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Design of an Arduino Mega-Based Walking Cane Assistive Device to Improve the Quality of Life for the Elderly in the Riau Islands Province

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Abstract.
Purpose: The number of people aged 60 or older is expected to increase globally by nearly three times from 737 million in 2009 to 2 million by 2050. Indonesia's population is projected to reach 28 million by 2045, making up nearly one-third of the total population. In 2020, the population aged 60 or older reached 29.52 million, with 29.52 million from the last two houses being occupied by a house due to numerous housing programs that require a close relationship between people. The study suggests that a house with a strong sense of belonging is a risky group required attention. The study uses a smartphone with a 180° panorama camera and GPS to help locating the house and performing its activities.
Methods: Anthropometry can be defined as the study of body dimensions, namely body size, shape, strength and work capacity for the purpose of body design and composition and prototyping.
Results: This research has resulted in elderly sticks that use sensors to help elderly mobility. This stick can detect the environment nearby the ESP32-Cam with the password "/Capture_photo" and is able to send information about the location of the elderly by sending a message to the GSM Number connected to the Arduino Mega with the password "Hello" and the device will send a message containing the location of the elderly.
Novelty: Based on previous research reviewed by researchers, it was found that similar research using Camera and GPS Technology to Improve the Quality of Life of the Elderly has not been carried out in the Riau Islands of Batam.

Keywords: Arduino mega 2560, Camera ESP-32 CAM, GPS, Elderly, Prototype, Riau islands province, Walking cane
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INTRODUCTION

Indonesia is one of the countries currently exuberant on development issues to balance the ongoing process of global modernization [1]. Every technological innovation is designed to simplify and provide benefits to human life, thus offering solutions to many problems, including assisting the daily lives of visually impaired individuals with limited physical capabilities [2]. The design of strategies to increase the potential benefits of an organization is very important for renewal by implementing modern strategies [3]. With the increasing development of social civilization in living conditions and health levels, the average life expectancy is increasing. This has led to an increase in population aging in modern society [4]. Globally, the number of people aged 60 or older is expected to nearly triple, increasing from 737 million in 2009 to 2 billion in 2050 [5]. According to forecasting results, Indonesia's elderly population is estimated to reach almost one-fifth of Indonesia's total population in 2045. In 2020, the number of Indonesia's population in the age category of 60 years and over is estimated to reach 28 million people or 10.7% of the total population [6]. Nearly three out of ten households (29.52 percent) in Indonesia are occupied by elderly people. This information is exceptionally important asmany welfare programs for the elderly employ a household-based

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approach, since the elderly are in dire need of the support of the people they live with. Nearly three out of five (59.21 percent) elderly act as the head of the household, the person who is responsible for the household's daily needs. According to cohabitation status, around one in ten (9.99 percent) elderly people live alone. WHO (1977) stated that elderly people who live alone are a risk group requiring special attention [7]. According to Disdukcapil, the population of the Riau Islands Province reached 2.06 million people in June 2021. Of this number, 1.42 million people (69.1%) of the population of this province live in productive age and 63.88 thousand people (3.11%) live in the non-productive age group [8]. To adequately address vulnerabilities, nurses or assistants must be able to critically analyse concepts of care and identify vulnerable elderly at various levels of health care [9]. As the population of seniors increases, there is a growing need for new technology that can help seniors in their daily lives [10]. The development of products specifically for the elderly can improve the daily living abilities of the elderly and improve their quality of life, which is very important for promoting social development. However, public perception about the aging population is still very inadequate and the importance of special products for the elderly is not widely recognised in society. Studies on product designs specifically for the elderly are needed considering that currently there are many problems in designing products specifically for the elderly, for example, there is no systematic and targeted product development [11]. The availability of risk management allows designers to respond appropriately to threats by developing and implementing effective behavioural strategies and implementing appropriate crisis management measures to mitigate risks in the face of uncertainty [12], [13]. Therefore, the research team created a tool for the elderly in the form of a cane which was designed with the anthropometric dimensions of the average elderly and has renewable technology. This cane tool for the elderly has a 180° panoramic camera feature that is connected to the Android application of family members, so they can see the location of the elderly. This walking stick is also equipped with GPS with the purpose of family members can track when the elderly go out and carry out their activities independently so they can feel safe and comfortable. Operation of Camera and GPS Technology use the Arduino Mega type 2560 Microcontroller.

