Check Skor

R1_DESIGN AND BUILD AN EARLY WARNING SYSTEM FOR HEALTH CONDITIONS IN CLIMBERS BASED ON FUZZY LOGI...

NO REPOSITORY 02

Document Details

Submission ID

trn:oid:::3618:135519120

Submission Date

Apr 17, 2026, 1:10 PM GMT+7

Download Date

Apr 17, 2026, 1:17 PM GMT+7

File Name

R1_DESIGN AND BUILD AN EARLY WARNING SYSTEM FOR HEALTH CONDITIONS IN CLIMBERS B....docx

File Size

4.7 MB

8 Pages

2,956 Words

15,667 Characters

12% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography

Match Groups

18 Not Cited or Quoted 12%
Matches with neither in-text citation nor quotation marks

2 Missing Quotations 1%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

11% Internet sources

5% Publications

9% Submitted works (Student Papers)

Match Groups

- **18** Not Cited or Quoted 12%
  Matches with neither in-text citation nor quotation marks
- **2** Missing Quotations 1%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

11% Internet sources
5% Publications
9% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Internet	ejournal.unuja.ac.id	5%
2	Internet	sistemasi.ftik.unisi.ac.id	2%
3	Student papers	President University on 2026-03-13	2%
4	Internet	repository.binadarma.ac.id	<1%
5	Internet	journal.upgris.ac.id	<1%
6	Internet	doaj.org	<1%
7	Student papers	Universitas Muhammadiyah Sidoarjo on 2019-04-09	<1%
8	Student papers	University of Glasgow on 2020-09-02	<1%
9	Internet	e-journal.lp2m.uinjambi.ac.id	<1%
10	Internet	ejurnal.univamedan.ac.id	<1%

11 Internet

www.mysciencework.com <1%

Journal of Electrical Engineering and Computer (JEECOM)
Vol. xx, No. xx (20xx), DOI: 10.33650/jeecom.v4i2
p-ISSN: 2715-0410; e-ISSN: 2715-6427

DESIGN AND BUILD AN EARLY WARNING SYSTEM FOR HEALTH CONDITIONS IN CLIMBERS BASED ON FUZZY LOGIC

Ahlul A'raaf Femas Salsabil[1], Agus Hayatal Falah[2], Jamaaluddin[3], Indah Sulistiyowati[4]
[1] Department of Electrical Engineering, Faculty of Science and Technology
[2] Universitas Muhammadiyah Sidoarjo, Jl. Raya Gelam No. 250, Pagerwaja, Gelam, Candi District, Sidoarjo Regency, East Java 61271

Article Info

Article history:

Received Month xx, 20xx
Revised Month xx, 20xx
Accepted Month xx, 20xx

Keywords:

ESP32
MAX30102
BMP280
Fuzzy Logic
Climber Health Monitoring

ABSTRACT

Mountain climbing is currently being popular with the public, both young people and adults. However, Many climbers pay little attention to physiological conditions and environmental factors when climbing. This study aims to combine these two factors, namely physiological factors and environmental factors as an effort to minimize the occurrence of accidents in climbing activities. Physiological factors, namely oxygen saturation and heart rate, are combined with environmental factors of air pressure, which will later be processed with *fuzzy logic* consisting of 27 *rule* bases. The test results on the sensor showed high accuracy with an average value of 98.21% for SpO2, 98.01% for heart rate, and 99.10% for air pressure. At the time of the air pressure value of <750 hPa the system is also capable of giving an alarm as a warning. Fuzzy logic testing is quite effective in determining a climber's health status, where the system consistently assigns a "Normal" status at low altitudes, changes to "Alert" when the air pressure begins to decrease, until it reaches a "Danger" status in extreme conditions. This proves that the system is able to provide an early warning on the condition of a climber.

Corresponding Author:
Ahlul A'raaf Femas Salsabil,
Universitas Muhammadiyah Sidoarjo, Jl. Raya Gelam No. 250, Pagerwaja, Gelam, Candi District, Sidoarjo Regency, East Java 6127
Email: femassalsabil.umsida@gmail.com

1. INTRODUCTION

Mountain climbing is one of the sports that is currently being favored by the community [1]. Mountain climbing can be categorized as an extreme sport and can cause injury and even death [2]. A person's journey from the lowlands to the highlands will undergo physiological changes that make the body have to adapt to it [3].

