Smart Armband for Early Detection of Hypothermia and Hypoxia with the Location Tracing System during Emergencies Based LoRa on Hikers

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Abstract
Hiking has a dangerous risk of accidents and deaths of hikers. It is caused by health problems, lost, and other accidents. A LoRa-based smart armband was designed to detect hypothermia, hypoxia, and emergencies in hikers based on the above explanation. Furthermore, all activities can be monitored using a web accessed through smartphones or computers. If hypothermia and hypoxia are detected, the smart armband will remind the hiker. The IMU sensor will detect movement orientation and acceleration of the hiker during emergencies to be sent to the hiking post for evacuation. All activity data are stored in a micro-SD for evaluation. From the test results, the armband functioned at temperatures ≤35℃, air pressure ≤ 560,2 mmHg, and acceleration ≥200 cm/s2. The test results also proved that the armband lasted up to 35 hours.

Keywords: *Armband, Hypothermia, Hypoxia, Emergency, LoRa.*

I. INTRODUCTION

Hiking is a favorite activity. The lack of preparation before hiking, e.g., physical, mental, and instrumentation preparations, will pose a dangerous risk leading to problems. These problems are accidents and deaths of hikers. According to the National SAR Agency (BASARNAS) data, accident, or death cases during hiking increase annually. From 2015 to 2018, there were 26 death cases from 130 hiking cases. Also, in 2019, 17 hikers were lost during hiking in Indonesia. Hiking accidents may be caused by health problems (47%), lost (29%), and other accidents (24%) (Ridwan, 2020).Health problems commonly occur during hiking are hypothermia and hypoxia. Environmental changes caused by height are the cause of hypothermia and hypoxia in hikers. The higher the environment, the lower the temperature, followed by increased moisture, wind speed, and sunlight intensity, and decreased oxygen pressure (Chawla and Saxena, 2014).Hypothermia often occurs in hikers is Accidental Hypothermia. Accidental Hypothermia is a condition where body temperature indeliberately drops below normal (36,5°C-37,5°C) to 35°C or more. This condition is due to environmental changes such as season, climate, or height. Hypothermia may occur due to increased heat loss, decreased heat production, or disturbed body heat regulation (Dow *et al*., 2019). When environmental changes take place, the body will retain body temperature as normal. This body protection is regulated by the hypothalamus as the body heat center, controlling cold and hot responses in the body (Danzl, 2017 and Dow *et al*., 2019).

Based on body temperature, hypothermia can be classified into mild (35-32oC), moderate (32-28 oC), and severe (<28 oC) (Soar *et al*., 2010). If the body temperature reaches 33°C to 34°C, hypothermia can be marked by reduced brain activities, e.g., confusion, apathy, fatigue, sleepiness, bad decision-making, and comma. When the body temperature drops under 30°C, a significant heart rate drop occurs, and the heartbeat slows down. If the body temperature reaches below 28°C, the heart will be susceptible to ventricle fibrillation. It can be triggered by acidosis, hypocarbia, hypoxia, or movements. The respiration response is decreased ventilation and respiratory acidosis caused by excessive carbon dioxide (Dow *et al*., 2019). Besides hypothermia, hikers are at risk of hypoxia during hiking. Hypoxia is when the body experiences oxygen availability reduction in the body. If this reduction is caused by height, where atmospheric pressure drops surrounding the environment, it is called Hypobaric Hypoxia (Chawla and