Previous research was employed for literature study and our reference in creating and designing Arduino Mega-Based Walking Cane Assistive Device as can be seen below:

1. Vibrotactile Guidance For Trips With Autonomous Vehicles For Persons With Blindness, Deaf Blindness, and Deafness [14], 2022. Research is conducted in Sweden and this research aims to improve independent travel for individuals who are visually impaired, deaf-blind, and deaf by addressing the challenges and technological possibilities at various stages of their journeys. Additionally, the study emphasizes the importance of ongoing research, especially for those with little or no vision, and explores the potential enhancements in design for vibrotactile guide devices within the context of autonomous cars.
2. A Third Eye With Human-Computer Interaction for the Visually Impaired [15], 2019. Research is conducted in Turkey and to diminish the reliance of visually impaired individuals on others because of their visual impairment. A total of ninety-six Braille cells are incorporated into the device's design. As a result, characters can be converted and displayed on these Braille cells within a block of 96 characters by utilizing Piezo Actuators within the Braille cell structure.
3. Experimental Study on Shoe Based Navigation System for the Visually Impaired [16], 2019. Research is conducted in India and the development of a shoe-based navigation system for the visually impaired is currently in progress, incorporating both Ultrasonic and Infrared Sensors. This innovative system is capable in detecting obstacles and interruptions along the user's path. Furthermore, it utilizes Wi-Fi to transmit distance data to caregivers or guardians via the cloud, thus presenting a valuable initiative to promote independent travel for the visually impaired, reducing their dependence on others.
4. An Electronic Smart Jacket for the Navigation of Visually Impaired Society [17], 2018. The research is conducted in India and a smart jacket has been designed specifically for individuals with visual impairments, featuring embedded sensors for obstacle detection and safe navigation. These sensors include a dedicated sensor, communication module, and a microcontroller. This electronic smart jacket represents a significant advancement over existing devices, as it combines both sensing and navigation functions within a single integrated unit. Experimental findings confirm outstanding performance, with a remarkable 98% accuracy in detecting obstacles within a range of 200cm.
5. Smart Path Guidance Mobile Aid for Visually Disabled Persons Utkal [18], 2016. The research is conducted in Japan and the development of an intelligent path guidance system, specifically a handheld mobility aid for the visually impaired, has been undertaken. This innovative device incorporates a smart sensor logic system and utilizes Fuzzy logic for enhanced functionality. Several dedicated system modules have been meticulously designed and seamlessly integrated. The final

prototype underwent testing at the Fiji Blind Society, with valuable feedback obtained from visually impaired individuals regarding its performance. The overarching objective of this initiative is to empower the visually impaired, enabling them to lead more active and independent lives.

6. Objects and Text to Enhance Navigation of Visually Impaired a New Architecture based AR for Detection and Recognition of Objects and Text to Enhance Navigation of Visually Impaired People [19], 2020. the research is conducted in Tunisia and a novel architecture based on augmented reality (AR) has been created to provide support for individuals with visual impairments. This AR-based architecture is designed to help individuals with visual impairments in identifying and quantifying their medication. Consequently, researchers have developed this AR architecture to aid in object recognition and assist the visually impaired in managing their medication.

METHODS

People always use products or goods that make their lives easier for daily basis, from getting up in the morning, working or other activities, to falling asleep [20]. With the advancement of technology, computer-aided design and manufacturing have been widely used in product design processes. For example, at the market research stage, computer data analysis may be introduced; at the concept stage, product sketches, renderings, and even real physical models are created through rapid prototyping based on computer-aided design, as well as design evaluation, reversal, and optimization iterations [21]. Anthropometry can be defined as the study of body dimensions, namely body size, shape, strength and work capacity for the purpose of body design and composition [22]. The human hand stands as the most intricate and specialized musculoskeletal instrument within the human body, requiring the highest level of involvement from the nervous system. Having the hand fully operational and possessing sufficient strength are essential for managing the challenges of daily life [23]. Based on data from Anthropometry Indonesia, the dimensions used in designing the Stick Tool are Hand Width and Elbow Height with an average dimension of 15.17 cm and 118.17 cm. For flowchart about this research can be seen in Figure 1.