One of the problems that often occur due to physiological changes to the body is [4]. Hypoxia is a critical physiological state characterized by an inadequate oxygen supply to the body's tissues, primarily driven by the decline in atmospheric partial pressure (PO2) at high altitudes. This condition leads to a significant drop in arterial oxygen saturation (SpO2), forcing compensatory cardiovascular responses that, if sustained, result in multisystem organ dysfunction and life-threatening complications such as High Altitude Cerebral Edema (HACE) [5]. This physiological strain is further exacerbated by the diminishing barometric pressure and the high physical demands of climbing activities.

Conventional measuring instruments such as oximeters and barometers are currently only able to detect values raw without knowing our condition directly [6]. Using a combination of environmental factors (air pressure) and physiological factors (heart rate and SpO2) can provide a comprehensive picture of a climber's body condition.

ISSN: 2715-6427

To process data characterized by inherent uncertainty and sensor noise, a flexible decision-making method such as Fuzzy Logic is required [7]. Fuzzy Logic is a computational approach that mimics human reasoning by categorizing continuous numerical data into overlapping linguistic sets, such as 'Low', 'Normal', or 'Height', through membership functions [8]. This method is particularly appropriate for monitoring climbers as it can handle the non-linear relationship between environmental pressure and physiological response, allowing for more objective and nuanced health assessments compared to rigid binary thresholds.

In a study conducted by Ginoni [9]. The system used only dwells on the oxygen saturation value and also the heart rate of a climber's body. Environmental factors such as air pressure greatly affect the conditions in our body. This happens because when a place has low air pressure, the oxygen produced will be less [10]. This will affect the heart rate and also the oxygen saturation in our body.

In the same research conducted by Nurhaji Meivita [11]. There are several shortcomings in the developed system. The system only focuses on physiological factors in the human body such as heart rate and oxygen saturation. Both approaches are considered to be less than optimal because they have not considered other important factors, such as environmental factors.

Environmental factors in the highlands cannot be separated from the physiological conditions of a climber. This very significant drop in air pressure leads to a decrease in oxygen pressure [12]. This condition can trigger a decrease in oxygen saturation in the body and an increase in heart rate. Without proper acclimatization, the continuity between environmental factors and physiological factors can create a high risk to the condition of a mountaineer.

Based on this background, by using two factors as a combination to provide an overview of the condition of the body, and also using fuzzy logic as a raw data processor to produce an objective decision. It is hoped that this tool can minimize the occurrence of unwanted things in the future that happen to a mountaineer.

2. METHOD

In this study, Research and Development (R&D) methods are used for system development *fuzzy* on the health detector in this tool [13]. This R&D method is used to assess effectiveness and to obtain desired results [14].

System Planning

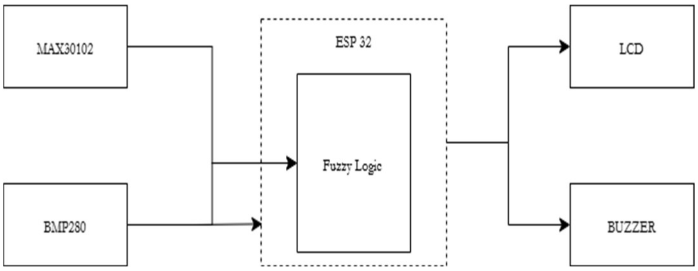

Figure 1. Block Diagram

Figure 1 explains how the system works. Where the MAX30102 and BMP280 sensors will be managed in ESP32 through *fuzzy logic* first and then will appear an output on the LCD in the form of the condition of the climber and also the raw values of the 3 parameters used.

However, on the BMP280, air pressure data is not only managed on *the fuzzy logic* system, but also managed directly with the ESP32 to turn on the buzzer output. The value set to turn on the buzzer is adjusted to the air pressure value that a human must be aware of, which is at <750 hPa.