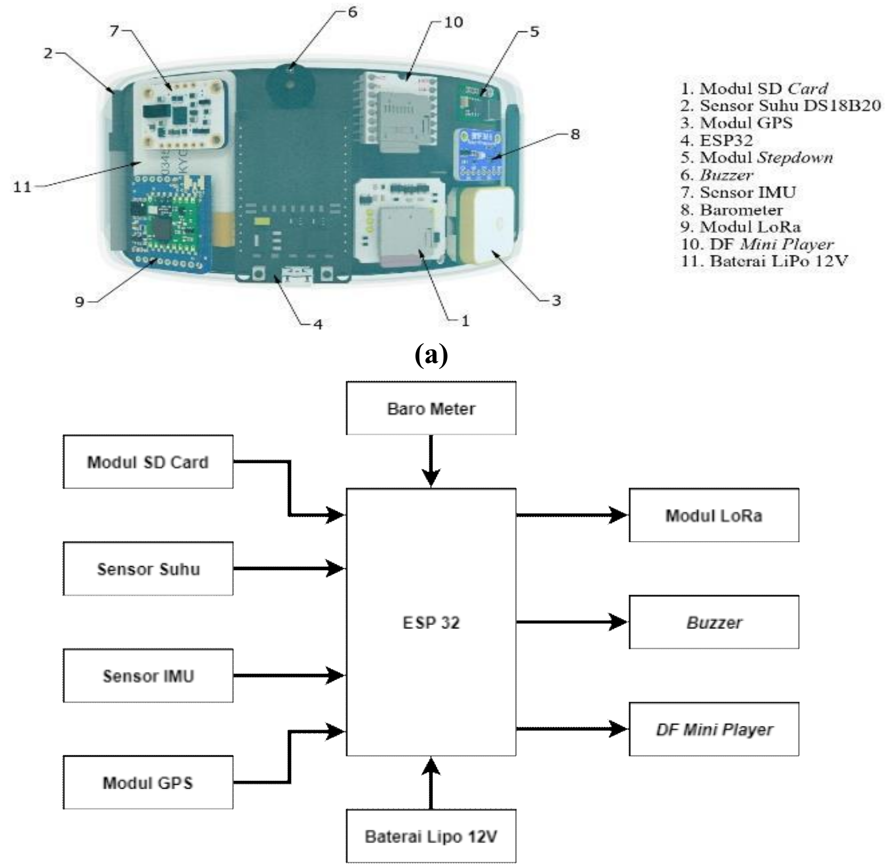
Saxena, 2014). It mostly occurs at heights over 2.340 m (8000 feet) (Luks, 2017). At sea level, the air pressure is 760 mmHg, and the atmospheric oxygen partial pressure is 159,2 mmHg. Meanwhile, at 2.500 m over sea level, the atmospheric air pressure drops to 560.2 mmHg, and its oxygen partial pressure is 117.4 mmHg (Chavala, 2018). Therefore, the higher the environment, the lower the available atmospheric pressure. This atmospheric pressure drop decreases available atmospheric oxygen partial pressure, followed by the pulmonary oxygen partial pressure. It shows the body's compensation in maintaining homeostasis in height (Chawla and Saxena, 2014). If such health problems are not treated, possibly fatal health problems and death may occur.Accident problems during hiking, e.g., lost hikers, can be caused by difficult path access due to the lack of road signs, steep paths, fatigue, loss, and fall (Uditama *et al*., 2018). Various dangers encountered during hiking are the cause of accidents during hiking. According to the Pengetahuan Pecinta Alam (PAPAS) (Erone, 2010), hiking dangers can be categorized into external and internal.

External dangers come from nature, such as being hit by rocks, cliffs, fog, lightning, and suddenly bad air. Meanwhile, internal dangers come from the hikers, such as a weak body, insufficient experiences and knowledge, and mental health problem records (Sujud, 2020). Moreover, the limited internet access in mountain area is another cause of difficult hiker search by trace the path that has been traversed (Arifin, 2016). Development and studies concerning an emergency condition detector armband are limited. Setiawan *et al*. (2016) developed a body warmer jacket using a PID controller based on Arduino. Meanwhile, Ardi *et al*. (2021) developed a jacket heated with a microcontroller and android-based electrical heater control. Wu and Chen (2021) asserted for creating a multifunctional wearable instrument based on radio communication for hikers. The designed wearable instrument has functions where users can communicate via transceiver radio, body temperature and heartbeat detector, an emergency button to send danger signals, battery saving, positioning, and a combination of drone and radio communication for searching and rescuing.These developments urged the authors to develop a smart armband for early detection of hypothermia, hypoxia, and emergencies and remote monitoring without signal. The monitoring is carried out via a web accessed through smartphones or computers. The armband design is practical to carry and easy to install on the hiker. Emergencies include lost, hypothermia, hypoxia, and falling during hiking. The emergency mode is active in emergencies, sending the hiker location to the hiking post for evacuation. The measurement data will be stored to evaluate hiker conditions.

