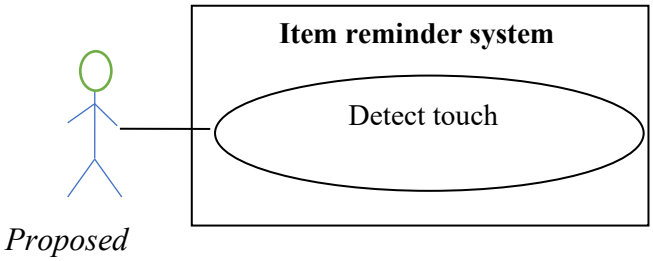


Fig. 5: The Use case diagram of the Smart Reminder System

Use Cases and their Instances



This use case enables the system to monitor and detect when a passenger is seated in the vehicle and when he or she is about leaving the vehicle by sensing the touch of their hand.

If the user removes his finger from the sensor, that is no touch is detected, the system should play a recorded reminder message. If touch is sensed that is the user is still seated in the bus, the system should remain calm.

The Communication Diagrams of the System

The communication diagram depicts what classes of the entire system interact with one another to produce overall results.

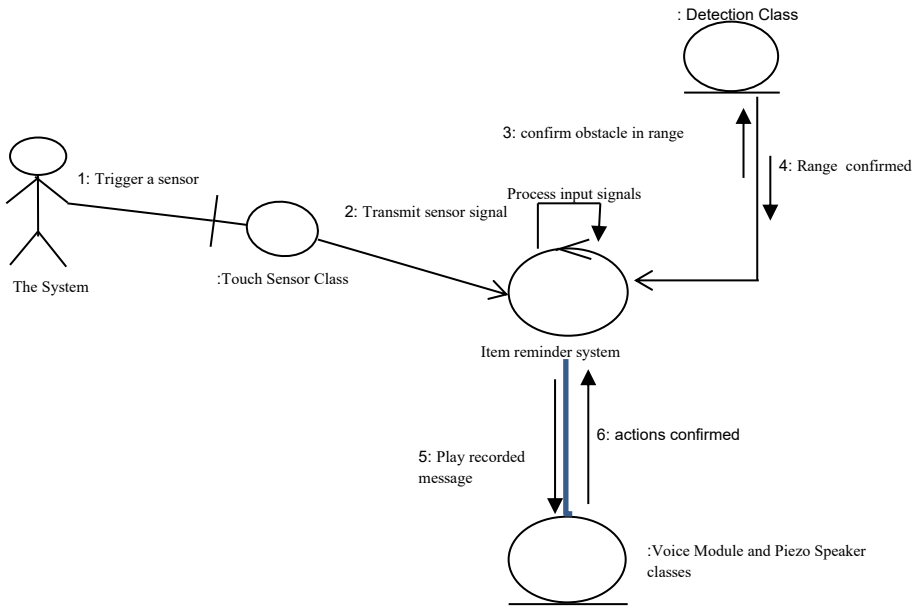


Fig. 6: Communication diagram for the detect obstacle use case

The communication diagram above shows what objects are present and interact with other objects in the whole system. The touch sensor is triggered by the system. It transmits its sensor output signal to the processing unit. The processing unit confirms that the signal value meets set condition and triggers the feedback units to take actions. The arrows show the flow of control from one object to another. Each process is numbered from 1 to 6. The name of the classes is preceded by a colon (:).

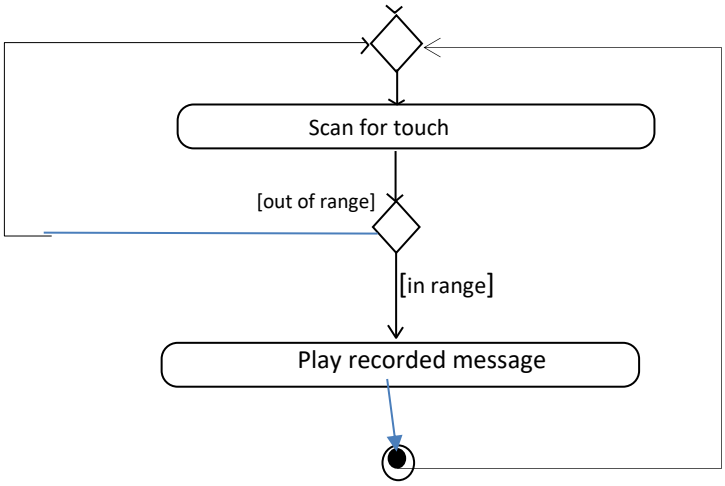


Fig. 7: Activity diagram for the detect human hand use case

The activity diagram above shows the flow of control while the system is actively working. The system starts and scans for touch and if one is detected (out of range), the system remains calm. But, if none is detected, the system plays a recorded message to remind the passenger to pick his items before alighting from the bus. After the feedback, control is returned to the scanner and the loop continues.