Fuzzy Logic Design

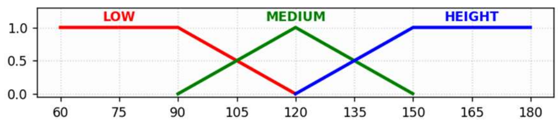

Figure 2. Heart *Rate* Fuzzy Set Variables

Controls *fuzzy* In the parameters of Figure 2, it is adjusted to the activities carried out and uses the age of adults, because mountain climbing is one of the activities that is quite strenuous. So, it's likely that the heart rate will do the extra work and increase the BPM value [15].

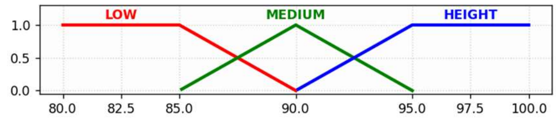

Figure 3. Oxygen *Saturation* Fuzzy Set Variables

Parameters *fuzzy* Figure 3 is the result of an analysis carried out on a person who is doing climbing activities. Where the average climber's oxygen saturation value is between 90% - 95% which is normal for quite strenuous activities [12].

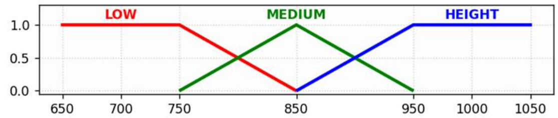

Figure 4. Air *Pressure* Fuzzy Assembly Variables

The air pressure parameters in figure 4 are adjusted based on the reality that occurs where the higher the ground level, the lower the air pressure that occurs [16].

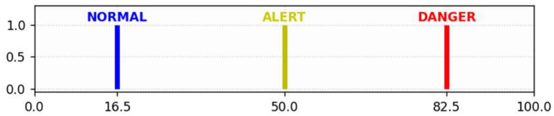

Figure 5. *Fuzzy* Output Set Variables

In figure 5, the value of the *fuzzy* output is generated from 3 predetermined input parameters, namely heart rate, oxygen saturation, and air pressure. Then the output value produced will be influenced by the input values that have been determined and can change according to the input value issued.

In the calculation of the output results using the COA method (*Center of Area*), where this method uses the midpoint of each output set to produce smoother results [17]. This method uses the equation,

$$Z_0 = \frac{\sum_{i=0}^{n} \mu(Zi).Zi}{\sum_{i=0}^{n} \mu(Zi)} \quad (1)$$

Rule Base

Table 1. Rule Base

No	Oxygen Saturation	HR	Air Pressure	Status (Output)
1	Low	Low	Low	Danger
2	Low	Medium	Low	Danger
3	Low	Height	Low	Danger
4	Medium	Low	Low	Alert
5	Medium	Medium	Low	Alert
6	Medium	Height	Low	Danger
7	Height	Low	Low	Alert
8	Height	Medium	Low	Alert
9	Height	Height	Low	Alert
10	Low	Low	Medium	Danger
11	Low	Medium	Medium	Danger

ISSN: 2715-6427

12	Low	Height	Medium	Danger
13	Medium	Low	Medium	Alert
14	Medium	Medium	Medium	Alert
15	Medium	Height	Medium	Alert
16	Height	Low	Medium	Normal
17	Height	Medium	Medium	Normal
18	Height	Height	Medium	Alert
19	Low	Low	Height	Danger
20	Low	Medium	Height	Danger
21	Low	Height	Height	Danger
22	Medium	Low	Height	Alert
23	Medium	Medium	Height	Alert
24	Medium	Height	Height	Alert
25	Height	Low	Height	Normal
26	Height	Medium	Height	Normal
27	Height	Height	Height	Alert

The rule base used has 27 rules that will later make a decision. In determining the number of rule bases is based on the calculation of the probability that occurs by calculating the number of inputs. Meanwhile, in decision-making based on analysis on studies and also adjusted to conditions that are likely to occur.

3. RESULTS AND DISCUSSION

3.1. Tool Design Results

The result of the design of this tool is a device to detect the health status of a climber and an early warning system as a warning for a climber.

This system provides an alarm warning when the air pressure value is at <750 hPa. In addition, it can also detect health status by attaching a finger to the MAX30102 sensor. Then by using 3 predetermined parameters and data processing with *fuzzy logic* lcd will display the results of a climber's health status.