II. METHOD

Fig 1. Study Framework

In Figure 1, the study process method was initiated by a literature study. In this step, the authors examined and read literature related to the study. Literature in this study included scientific journals, books, or internet sources. Subsequently, the authors designed the hardware, software, and electrical scheme.



(a)

(b)

Fig 2. (a) Design Illustration **(b)** Hardware Diagram Block

In the hardware designing step, the authors created a design following the figure. The material was a drill cloth of 10 x 7,5 x 3 cm^3. This armband consists of electronic components to run the entire system.This instrument uses a LiPo 4,2V battery as the main power source. Input comprises a DS18B20 sensor, barometer, IMU sensor, GPS module, and SD card module. The output comprises a buzzer, DF mini-player, and LoRa module. Data are processed using the ESP32 in this instrument. Temperature, air pressure, and movement reading data are sent to the web accessed through smartphones or computers to monitor hiker conditions.

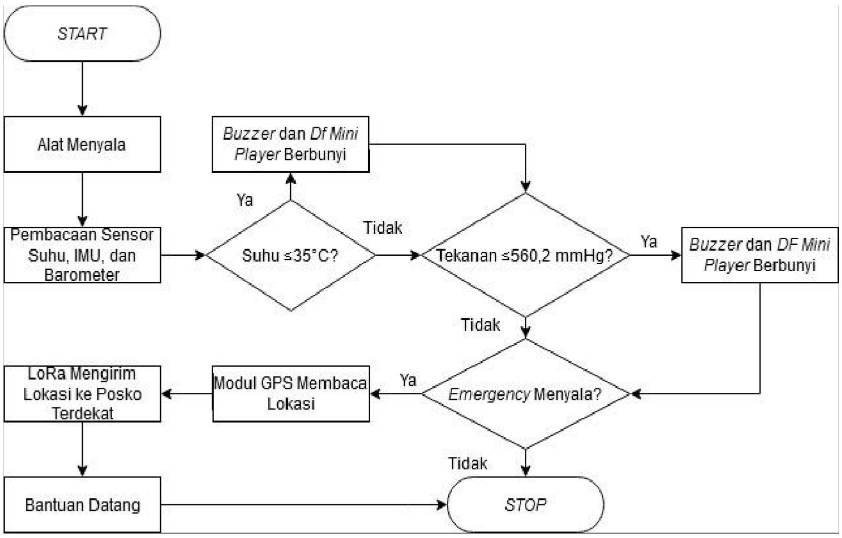


Fig 3. Flow Diagram

In the software designing step, the authors designed software, which includes in this study's system flow.

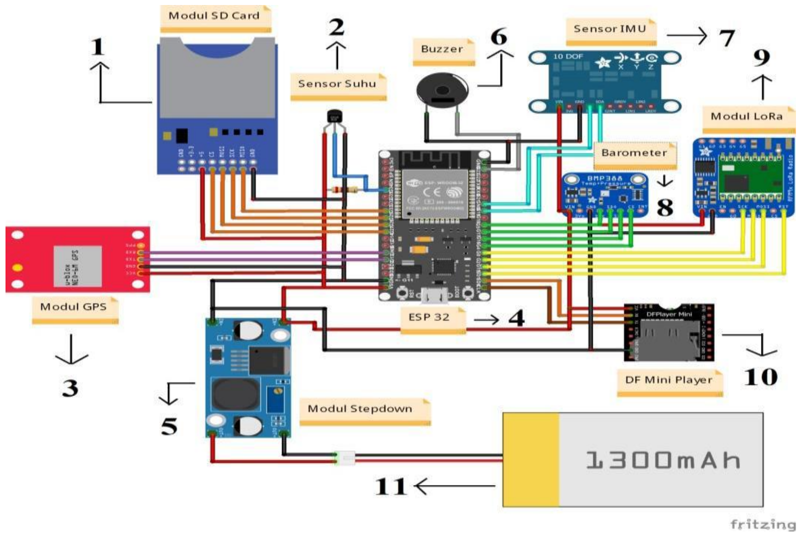


Fig 4. Overall Electrical Sequence

Figure 4 displays the overall electrical sequence used in this instrument. It consists of an SD card module, DS18B20 sensor, GPS module, ESP32, stepdown module, buzzer, IMU sensor, barometer, LoRa module, DF mini-player, and LiPo 4,2V battery.

