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Smart Cane for the Blind in Wetland Areas

Imam Yuwono[1], Mohd. Hanafi[2], Utomo[3]
Lambung Mangkurat University, Indonesia[1], National University of Malaysia, Malaysia[2], Lambung Mangkurat University, Indonesia[3]
Email: imam.plb@ulm.ac.id
Corresponding Author Email: mhmy6365@ukm.edu.my

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Abstract
The South Kalimantan region of Indonesia is included as a wetland area, a basin area in the lowlands that is heavily submerged by spilling water from rivers or rainwater collected during the rainy season. During the dry season, the water becomes dry. Wetland areas for blind people become serious problems, for example, identifying standing water, detecting obstacles, temperature and fire. Therefore, a smart cane was developed based on Arduino Nano, an ultrasonic sensor equipped with a Global Positioning System (GPS) module. The smart cane was designed to be equipped with Bluetooth and delivered through the service. Internet of Things (IoT) was connected to an Android application to access GPS. With the IoT service, the smart cane does not need to be held but placed on the waist so that the visually impaired appear like a vigilant person. In addition, using the IoT, the movement of blind people will be able to be monitored by caregivers through the Android application.
Keywords: Arduino Nano, Ultrasonic Sensors, GPS, IoT Services, Wetlands, Blind

Introduction

Over the past few decades, many systems have been developed that allow electronic devices to contribute to mobility and orientation in visually impaired people. Various research studies utilizing information and communication technologies (ICT) have been conducted to help overcome these mobility and orientation problems. The efficiency of ICT has been the subject of several research studies, all of which point to room for improvement. Therefore, this present study proposes the design and development of an Android-based smart cane application. This proposed device has certain features that are useful for the visually impaired to move around the wetland environment in which they live. The suggested device includes several characteristics that assist people with visual impairment in navigating their living environment, such as a wetland. This smart cane is embedded with various types of sensors, such as detecting obstacles on the ground and for upper body parts from a certain distance. It is set according to the convenience of Visual Control Post (VCP) so that users can avoid obstacles in time without collisions.

Other sensors detect small puddles or wet surfaces on the VCP ramp, which helps users avoid sliding. In addition, the system is coupled with a GPS module that receives the latitude and longitude of the VCP location and sends it to a database for future destinations. Therefore, an application (App) was created that helps parents or caregivers of VCPs to track their children in real-time. Another App used by VCP allows contacting parents or guardians easily and immediately in an emergency. For recapitulation, VCPs, as well as their parents, felt safe and relaxed, as they were able to contact each other without difficulty.

Related Research Studies

Various researchers are conducting many studies to provide efficient navigational assistance to visually impaired people/ blind. Initially, blind people only depended on others for their basic needs and mobility. Research on blind canes has developed in the last ten years, including those using Arduino Nano, utilizing Multi Ultrasonic Electronic Travel Aids (MU-ETA), Radio Frequency Identification (RFI) frequencies, Global System for Mobile Communications (GSM), Global Positioning System (GPS), and the Internet of Things (IoT).

Arduino Nano-based cane design

Yuwono et al (2021) designed a talking cane using an Arduino nano micro-controller equipped with a proximity sensor. Therib (2017) Therib created a cane-based method to assist the blind in avoiding accidents with objects. The cane features two SRF06 ultrasonic sensors and an Arduino microcontroller. It has two sensors installed on it, one at a precise 40-degree angle for detecting stairs or holes and the other for detecting obstructions in front of the blind, such as walls or other people. The vibration motor and buzzer are alerts, while the humidity sensor detects moist surfaces. The device can see obstructions, potholes, stairs, and wet terrain. The weakness of this design is that the user is sometimes confused in interpreting the monotonous message of many sensors.