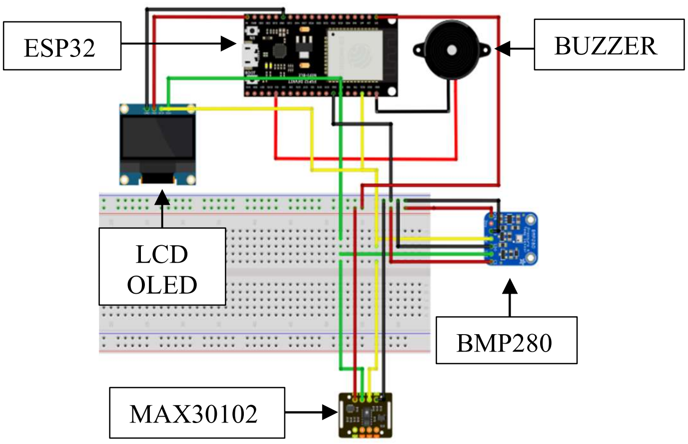

Figure 6. Wiring Tool Network

Figure 7. Tools in standby mode

Figure 8. Tool Under Testing Conditions

3.2. Sensor Testing

In this test, the results of the sensor readings will be compared with the results of the standard measuring instruments. This test focuses on finding the error percentage and accuracy percentage values between the sensor readings and the standard measuring instruments using 2 calculations, the first calculation is to find the error value from the sensor reading results to the standard measuring instrument results,

$$\text{Error}(\%) = \frac{X_s - X_r}{X_s} \times 100\% \quad (2)$$

ISSN: 2715-6427

Description :
X_s= Standard measuring instrument values
X_r= Sensor reading value
After calculating and obtaining the error value result, the accuracy value of the sensor reading results against the standard measuring tool will be searched, using the second calculation,

$$\text{Akurasi}(\%) = 100\% - \text{Error}(\%) \quad (3)$$

Table 2. Heart Rate Results Testing

No	X_s	X_r	Error(%)	Accuracy(%)
1	92	91	1,08	98,92
2	91	90	1,09	98,91
3	87	85	2,29	97,71
4	85	82	3,52	96,48
Rata – Rata			1,99	98,01

Table 3. Oxygen Saturation Results Testing

No	X_s	X_r	Error(%)	Accuracy(%)
1	99	100	1,01	98,99
2	98	100	2,04	97,96
3	98	99	1,02	98,98
4	97	100	3,09	96,91
Rata – Rata			1,79	98,21

This test was carried out with 4 experiments, in which the sensor MAX30102 to detect oxygen saturation and heart rate values compared to an oximeter measuring device that detects the same parameters. In table 2, namely the heart rate parameters produce an average accuracy value of 98.01%. Meanwhile, in table 3, namely the oxygen saturation parameter, the average accuracy is 98.21%, where both results can prove that the reading results from the sensor are quite precise with the readings of standard measuring instruments.

Table 4. Air Pressure Yield Testing

No	X_s	X_r	Error(%)	Accuracy(%)
1	1011	1010	0,98	99,02
2	987	1009	2,22	97,78
3	852,3	850,1	0,25	99,75
4	750	749,1	0,12	99,88
Rata – Rata			0,89	99,10

In the results of the air pressure test in table 4, it was carried out in 4 places with different heights. This comparison uses a BMP280 sensor and a weather channel website to detect air pressure values. The results of the test received an average score of 99.10% where the results of the sensor readings and also the results on the website were very precise.

3.3. Overall Tool Testing

The test of the entire equipment was carried out by doing a climb on the Puthuk Gragal. The test was carried out by 4 different climbers and 3 different altitudes.