Analysis of the Component Parts of the System

The system will be made up of three major sub units namely: detection unit, control unit and feedback unit. These units are discussed below:

Control Unit (Arduino Nano)

The Arduino microcontroller board, created by Arduino.cc, operates on the ATmega328P or ATmega168 chipset. It is widely applied in automation, robotics, and embedded system development, serving as a practical platform for electronic innovation. Designed to be beginner-friendly, Arduino offers an easy learning curve for students and individuals without prior programming or engineering experience. In this system, the microcontroller functions as the central processing unit that handles all incoming data from the ultrasonic sensor. When the sensor detects an object or measures distance, the controller, programmed using C++, executes the required computations and logical operations to manage the system's response automatically.

Detection unit

This unit is responsible for detecting when there is a touch comes and sends corresponding signal to the control unit for further analysis and computing. One sensor makes up this unit: Touch sensor. Touch Sensor: The TTP223 is a touch pad detector IC which offers one touch key. The touching detection IC id designed for replacing the traditional direct button key with diverse pad size. This sensor is used mostly in any place where low to no force human touch sensing is desirable.

The sensor is small and easy to use. Since it operates on 5 volts, it can be hooked directly to an Arduino or any other 5V logic microcontrollers.

Touch Sensor has been used in this research work to detect touch of a passenger's finger. If no touch is detected, the system plays a reminder message.

The Feedback unit:

They are used by the system to give feedback to the user. Voice module and piezo speaker have been used in this research work. The vibration module has the piezo speaker attached to it.

Piezo speaker:

The speaker attached to the voice module is used in the research work to give the user/passenger audio feedback in case the system detects that the user has removed his finger from the sensor. It has two wires: red (+5v) and black (0v).

Main system interface design

The OUT pin of the touch sensor is interfaced with digital pin D4 of the microcontroller. The sensor's VCC and GND terminals are linked to the positive and negative rails of the breadboard, respectively. Likewise, the anode of the power LED is connected to pin D3, while the positive terminal of the speaker is wired to pin D6 of the microcontroller. All component ground connections are tied to the breadboard's negative rail to complete the circuit. The entire setup is powered by a 9V battery, with its positive lead attached to the VIN pin and the negative lead connected to GND on the microcontroller board. The controller then regulates and distributes a 5V output, which supplies power to all the connected peripheral components.

