SBVI: A low-cost wearable device to determine location of the visually-impaired safely

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Abstract. Visually Impaired (VI) is blind people that low vision. They are difficult to recognize an environment like an indoor building or pedestrian. So, that needs a tool which suitable and smart for them. Many research and products have been developed assistive device increasing with smart technology, but it requires a high cost. For our purpose, its to develop a low-cost device and connected to the smart mobile. We are consisting to develop a smart prototype, it can use to determine the localization of blind people when lost or need support. By utilizing mobile apps on smart mobile, it provides a map-based message for the Visually Impaired safely. The device made small size and accurately.

1. Introduction
Blind or we called the Visually Impaired people, they have health disorders due to major difficulties for mobility access in the environment. So, they will get risk and complexity for obtaining the environment like room building or the pedestrian's spot [1], [2]. Those viewed when moving around pedestrian and unknown spots without guiding assistance, it gets lost or disturbed by irresponsible people. Actually, some people can be helping them, but that not giving more solutions if they stayed out of place. As for the Visually Impaired usually they utilize instincts in recognizing the environment but not all can be known or memorized. We know around in environment it not only available a signpost for blind people but also mostly not appropriated for them. So, much research is done developed and built more devices or may special line by various technologies implementation [3]–[5]. As we all use smart devices but it has a complexity to hard or expensive when used for blind caused their needs practices, adapted in several times as well as needs much money. According to blind people, they need some wearable tools to accompany and protect them in activities safely.

So, from that background, this research has developed a small smart device to give simplicity and also inexpensive. By using the Internet of Thing (IoT) which is currently very developed by various researches [6]. Our project name is SBVI (Smart Bracelet for Visually Impaired), which can work to help the blind when lost and need supports, also protecting them. Its made by low-cost parts and material. Furthermore, this study only focuses on Indonesian blind people. In addition, this research was supported by a university research grant and Indonesian blind private institution.

2. Low-Cost Design
When the Visually Impaired needs assistive devices. This research develops worthy technology for the deaf, especially to protect the Visually Impaired safely. So, we design a device with prioritizing
suitable functions. Our concept is to help the Visually Impaired when get lost. Our concept is to help the Visually Impaired when get lost in various locations. This system has developed utilize low-cost material part which uses the electronics component. Moreover, that design uses a minimum budget of more than $100, each part available to buy in the electronic market. The purpose idea is facilitating the assistive technologies for the Visually Impaired in their activities. The overall cost spent to build the prototype is $47; its shown detail presented in Table 1.

Table 1. Parts of device

| Component           | Unit Price ($) | Quantity needed | Subtotal Cost |
|---------------------|----------------|-----------------|---------------|
| (GPS) U-Blox Neo-6M | 18             | 1               | 18            |
| (GSM) SIM 900-a Module | 14         | 1               | 14            |
| Arduino Micro       | 7              | 1               | 7             |
| Button              | 1              | 4               | 4             |
| Li-ion Batteray     | 2              | 1               | 2             |
| Additional Material | 2              | 1               | 2             |

3. Research Work

3.1. SBVI architecture
The system section of the design mainly using GPS sensor and GSM module installed, it used to detect and to send satellite data and convert as a message. GPS has a unique ability that can transmit data through real-time and mostly smart device used it for obtaining a position [7]. We used a microcontroller that can be controlling the system also proceed the data. In message text, its included the support message when they are needs a help. In other that, we used the google map apps to display the location map in the smartphone. To activate the device and transmits a notification, the user must be pressed the buttons it. There is two button which is the first button for activation and the second button for sending. Our system only uses minimum supply and long life caused design system its smaller and worthy. In another case, we use the cheap materials and wearable parts like a elastics bracelet and 3D printing its for PCB design. Figure 1 and Figure 2 both are shown the system design and the system work.