Table 5. Tool Testing at an altitude of 214 MDPL

No	Oxygen Saturation (%)	HR (BPM)	Air Pressure (HPA)	Status (Output)
1	100	91	1009	Normal
2	100	90	1009	Normal
3	99	85	1009	Normal
4	100	82	1009	Normal

Table 6. Tool Testing at an altitude of 1165 MDPL

No	Oxygen Saturation (%)	HR (BPM)	Air Pressure (HPA)	Status (Output)
1	92	130	850,1	Alert
2	90	125	850,1	Alert
3	87	120	850,1	Alert
4	88	119	850,1	Alert

Table 7. Testing of the tool at an altitude of 1480 MDPL

No	Oxygen Saturation (%)	HR (BPM)	Air Pressure (HPA)	Status (Output)
1	84	135	749,1	Danger
2	83	130	749,1	Danger
3	85	133	749,1	Danger
4	84	132	749,1	Danger

Based on the test results in tables 5, 6 and 7, this system shows responsive and accurate performance in classifying the results of a climber's health status. At an altitude of 214 MDPL with an air pressure of 1009 hPa, the system establishes a normal state because the value of oxygen saturation (SpO2) is optimally valued and the heart rate is within reasonable limits. As the altitude increases at 1165 MDPL, the air pressure decreases at 850.1 hPa, which results in the body's compensation in the form of increased heart rate and decreased oxygen saturation, so that *the fuzzy* algorithm changes the status to alert. The alarming conditions occurred at an altitude of 1480 MDPL with a drastic drop in air pressure of 749.1 hPa, which triggered an alarm, a decrease in oxygen saturation values and a drastic increase in heart rate values, which turned the *fuzzy* algorithm into a danger. This proves that the integration of the MAX30102 sensor and BMP280 through Fuzzy logic is able to provide consistent early warning of climbers' health risks due to extreme changes in atmospheric pressure at high altitudes**.**

4. CONCLUSION

This research successfully developed a prototype for monitoring climbers' health by integrating the MAX30102 and BMP280 sensors. The system operates by detecting atmospheric pressure to trigger an alarm at thresholds below 750 hPa and to determine altitude (MDPL), while the MAX30102 sensor captures real-time oxygen saturation (SpO2) and heart rate. These three parameters are processed through a Fuzzy Logic algorithm with 27 rule bases to classify health status, which is then displayed on an OLED screen.

Validation tests demonstrate high reliability, with the BMP280 sensor achieving 99.10% accuracy, and the MAX30102 sensor reaching 98.21% for SpO2 and 98.01% for heart rate. Functionally, the fuzzy logic effectively maps conditions, maintaining a 'Normal' status at low altitudes (214 MDPL), shifting to 'Alert' as pressure decreases (1165 MDPL), and reaching 'Danger' in extreme conditions (1480 MDPL) where SpO2 drops significantly. This integration of physiological and environmental data demonstrates significant novelty, providing a robust early warning instrument to prevent hypoxia risks among mountaineers.

.

ACKNOWLEDGEMENTS

The author is profoundly grateful to the Almighty for His endless blessings and divine guidance. Heartfelt appreciation is also extended to his parents, and lecturers, whose unwavering support and invaluable assistance were instrumental throughout the completion of this research.

REFERENCES

[1] G. Rizki Padilah, G. Purnama Insany, and K. Kamdan, “Rancang Bangun Website bagi Komunitas Pendaki Indonesia Menggunakan Metode Waterfall: Studi Kasus Gunung Gede Pangrango,” *Pros. TAU SNARS-TEK Semin. Nas. Rekayasa Dan Teknol.*, vol. 4, no. 1, pp. 24–34, Aug. 2024, doi: 10.47970/snarstek.v2i1.710.
[2] Z. D. Mutia Rahmi1, “Persepsi Risiko Keselamatan dalam Kegiatan Pendakian Gunung,” 2021.

ISSN: 2715-6427

[3] F. P. Salipadang, V. R. Danes, and M. E. W. Moningka, “Hubungan Perbedaan Ketinggian dengan Perubahan Tekanan Darah pada Pelaku Perjalanan dari Dataran Rendah ke Dataran Tinggi dan dari Dataran Tinggi ke Dataran Rendah,” 2022.

[4] R. Rositasari, “ANCAMAN HIPOKSIA BAGI EKOSISTEM PESISIR; PENGGUNAAN INDEKS AMMONIA-ELPHIDIUM (A-E) SEBAGAI PROKSI,” *OSEANA*, vol. 45, no. 1, pp. 82–92, Apr. 2020, doi: 10.14203/oseana.2020.Vol.45No.1.88.