Multi Ultrasonic Electronic Travel Aids (MU-ETA) based cane design

Yuwono et al (2021) developed a talking cane with a proximity sensor, water, fire sensors, and Bluetooth so those with visual impairments can hear the cane's sound without disturbing others. Obstacle Detection ETA is intended to identify obstacles on the road and alert visually impaired people to prevent accidents. Sharma (2015) Sharma created the "virtual eye" device that enables the blind to move around more easily in certain places. Dong (2016) developed crutches for blind people using ultrasonic distance detection to identify obstructions. The device consists of three ultrasonic sensors to detect and avoid obstacles from above the head, in front, on the right, and left front. The STC15F2K60S2 micro-controller controls the system and processes signals between the ultrasonic transmitting and receiving modules to obtain distance information. Mocanu et al (2016) designed a device that can be used to detect obstacles efficiently. The system uses sensors, computer vision, and machine learning techniques. This system enables four ultrasonic sensors. Ramadhan (2020) created a smart cane to improve blind people's independence and safety. An Arduino Uno and an ATmega328 microprocessor with various sensors are integrated into the designed system. Obstacles are detected using the HC-SR04 ultrasonic sensor, falls are detected using the ADXL345 accelerometer, and aid requests are detected using the voice recognition sensor. Chi et al (2021) Chen designed a cane to help blind people walk. The device developed consists of an Arduino Uno controller to process signals obtained from different sensors, two ultrasonic sensors, HC-SR04 to detect obstacles, and an Infra-Red (IR) sensor to detect stairs. The research above relies on a sensor function based on the principle of reflected sound waves, while the Infra-Red (IR) sensor works based on reflected light waves. The IR sensor has a weakness in dark conditions, so in bright conditions, it performs better, but it can sometimes fluctuate in various light conditions and is also disturbed by sunlight. Therefore, these are some of the limitations of using IR sensor-based devices. However, ultrasonic sensors apply to light and dark conditions and are unaffected by many other factors such as dust, smoke, mist, vapor, and lint. In addition, ultrasonic sensors have a more extended detection range than IR sensors. However, IR sensors are cheaper than ultrasonic sensors.

Radio Frequency Identification (RFI) frequency-based cane design

Saaid et al (2009) designed a radio frequency identification walking cane. This cane helps the visually impaired to walk on the pavement and avoid falling off the pavement by calculating the distance between the visually impaired and the curb border. A Radio Frequency Identification (RFI) tag, an RFI reader, middleware, and a database are the main components of RFI technology. In this system, the RFI tags are placed on the pavement center at a certain distance from each other. As the visually impaired get closer to the border, a reader attached to the cane detects the frequency of the tag, and the vibration is generated to alert the user. This system is effective because the RFI technology provides an accurate detection rate, but for this, many RFI tags must be placed in many places. Ramarethinam et al. (2014) designed a walking cane to help blind people move independently indoors and outdoors. The designed wand is embedded with an SRF02 sonar sensor for obstacle detection, and RFI and GPS modules are used for indoor and outdoor location detection.

Global System for Mobile Communications (GSM) based cane design

Velázquez et al (2018) created an ultrasonic sensor that uses GPS to track the user’s whereabouts and GSM to deliver location or emergency alerts to parents. Additionally, it emphasizes elements that offer efficient and affordable navigational support. This system includes a micro-controller, GPS NEO6MV2, SIM900 GSM, and ultrasonic sensor HC-SR05. Swain et al (2017) developed a cane with the sensor installed that can detect obstacles in front with sensors and produce various voice buzzers depending on the direction. GSM technology has already been mentioned for communication. GSM is a worldwide technology, but it has certain limitations, such as bandwidth lag so that the transmission may suffer with many users. GSM is a second-generation technology, but faster technologies like 3G, 4G, and 5G have developed in different networks. Again, this can interfere with specific electronic devices, such as hearing aids.

Global Positioning System (GPS) based cane design

GPS receiver, programmable interface controller microcontroller using Peripheral Interface Controller (PIC), voice recorder, liquid crystal display, microphone, and headset. Huang et al (2015) designed a “replacement eye for the visually impaired” that assists in obstacle detection and AP direction navigation. The system consists of a TI MSP430G2553 micro-controller as an embedded device, two HC-SR04 ultrasonic sensors, and three mobile vibration motors. Morad (2010) designed a “talking GPS” to assist the blind in independent navigation. The developed device is based on localization and does not have an obstacle detection feature. Hidayat & Supriadi (2019) Hidayat developed an ultrasonic sensor to detect obstacles in front of it by utilizing reflected ultrasonic waves, sensors detector water to know if there is puddle water or flood in front, and sensors beat heart to monitor users’ condition. Rao & Singh (2021) Rao designed obstacle identification device, Global Positioning System global (GPS), pit and ladder detection, water detection, and global system for mobile communications (GSM) to perform daily activities of the visually impaired quickly. Ren et al (2021) designed a guide cane based on the STM32F103C8T6 micro-controller to improve safety for blind people. The ultrasonic module completes the distance measurement, and the GPS module finds the blind. When the distance to the obstacle is no more than 100cm, the cane guide gives an alarm and shiver to warn the blind people. Pawaskar et al (2018) designed a cane using a proximity sensor equipped with GPS to determine a moving location in the form of coordinates. Nazri et al (2021) Nazri designed an ultrasonic sensor-based walking cane for the visually impaired. The ultrasonic sensor module, HC-SR04, is used to detect obstacles in the path of the blind, and a buzzer is used to alert the person. Gayatri designed a cane that used a Raspberry Pi microprocessor, sensors for detecting obstacles, GPS units, speakers, and other interconnecting parts. Internet of Things (IoT)-based cane design