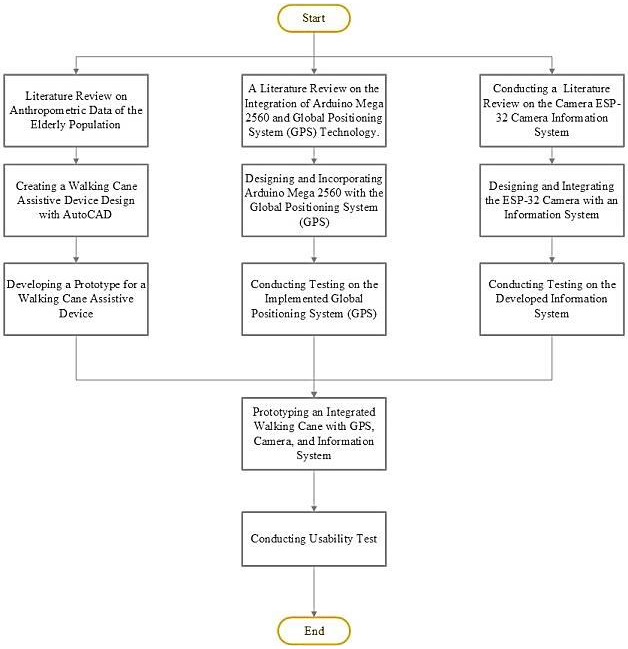

Figure 1. Research flowchart arduino mega-based walking cane assistive device

The Arduino Mega 2560 is a precise microcontroller board that follows an open-source design, serving as the next iteration of the Arduino Mega, which utilizes the ATmega2560 SMD chip as its foundation [24].

Cane Walking Aid Design

The cane design process is carried out using AutoCAD software [25], with careful consideration of human body dimensions. This process is intended to ensure that the cane is not only functional but also meets critical aspects such as safety, security, and user comfort [23]. By applying ergonomic design principles, the 3D cane design was done meticulously to ensure that its shape and size align with human body

characteristics, thus reducing the potential for injury or discomfort during use [26]. The visual results of the 3D cane design are shown in Figure 2.

Figure 2. Cane walking aid 3D design

After creating the 3D design using AutoCAD software, researchers proceed to develop a prototype based on this design. The walking aid cane is designed according to the average anthropometric data of the elderly population in Indonesia. The stick adheres to anthropometric dimensions such as Grip Diameter (GD) and Standing Elbow Height (SEH), measuring 16 cm and 118 cm respectively. For a visual representation of the prototype, please refer to Figure 3:

Figure 3. Cane walking aid prototype

Block Diagram Robot Design

The primary choice for the design of the robot used in the smart cane microcontroller brain is the Arduino Mega 2560 [24]. The Arduino Mega 2560 is selected because it possesses sufficient processing power to control various functions that will be implemented in the robot.

In the next stage, the Arduino Mega 2560 will be programmed with customized code to control the necessary functions in the robot, including integration with additional components such as the ESP32 Camera and SIM808 GSM/GPS [27]. This integration will enable the robot to track the user's position and capture visual data from the user's surroundings through the camera mounted on the smart cane. By integrating all of these components, the robot is expected to provide high-precision user position tracking capabilities and the ability to visualize the user's surroundings through the smart cane. The conceptual design of the developed robot is illustrated through the block diagram in Figure 4.

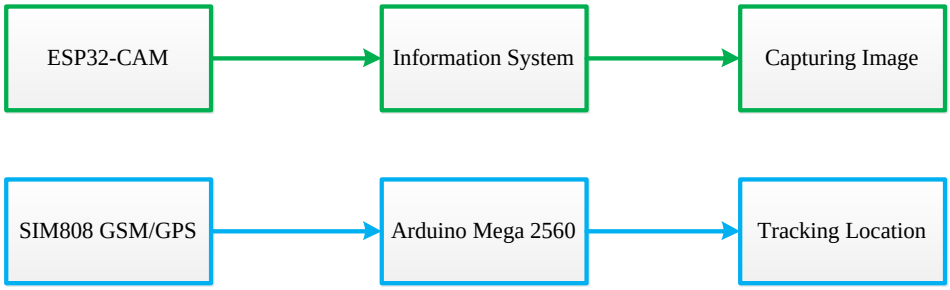

Figure 4. Block diagram arduino mega 2560

RESULTS AND DISCUSSIONS

Robotic Design

A robotic system encompasses a spectrum of configurations, ranging from basic single manipulators to fully equipped robotized Computer Integrated Manufacturing (CIM) systems [28]. Notable examples include single manipulators, multiple robot systems, and Flexible Manufacturing and Flexible Assembly Systems (FMS, FAS) that incorporate service robots. Additionally, specialized robotic applications, such as micro-robots, surgical robots, space and underwater robots, as well as walking and wall-climbing robots, can also be considered [29]. For robotic design of Cane Walking Aid design can be seen below:

1. ESP32-Cam Camera

The ESP32-Cam Camera is a camera module used to capture images and videos, which can be utilized for visual tracking and monitoring [30]. In the camera coding segment, the researcher employed Arduino IDE software version 2.2.1. The Arduino Software (IDE) simplifies the process of code composition and offline uploading to the board. The following is Pseudocode for the coding details:

```
START
    DECLARE ssid AS CONSTANT STRING
    DECLARE password AS CONSTANT STRING
    DECLARE BOTtoken AS STRING
    DECLARE CHAT_ID AS STRING
    DECLARE capture_Photo_with_PIR_state AS BOOLEAN
    DECLARE Messages AS BOOLEAN
    FUNCTION sendPhotoTelegram
        // Implementation of the sendPhotoTelegram function
    END FUNCTION
    FUNCTION MAIN_PROGRAM
        START
            IF capture_Photo_with_PIR_state IS ON THEN
                CALL sendPhotoTelegram()
            END IF
            IF Messages IS ON THEN
                CALL sendPhotoTelegram()
            END IF
        END FUNCTION
END PROGRAM
```

The electronic circuitry of the ESP32 Camera is shown in Figure 5:

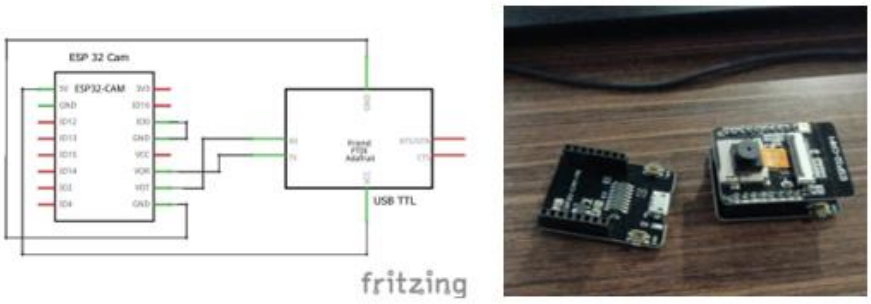

Figure 5. Electronic circuitry of the camera and PIR sensor and camera ESP32-Cam with PIR sensor

The system starts working when the laptop is connected to a WiFi network. The ESP32 Cam is then connected to the laptop and uses the assistant's mobile hotspot WiFi connection to obtain an IP address. In case the IP address cannot be created, we must ensure the functionality of the WiFi network. Afterward, the PIR sensor detects motion, causing the ESP32 Cam camera to capture the view in front of it and send the family or assistant's smartphone application. One of the smartphone applications used is Telegram. For our testing can be seen in Figure 6:

Figure 6. Photo testing of ESP 32 cam using PIR sensor with application telegram

After command is typed "/capture_photo" as seen in Figure 6, ESP 32 Cam will send photo to our application (we use Telegram application). We can receive photo like Picture 6 and ESP 32 Cam will send the surrounding area to give information about the elder so we can locate where the elder is. PIR Sensor supports the ESP 32 Cam and will send photo automatically if it detects foreign object or other motion.

2. SIM 808

The SIM808 GSM/GPRS/GPS board is a development board created by AND Technologies for Arduino, equipped with a Quad-band GSM/GPRS engine also it supports GPS satellite navigation. The combination of GSM/GPRS/GPS allows remote monitoring and control of systems via SMS. SIM808 serves as a communication module that provides GSM/GPRS/GPS network capabilities for communication. SIM808 is in the form of a shield that can be directly integrated with Arduino. It requires a voltage supply ranging from a minimum of 5 volts to a maximum of 12 volts, indicating the physical form and specifications of the SIM808 module. Moreover, the operator can receive status updates about the PV array through SMS notifications facilitated by a GSM module, specifically the SIM808 module [31].