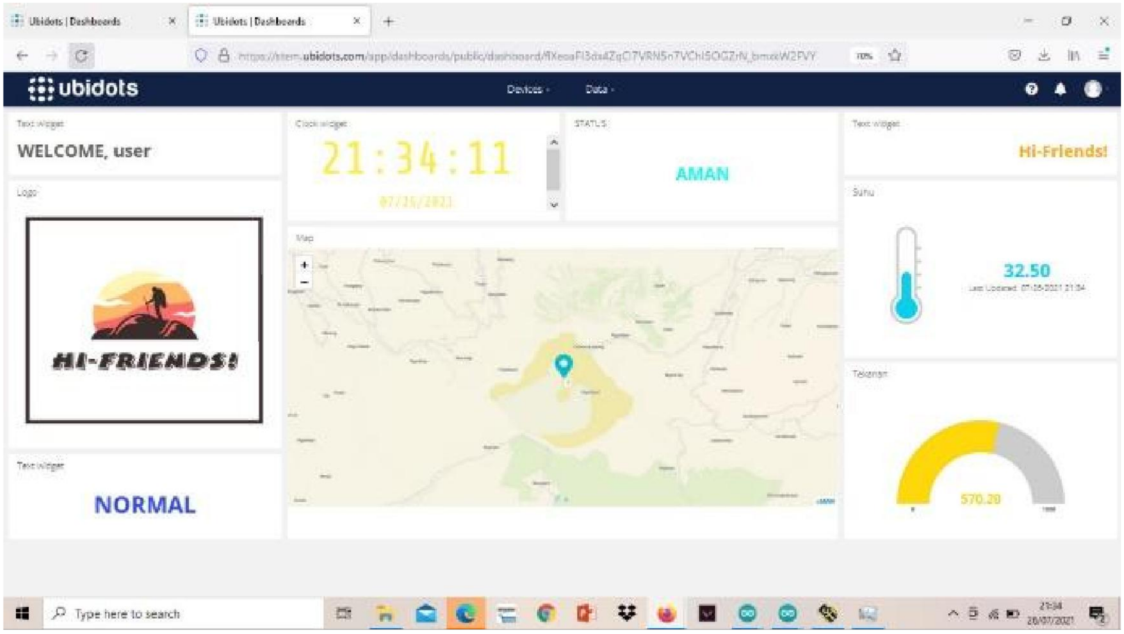


Fig 5. Monitoring Web Display

The application is accessible from a Personal Computer (PC) or handphone's browser—type https://bit.ly/webHiFriends as the browser link. The monitoring web display is presented in Figure 5. In the hardware and software integration step, the authors connected both wares to become a system working in harmony. Then, the instrument was tested separately and simultaneously in a system. In the analysis and conclusion step, the authors summarized study results to generate the desired outcome.

III. RESULT AND DISCUSSION

In this result and discussion section, several tests and analyses were applied to all input and output parts. Sensor tests and analyses aimed to discover whether the sensor works well as an input following the plan. Calibration was performed to ensure the sensor was working well. The tests are as follow:

1. Battery Resistance Test Result

The instrument used three LiPo 4,2V 4500 mAH batteries. The test was performed by measuring current and voltage consumption periodically to discover the instrument resistance during usage. The test result revealed current consumption of 380 mA. Therefore, in the calculation, the instrument can last for 35 hours.

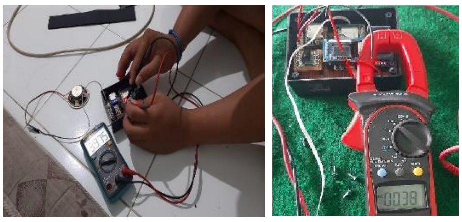


Fig 6. Battery Resistance Test

The test was carried out every ten minutes to observe the battery voltage. The instrument remained in use until the battery voltage reached 2,7V. The test results are presented in Figure 7.