3.2. SBVI Hardware and software
Our device is used electronic sensor and part. The main sensor is the GPS U-Blox Neo 6M series that important for our device its to obtaining the land coordinate data (i.e. latitude, longitude, speed Mph). After getting the coordinate, the system will convert it using Arduino pro-mini (microcontroller series) as a message notification. For send the data to a smartphone, the system used the SIM 900a-GSM
module type which needs an Indonesian SIM card model. To build the device it uses additional software for drawing schematics system [8]. Two push button mounts in the device are used to process start/stop and transmit the message data. Due to several part needs and limited supply, so we utilized the step-up/down module it can be floating of voltage. Furthermore, to switch on the system, we used a Li-ion battery of 9 Volt. To adjust the minimize the wearable device, also we design neatness the cable tagging.

![Flowchart](image)

**Figure 2.** Flowchart

4. **Results and Discussion**
After a developed prototype, next stage is implemented to subject and trained by user exercise and get around in several locations. The system has been tested in five locations of four campus buildings and two public areas. Performance measurement that is determined accuracy of location recognized and message received
4.1. User Experiences
The prototype was small size designed it can be mounted on the arm or wrist. The tutorial installing process for the blind is shown in Figure 3. The procedure of test and train the device as follows:
1) We choose the visually impaired as the user and the trainer as the personal operator.
2) To introduce the system setting and start through an additional native speaker.
3) A user activates the system by the first button and next, they must be walking around into nearby spot
4) After that, they must button pressed of the second button in the random spot
5) Before the Personal operator activates the internet access in the smartphone, while they will get a message from a user device, they can be displayed through an online map and take it.
6) The personal operator also observes and check the accuracy of the direction parameter of user location

![Figure 3. User tutorial](image)

We were tasted by five subjects and get around six locations. we still semi-guided training and testing by walking or using the vehicle.

4.2. Message Notification
A notification message it provides for the personal operator. That included two messages which a help message and location map. The aiding message has three options, first about the information needs of directions, disruptions, traps of strangers. Figure 4 shown the message notification.

![Figure 4. Three optional message and link of map for knowing the user need](image)
4.3. Map-based localization

The prototype device is utilized the online map through mobile apps by google map database. That has
the advantage to recognize and detect the location within accurate of position coordinates using
satellite database also its free access. To display the map, the operator used a smartphone and must
connected internet network. One of visualization of map-based localization its present in Figure 5.
That is the result of user test it conducted between 3rd campus to the 5th campus of Universitas
Ahmad Dahlan.

![Figure 5. Tracking user using online map](image)

4.4. Performance Correction

This study is done tested that finished by walking around in six locations. We conducted to recognize
campus spots and random spots both happen in Yogyakarta, Indonesia. The campus spot is
chosen at Universitas Ahmad Dahlan which have five campuses building in several locations also
conducted city centre spot and airport in Yogyakarta. We used two parameters to measure its obtained
by distance and accuracy of system recognize. Eq (1) its use to performance calculate of the system.
Table 2 is present the system ability through user experience.

| Operator Spot       | User Location          | Distance Rate (KM) | Miss Distance (Meter) | Accuracy (%) |
|---------------------|------------------------|--------------------|-----------------------|--------------|
| 3rd Campus of UAD   | 1th Campus of UAD      | 1.3                | 10                    | 99.23        |
| 3rd Campus of UAD   | 2nd Campus of UAD      | 1.4                | 20                    | 98.57        |
| 3rd Campus of UAD   | 4th Campus of UAD      | 2.9                | 21                    | 99.27        |
| 3rd Campus of UAD   | 5th Campus of UAD      | 2.7                | 50                    | 97.82        |
| 3rd Campus of UAD   | City Centre of Yogyakarta | 2.8              | 20                    | 99.28        |
| 3rd Campus of UAD   | Yogyakarta Airport     | 5.2                | 15                    | 99.71        |

Accuracy average as follows = \[
\frac{(\text{Distance rate} - \text{Miss distance})}{\text{Distance rate}} \times 100\% \tag{1}
\]

5. Conclusion

We purposed to build a low-cost wearable device it appropriate for blind. By using low-cost parts and
material which provided to develop a simple device and can be mounted on the arm or wrist. The
device can be accompanied and protect the visually impaired safely it provided user tracking and
support assist through the real-time message. Our device has generated an ideal concept and suitable
prototype for ease of use. In other studies, we will build a different smart device by medical approachment to blind and disability people.

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