Velazquez et al (2021) Subranomian designed smartphone with mode haptic chosen for allowing detection which easier. Module Bluetooth is used to Upgrade performance Suite control and the next developed application to convert Text to Speech. Apu et al. (2022) designed an IoT-based smart cane for blind people to overcome obstacles, water recognition, front obstacle detection, and localization of holes and stairs using different sensors. The GPS module is used to make daily work easier. However, from the observations, the blind prefer to appear without using a cane.

In this paper, we propose the development of a cane for the visually impaired by integrating a mobile application using IoT technology. In this system, we combine a microcontroller with a mobile application. This smart cane is based on temperature detection sensors, distance obstacles, puddles, and heat of fire which will be sent through the IoT service to the android application. Through the android application, cane users can access GPS, receive voice commands regarding the current location, and get guidance to the destination location. With IoT management, cane users can receive voice-based information about conditions based on what the sensor reads about temperature, fire heat, puddles and potholes, and bumps. The innovation of this paper is that using the IoT service is very effective for the blind. Among others, the cane does not need to be held but placed on the waist; the blind person is not burdened with swinging the cane. The blind will appear like an alert person going without a long cane. In addition, using the IoT, the movement of the blind will be monitored by caregivers through the Android application. The weakness of the IoT service application series placed on the waist is that the height of the sensor is always set to adjust the cane user’s height.

Picture 1: Sensor circuit, worn on the waist

Method
The method employed in this study is a design technique consisting of several stages, namely: (1) Identification of the needs of the blind; (2) Analysis and tracking of distance requirements; (3) Designing hardware and software; (4) Making tools that are safe and convenient; (5) Testing of proximity sensors and GPS tracking devices; (6) Device operation.

Research Findings
This smart cane device is a tool that was created to enable the blind moves more easily from one location to another. Unlike traditional blind canes, this Smart cane features several sensors, allowing it to alert the user when holes, obstructions, and other things are present. Additionally, the device is outfitted with a program created primarily to offer a turn-by-turn navigation function that makes it simpler for those who are blind to get to a certain point of interest. Ease of use is also a consideration so the system can use voice commands. The short workings of the Smart cane system consist of 3 devices: Smart cane functions as a navigational aid that has additional functions, namely sensors that are used for several detections, including Sensors to detect obstacles/objects in front, sensors to detect the presence of holes in the road, sensors to detect high temperatures (e.g., caused by fire). Android smartphone, which serves as the Smart cane system's primary processor, is outfitted with a program created especially for it. The application's features include: Receiving data from sensors on the smartphone cane, processing the data and producing audio notifications, sending audio notifications to Bluetooth headsets, offering turn-by-turn navigation, choosing the location of the navigation destination using a command sound, and using Bluetooth headsets as a delivery method for audio notifications.
Smart cane feature

Detection	Detects obstacles ahead	2 . detection distance meters Detection technology use laser
	- Detect holes in Street	Detect holes with a depth of more than 10cm (can be set from the application android) Detection technology using laser
	- Detect temperature	Detects high temperatures that could be caused by fire etc Range 0-200 degrees Celsius Technology using Thermocouples
	- Detect puddles of water	- Using probe technology electrode
Controller	- micro-controller	- NodeMCU / Beetle BLU
Connection	Smartcane connection to Smartphone Android	- Bluetooth 2.0 (serial)
	- Connect the Android smartphone to a headset	- Bluetooth 2.0 (audio)
Notifications	- Notifications Audio	
Navigation	Turn-by-turn navigation Sensor GPS	Mapbox API Technology Using the available GPS sensor on the Android smartphone

Order	- Command voice	Indonesian Speech Recognition technology from Google Speech Recognition FIRE
Power	Smart cane Smartphone Bluetooth headset	Rechargeable LiPo battery type 18650 2300mAh Rechargeable LiPo battery Rechargeable LiPo battery

The Flow of the System

The flow of the software design system follows the work principle flow, as shown in Figure 1.