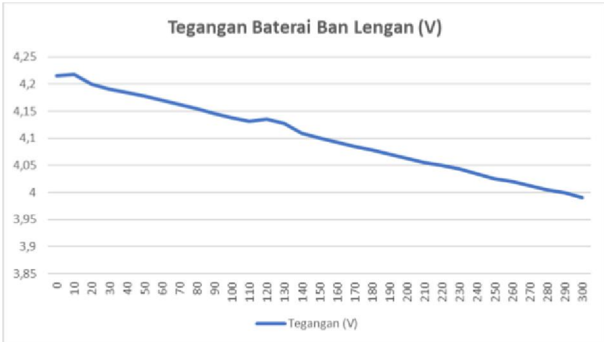


Fig 7. Battery Resistance Test Graph Result

2. *Hypothermia and Hypoxia Detection System Test Result*

Hypothermia detection in this instrument utilized a DS18B20 sensor, where the sensor surface interacts with the skin. Hypoxia detection was based on barometer reading. ESP32 obtains data from the sensor to be processed, activating the buzzer and DF mini-player based on the predetermined setpoint. The setpoint is temperature ≤35ºC and air pressure ≤560,2 mmHg; when they are exceeded, the buzzer and DF mini-player will be turned on. The test results are presented in Table 1, noting that the reminders of hypothermia and hypoxia are different.

Table 1. Hypothermia and Hypoxia Detection System Test Result

Test No.	Temperature (ºC)	Pressure (mmHg)	*Buzzer* and DF *Mini Player*
1	36,5	735	Off
2	36,6	732	Off
3	36,7	740	Off
4	36,8	735	Off
5	36,7	733	Off
6	36,6	730	Off
7	36,6	731	Off
8	34,9	733	On Hypothermia
9	34,5	734	On Hypothermia
10	34,6	730	On Hypothermia
11	35,5	725	Off
12	35	796	Off

	,6		
13	35,9	633	Off
14	36,0	615	Off
15	36,2	604	Off
16	36,1	571	Off
17	36,3	572	Off
18	36,4	550	On Hypoxia
19	36,6	548	On Hypoxia
20	36,5	553	On Hypoxia
21	36,2	624	Off
22	36,2	665	Off
23	36,1	659	Off
24	35,8	598	Off
25	36,0	580	Off
26	36,2	578	Off
27	33,9	560	On Both
28	34,0	558	On Both
29	33,8	550	On Both
30	34,2	547	On Both

3. *Emergency Test Result*

The test was conducted by rapidly moving the instrument to read the acceleration on the IMU sensor, triggering ESP32 to send the longitude and latitude from the GPS module. The test was performed by reading acceleration from the IMU module. If the acceleration ≥ 200 cm/s2, the instrument will send the last location data from the GPS module so that hikers can be found and get help quickly, reducing plausible risks. The emergency test results are presented in Table 2.

Table 2. Emergency System Test Result

est No.	Acceleration (cm/ s^2)	Emergency Mode	GPS Module Sends Location
	0	*Off*	-
	0	*Off*	-
	4	*Off*	-
	8	*Off*	-
	210	*On*	Success
	12	*Off*	-
	0	*Off*	-
	0	*Off*	-
	276	*On*	Success
	0	*Off*	-

0			
1	0	*Off*	-
2	0	*Off*	-
3	335	*On*	Success
4	0	*Off*	-
5	0	*Off*	-
6	228	*On*	Fail
7	0	*Off*	-
8	240	*On*	Success
9	0	*Off*	-
0	0	*Off*	-
1	236	*On*	Success
2	0	*Off*	-
3	0	*Off*	-
4	3	*Off*	-
5	125	*On*	Fail
6	344	*On*	Success
7	356	*On*	Success
8	189	*On*	Success
9	110	*On*	Success
0	256	*On*	Success

The test results revealed failure due to the disturbance on the connection between LoRa module, resulting in failure opportunity in sending GPS longitude and latitude.

4. Test Result of Data Delivery Using LoRa

LoRa was employed to send data from the instrument to the gateway since the actual condition has no cellular network.