In the SIM 808 coding segment, the researchers employ Arduino IDE software version 2.2.1. The Arduino Software (IDE) simplifies the process of code composition and offline uploading to the board. The following is pseudocode for the coding details.

```
START
    DEFINE MESSAGE_LENGTH = 160
    DEFINE STRING_LENGTH = 12
    DECLARE MESSAGE[MESSAGE_LENGTH]
    DECLARE INCOMING_MESSAGE[300]
    DECLARE LATITUDE[STRING_LENGTH]
    DECLARE LONGITUDE[STRING_LENGTH]
    DECLARE SPEED[STRING_LENGTH]
    DECLARE PHONE_NUMBER[STRING_LENGTH]
    DECLARE TIMESTAMP[STRING_LENGTH]

    FUNCTION READ_SMS()
        READ messageIndex AS sim808.isSMSunread()
        IF messageIndex > 0 THEN
            READ_SMS_CONTENT()
            GET_GPS_DATA()
            SEND_SMS()
            DELETE_SMS(messageIndex)
        END IF
    END FUNCTION

    FUNCTION READ_SMS_CONTENT()
        READ MESSAGE AS sim808.readSMS(messageIndex, message,
MESSAGE_LENGTH, PHONE_NUMBER, TIMESTAMP)
    END FUNCTION

    FUNCTION GET_GPS_DATA()
        START
            WHILE NOT sim808.attachGPS() DO
                WAIT(1 SECOND)
            END WHILE
            WAIT(3 SECONDS)

            WHILE NOT sim808.getGPS() DO
                // Wait until GPS data is acquired
            END WHILE

            LATITUDE <- sim808.GPSdata.lat
            LONGITUDE <- sim808.GPSdata.lon
            SPEED <- sim808.GPSdata.speed_kph

            CONVERT_FLOAT_TO_STRING(LATITUDE, 4, 6, LATITUDE)
```

```
            CONVERT_FLOAT_TO_STRING(LONGITUDE, 4, 6, LONGITUDE)
            CONVERT_FLOAT_TO_STRING(SPEED, 6, 2, SPEED)

            INCOMING_MESSAGE <- "http://maps.google.com/maps?q=" + LATITUDE
+ "," + LONGITUDE + "\n"
        END FUNCTION

    FUNCTION SEND_SMS()
        START
            PRINT("Start sending message...")
            PRINT(INCOMING_MESSAGE)
            PRINT(PHONE_NUMBER)
            sim808.sendSMS(PHONE_NUMBER, INCOMING_MESSAGE)
        END FUNCTION

START_PROGRAM
    mySerial.begin(9600)
    Serial.begin(9600)

    WHILE NOT sim808.init() DO
        PRINT("Sim808 initialization error")
        WAIT(1 SECOND)
    END WHILE

    WAIT(3 SECONDS)

    PRINT("Initialization successful, please send an SMS message!")

    WHILE TRUE DO
        READ_SMS()
        PRINT("Please send an SMS message!")
    END WHILE
END_PROGRAM
```

For our SIM 808 Module attached with GSM card can be seen in Figure 7:

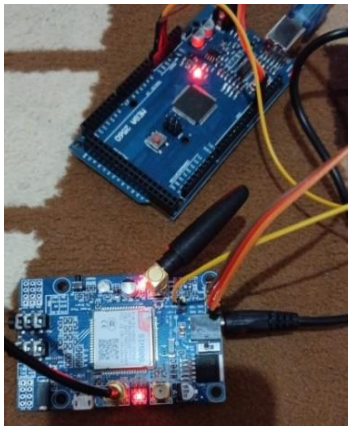

Figure 7. SIM 808 attached to arduino mega 2560

SIM 808 attached with GPS Simcard is important in module. It will reply our SMS with GPS coordinate (we directed the coordinate with Google Maps). We need to send SMS to number registered to get SMS reply with coordinate where the GPS holder is. SMS reply with coordinate can be seen in figure 8:

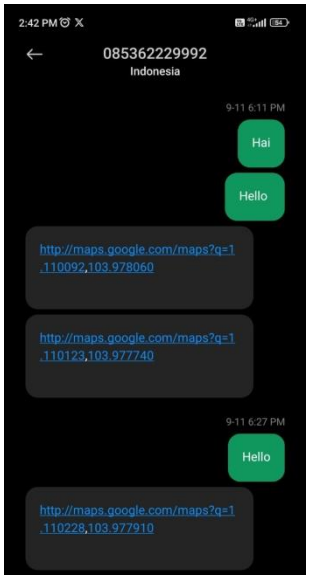

Figure 8. SMS notification from SIM 808

After we got SMS reply, we can tap the link provided to open the location of GPS. On this term we put on prototype and we can track the elder.