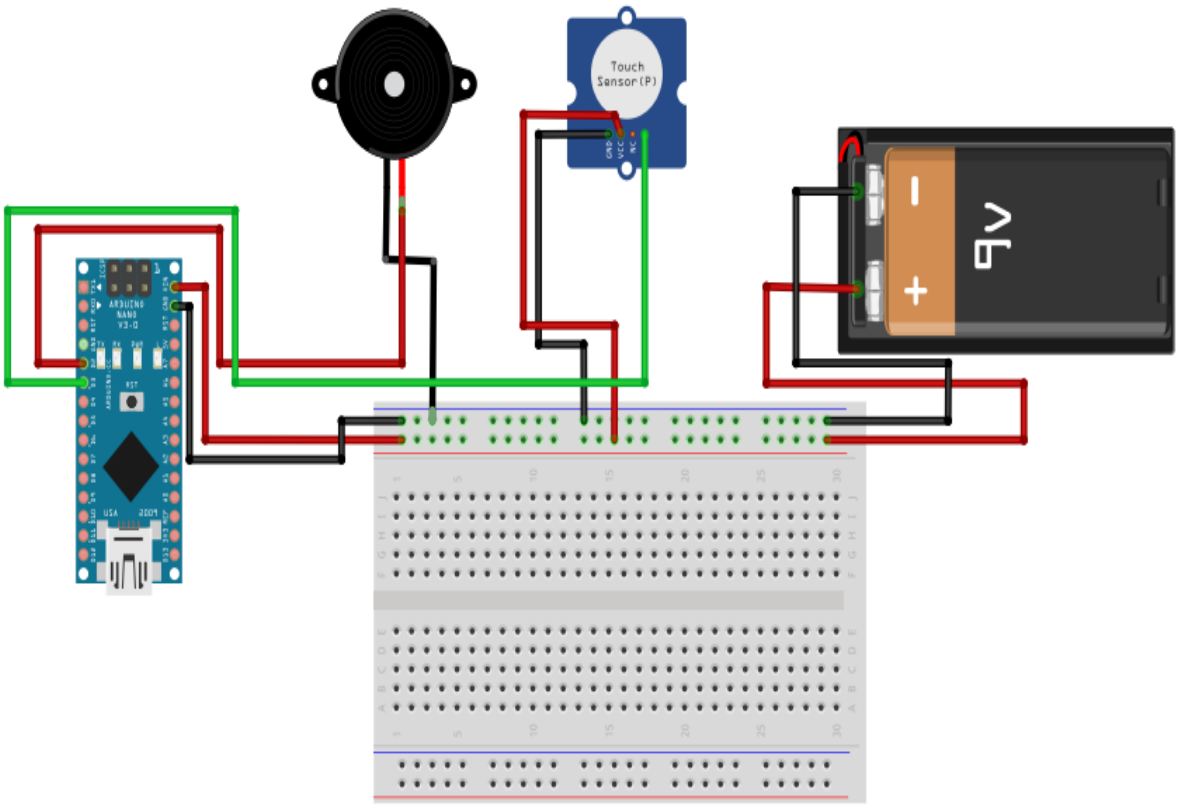


Figure 8: System interface design

Program Module Design

A program is composed of several modules, each responsible for executing specific service functions required by the application. The design process involves abstracting these functions into distinct modules capable of handling multiple requests autonomously and efficiently.

In this embedded system, the modules are sensors or transducers. They have been designed and preprogrammed to take certain inputs from their environment and convert them to either digital or analog outputs which are inputs to the microcontroller.

The Touch sensor module is responsible for reading human contact with the item and giving out analog or digital signals to the controller for further computations.

The modules send signals to the microcontroller which has been programmed to respond to the signals accordingly. The major work of the microcontroller is to compute the readings from the sensor and determine the outputs.

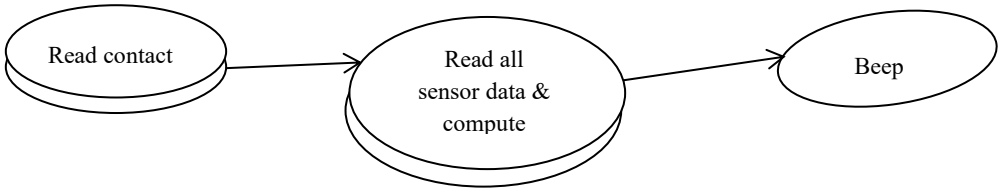


Figure 9: Program Module Design

Test Results

The system monitors the passengers' seats for a misplaced item. Once an item is about to be misplaced, the system raises alarm to remind the passenger about it. All the above test results have been thoroughly summarized in table 1.

Table 1: Summary of the Test Carried out on the Smart System

Operations	Expected result	Actual result	Remark
The system was powered on	All components should receive specified input voltage to power on	All components were powered by 9v battery used.	Good
The touch sensor monitors the passenger's seat for the chances of misplacing an item.	The touch sensor should monitor the passenger's seat for the chances of misplacing an item	The touch sensor monitored the passenger's seat for the chances of misplacing an item	Good
Once the chance is high, the system raises an alarm to remind the user about it.	Once the chance is high, the system should raise an alarm to remind the user about it	The chance was high and the system raised an alarm to remind the user about it	Good

The system was tested and all the expected results were equal to the actual results as seen in the table 1 above.

CONCLUSION

This work has used a more reliable and accurate approach to remind the users of their items especially while leaving a public place like vehicles, schools, parks, etc. The system uses a touch sensor and buries it under the seat of passengers and when the passenger sits down the system does nothing. But, when

they stand up from the bus, the system should play a recorded voice to remind the passengers to pick up any of their items.

With this system now, both the drivers and their passengers will have reduced chances of forgetting or misplacing their valuable items in commercial buses.

This system should be installed by the sides of passenger's seat in order to work effectively.

The authors recommend that the system should not be fixed by unauthorized technicians in order to avoid creating further issues. The system should be kept in a place that is void of water or other liquid substances to avoid damage.

Finally, I further recommend that the system be built with the ability to call the owner on phone some minutes after being misplaced.

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