Fig 8. Data Delivery Using LoRa Test

The test results of data delivery using LoRa are presented in Figure 9. From several trials, the LoRa module often experienced disturbances in delivering and receiving data.

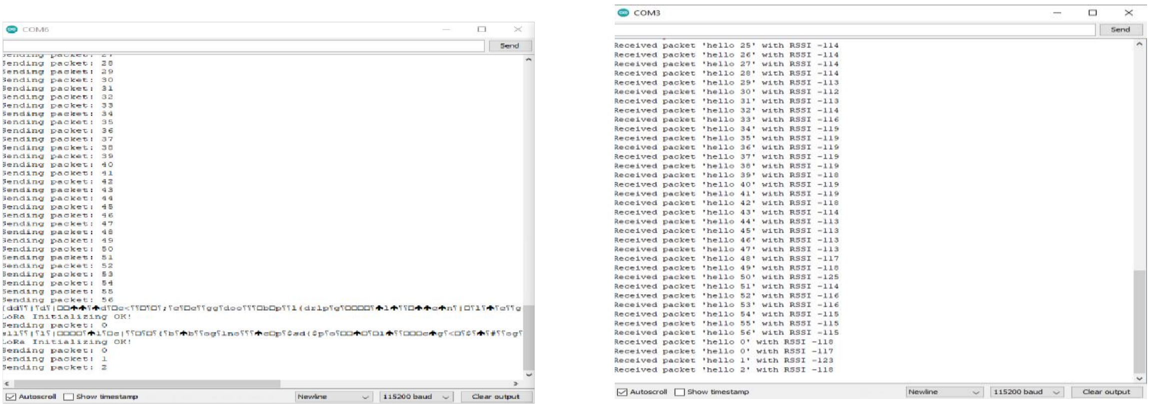


Fig 9. Data Delivery Using LoRa Test Results

5. Medical Record Storing System Test Result

Data of sensor reading are stored in SD card module, then processed and presented in a graph. The test results are presented in Figure 10.

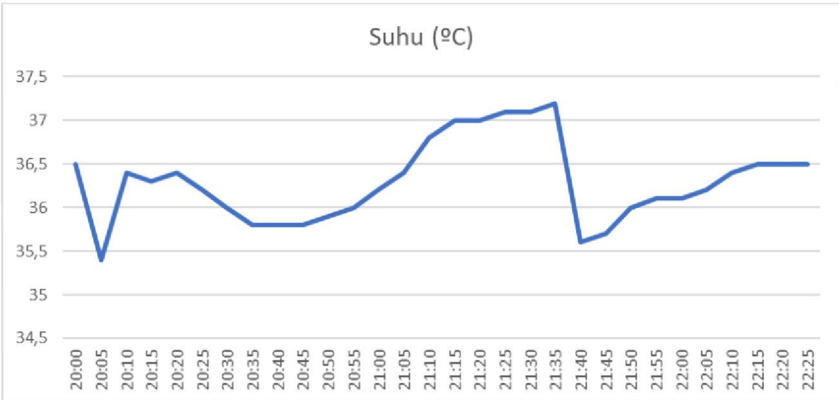


Fig 10. Medical Record Storing System Test Graph Result

6. Overall System Test Result

The test was performed by testing the instrument to discover the overall system performance. The instrument has worked well as expected.

Fig 11. Overall System Test

IV. CONCLUSION

Based on the result and discussion, the authors drew several conclusions:

1. The battery resistance test revealed that the instrument could last for 35 hours. Also, the instrument managed to work until the battery voltage reached 2.7V.
2. The hypothermia and hypoxia detection system test result showed that the buzzer and DF mini-player are on based on the predetermined setpoints, i.e., temperature ≤35ºC and air pressure ≤560,2 mmHg.
3. The emergency test result demonstrated that the instrument will send the latest location data from the GPS module based on the acceleration. Location data delivery failure may occur due to the disturbance in the LoRa module connection.

4. The data delivery using LoRa test result concluded that the LoRa module sometimes experienced disturbances in sending or receiving data.
5. The medical record storing system test result showed that each sensor reading data will be stored in the SD card module.
6. The overall system test result concluded that the instrument worked well as expected.

V. ACKNOWLEDGMENTS

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