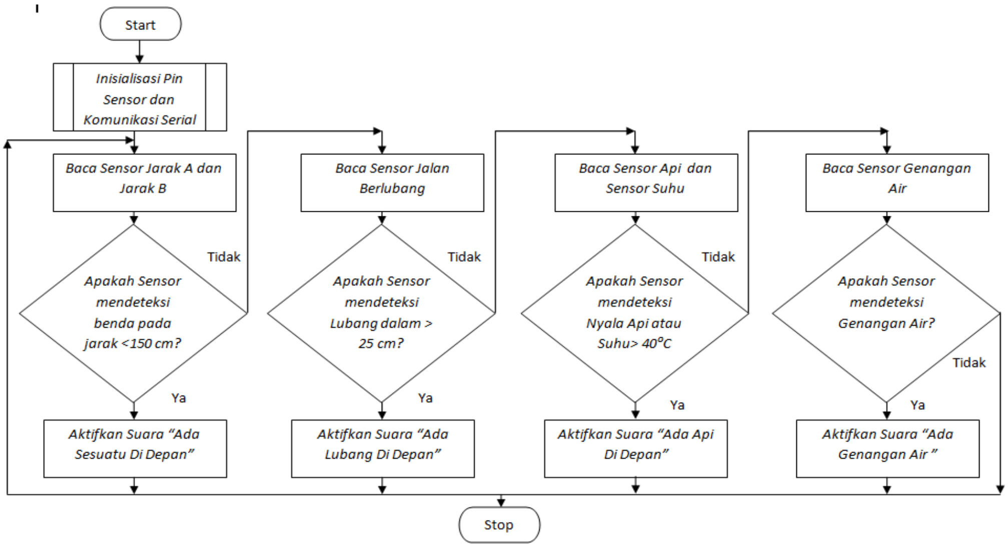


Figure 1: The software flow design

Mobile Application Integration Using IoT Technology

The following is an IoT-based android application development design

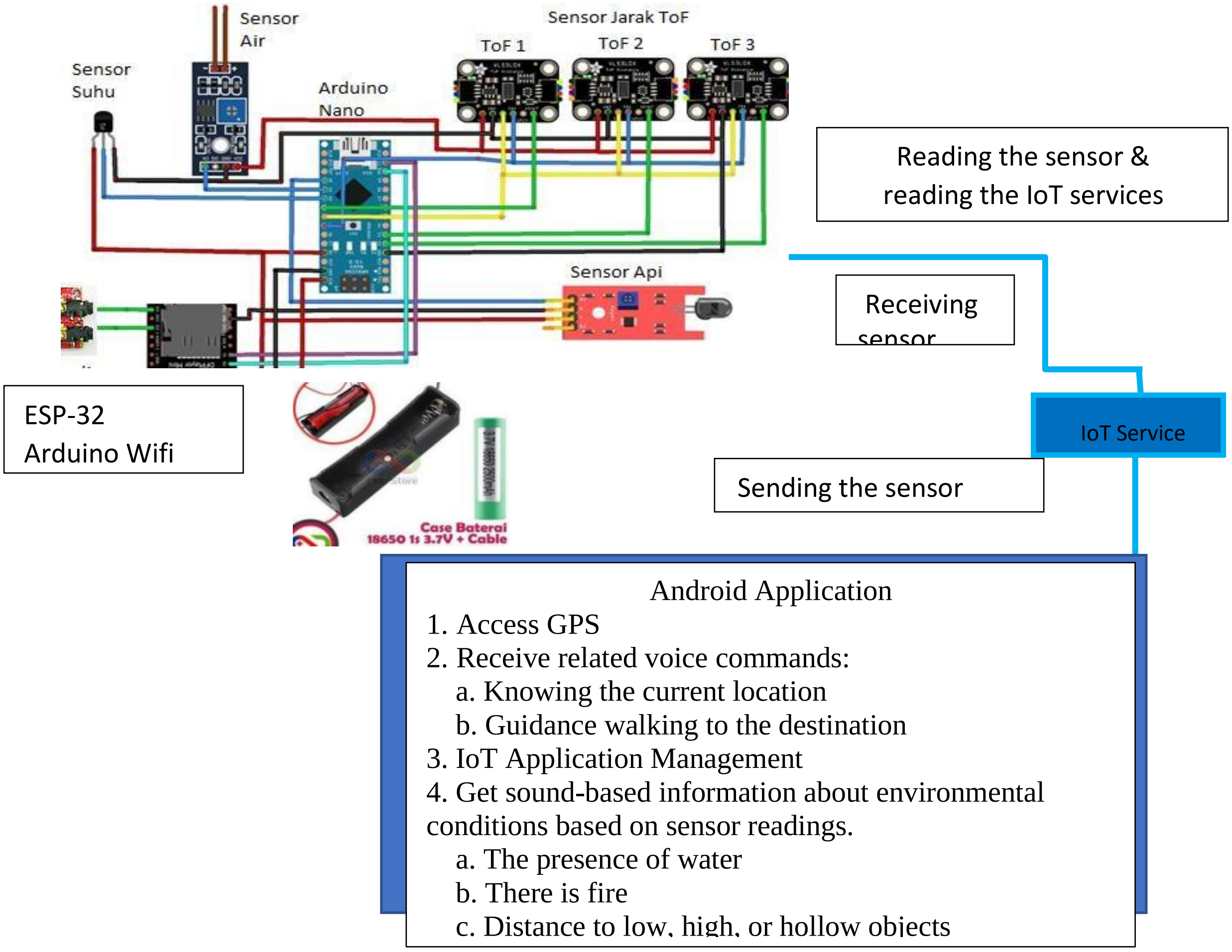
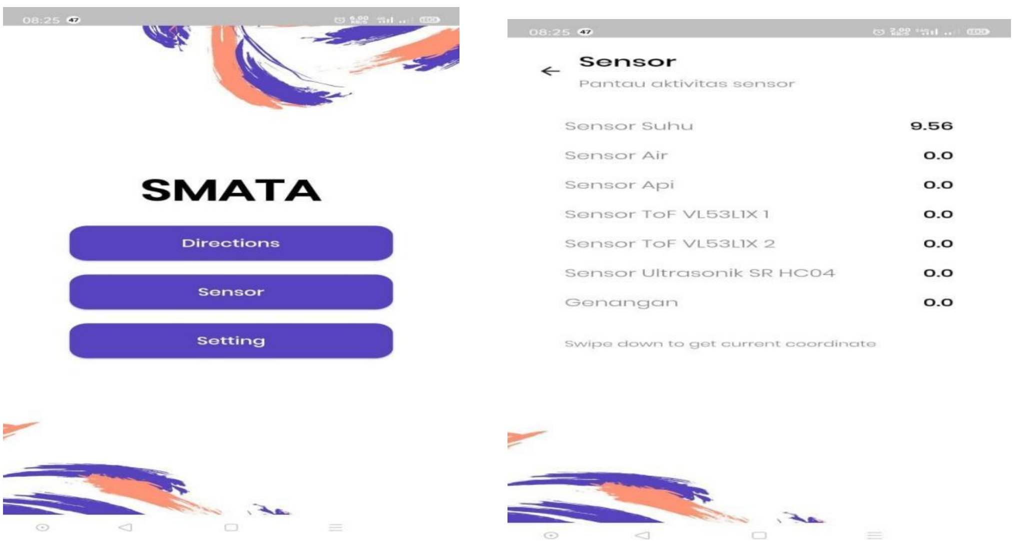


Figure 2. The developed tool design

SMATA application pictures that will support cane operation



Picture 2. SMATA Application Display

Conclusion

This study presents the development of a smart cane with various sensors to protect the blind from fires, mounds, and standing water in wetlands. Messages from Arduino nano sensors will be converted to audio to help users understand the information they have received. The smart cane has a GPS module and a GSM/GPRS module. The GPS module uses the data it gathers to help monitor visually impaired people and makes it simpler for blind individuals to make emergency calls. All of these elements help enable blind persons to navigate independently.

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