3. GPS

The SIM808 GSM/GPS module will be used to retrieve user location data through GPS signals and to communicate with other devices or servers via the cellular network [32]. The Electronic Circuitry of the GPS System is shown in Figure 9.

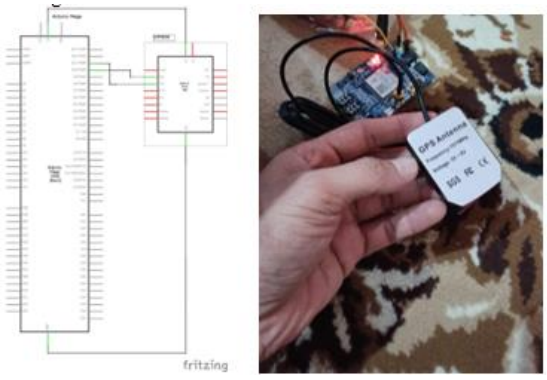

Figure 9. Electronic circuitry GPS and GPS antenna

Researchers perform the coding work using The Arduino Software (IDE). The following is pseudocode for the coding details.

```
START
    DECLARE MESSAGE_LENGTH AS INTEGER
    DECLARE message[MESSAGE_LENGTH] AS CHARACTER ARRAY
    DECLARE messageIndex AS INTEGER
    DECLARE MESSAGE[300] AS CHARACTER ARRAY
    DECLARE phone AS CHARACTER
    DECLARE datetime AS CHARACTER

    FUNCTION sendSMS
        // Implementation of the sendSMS function
    END FUNCTION
```

```
FUNCTION getGPS
    // Implementation of the getGPS function
END FUNCTION

FUNCTION readSMS
    // Implementation of the readSMS function
END FUNCTION

FUNCTION MAIN_PROGRAM
    START
        IF messageIndex > 0 THEN
            CALL sendSMS
            CALL getGPS
            CALL readSMS
        END IF
    END FUNCTION
END PROGRAM
```

After doing coding work above, we shall send SMS the number which is registered on SIM 808. After we got the SMS notification from registered number, we click the link on thes SMS then as the result, we are directed to Google Maps Application with real time coordinate where the module is located. The coordinate can be seen in figure 10 below:

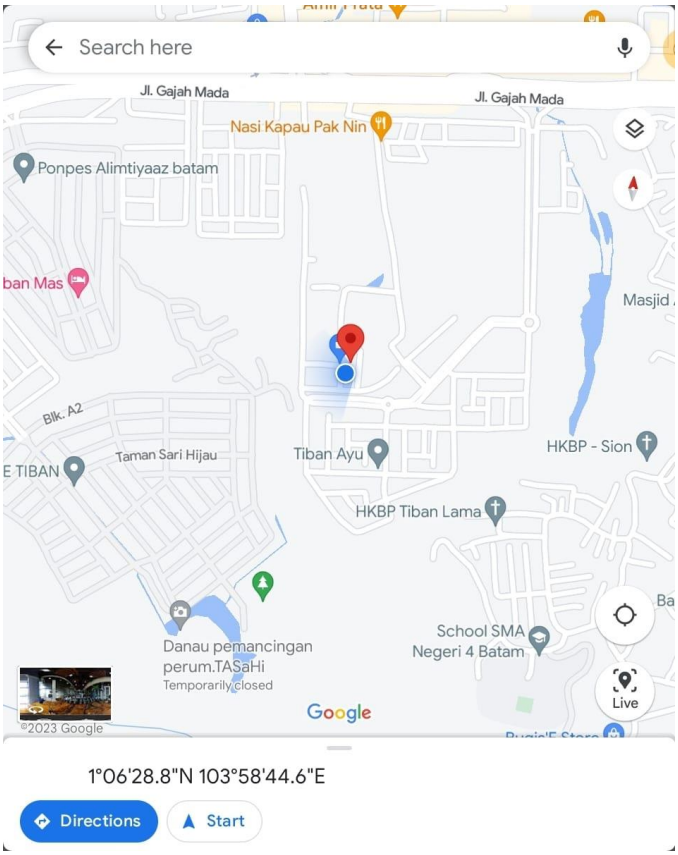

Figure 10. Result of GPS module with IDE software on google maps applications

Figure above is sent to SMS reply from registered number. So we as assistant or family will know where is the location of the elder by sending the SMS, get SMS reply, open link, and check the location on GPS periodically as needed.