[5] A. H. Wahyudi, E. R. Widasari, and H. Fitriyah, “Rancang Bangun Sistem Deteksi Hipoksia berdasarkan Detak Jantung dan Saturasi Oksigen menggunakan Low Power Mode dengan Metode Naïve Bayes,” 2022.

[6] B. Yulianti and I. Prakoso, “Rancang Bangun Pulse Oximeter Menggunakan Aplikasi Blynk,” vol. 12, 2023.

[7] M. M. Hadist, I. Sulistiyowati, S. Syahrorini, and A. H. Falah, “SISTEM PENGAMBILAN KEPUTUSAN OTOMATIS BERBASIS FUZZY UNTUK KELAYAKAN REUSE AIR DRAIN MESIN RETORT,” vol. 14, no. 1, 2026.

[8] J. Jamaaluddin, E. Rosnawati, I. Anshory, I. Sulistiyowati, and S. Syahrorini, “The utilization of levelled fuzzy logic for more precision results,” *J. Phys. Conf. Ser.*, vol. 1402, no. 7, p. 077037, Dec. 2019, doi: 10.1088/1742-6596/1402/7/077037.

[9] F. H. Ginoni, “SISTEM PERINGATAN DINI TERHADAP KONDISI TUBUH PADA PENDAKI GUNUNG BERBASIS FUZZY LOGIC,” 2019, [Online]. Available: http://eprints.itn.ac.id/id/eprint/3565

[10] A. S. Hanifah, “Pengaruh tekanan udara dan swing time terhadap kadar oksigen yang berasal dari oksigen konsentrator bertingkat,” 2022, [Online]. Available: http://etheses.uin-malang.ac.id/id/eprint/41939

[11] D. N. Meivita, “Rancang Bangun Alat Ukur Kondisi Kesehatan Pada Pendaki Gunung Berbasis Fuzzy Logic,” 2016.

[12] M. R. Baihak, “ANALISIS PENGGUNAAN SMARTWATCH DALAM PEMANTAU DATA FISIOLOGIS PENDAKI GUNUNG GENERASI Z,” UNIVERSITAS ISLAM INDONESIA, 2025.

[13] R. Virmansah, I. Sulistiyowati, and A. Ahfas, “IMPLEMENTASI SISTEM SMART DOORLOCK KOST BERBASIS ESP32 DENGAN DETEKSI STATUS TAGIHAN MENGGUNAKAN LOGISTIC REGRESSION DAN MONITORING APLIKASI MOBILE,” vol. 14, no. 1, 2026.

[14] D. E. P. Febrian, A. Wisaksono, and I. Anshory, “SISTEM MONITORING GAS DAN SUHU PADA BIOGAS DIGESTER UNTUK MENINGKATKAN KINERJA KOMPOR,” vol. 13, no. 2, 2025.

[15] H. D. Puspita and G. Puspawardhani, “PENENTUAN KLASIFIKASI BEBAN KERJA BARU BERDASARKAN PREDIKSI KADAR OKSIGEN DALAM DARAH DENGAN MEMPERTIMBANGKAN DENYUT JANTUNG, TEMPERATUR TUBUH DAN KONSUMSI OKSIGEN PADA PEKERJA JASA KULI ANGKUT,” *Infomatek*, vol. 22, no. 2, pp. 89–100, Dec. 2020, doi: 10.23969/infomatek.v22i2.3338.

[16] L. Rosyanti, I. Hadi, D. Y. S. Rahayu, and A. B. Birawida, “Mekanisme yang Terlibat dalam Terapi Oksigen Hiperbarik: theoritical review hyperbaric oxygen therapy/HBOT,” *Health Inf. J. Penelit.*, vol. 11, no. 2, pp. 180–202, Dec. 2019, doi: 10.36990/hijp.v11i2.144.

[17] A. H. Falah, M. Rivai, and D. Purwanto, “Implementation of Gas and Sound Sensors on Temperature Control of Coffee Roaster Using Fuzzy Logic Method,” in *2019 International Seminar on Intelligent Technology and Its Applications (ISITIA)*, Surabaya, Indonesia: IEEE, Aug. 2019, pp. 80–85. doi: 10.1109/ISITIA.2019.8937148.