4. Combined Modul

Having created those modules, we combine those modules into one prototype so we can try the Walking Cane Assistive Device.The scheme of hardware can be illustrated as the following:

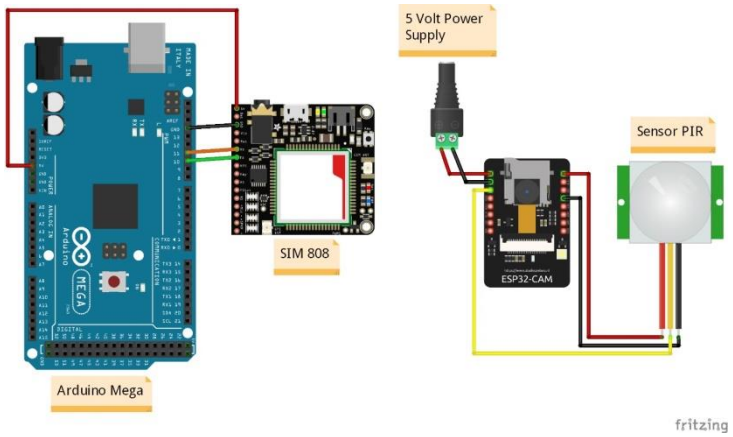

Figure 11. Schematic of the hardware of walking cane assistive device

We combine the modules and assemble them to get the function, then, we combined them with walking cane prototype. The combined prototype with walking cane can be seen inin Figure 12.

Figure 12. Prototype of arduino mega-based walking cane assistive device

5. Usability Testing

After combining the all module, researchers conduct several usability testings with an elderly. All modules are working like figures above. The prototype is going well even after we combine it into one box of module. The elderly can use it directly and the assistant or family of elderly can use the prototype. Usability testing can be seen in Figure 13.

Figure 13. Usability testing of prototype arduino mega-based walking cane assistive device

Our prototype design refers to ergonomic design. The prototype design is comfortable to use since it is based on to the height of the user's arm while the user's hand grip refers to anthropometric design. Our design is based on anthropometric awareness so the elder use it comfortably according to usability tester above.

We create this walking cane with Arduino-based to help the elderly in Riau Islands Province. We compare to other walking cane assistive device to ours. The comparison can be seen in Table 1 below:

Table 1. Comparison of walking cane assistive device to ours

No	Other Research	Year	Proposed Research Compared to Our Research		Our Novelty
			Strength	Weakness	
1	Design and implementation of a solar powered navigation technology for the visually impaired [33]	2022	With vibrating sensor can help elderly as well	Using solar panel energy and battery. Not really effective energy consumption	• This product utilizes the latest technology, including GPS. This allows seniors to access the latest technological developments to improve their quality of life. • Anthropometric design can boost user comfort while using the Prototype. • This kind of research is never conducted in Riau Islands Province • It supports elder's daily activities without needs of supervision from family members or assistant.
2	A survey on Assistive Technology for visually impaired [34]	2020	With animal detection and with currency denomination detection	It still hasn't shown the energy source of the prototype and expensive	

CONCLUSION

Based on the results of the testing of the Arduino Mega-based elderly stick system that has been carried out, the following conclusions can be drawn as the results. This study indicates that families do not need to worry, and the elderly can become more independent because the Module t installed on the walking cane. This research has resulted in elderly sticks that use sensors to help elderly mobility. This stick can detect the environment around the ESP32-Cam with the code "/Capture_photo" and is able to send information about the location of the elderly by sending a message to the GSM Number connected to the Arduino Mega with the SMS text and the device will send a message containing the location of the elderly via Google

Maps in real time location. From the test results of the entire system, it can be concluded that this stick can operate optimally. Therefore, the elderly can do their daily activities normally without surveillance from their assistant or family members.

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