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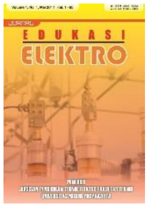

IoT-based Pregnant Mother Contraction Monitoring System Design

Sahrul Romadhoni[1](✉), Indah Sulistiyowati[1], Mar'ati Amalia[1]

[1] Universitas Muhammadiyah Sidoarjo, Jawa Timur, Indonesia

sahrulromadhoni0312@gmail.com

Abstract — Pregnancy is an important stage in a woman's life that requires special monitoring and care to ensure the well-being of both mother and fetus. The presence of uterine contractions is an important indicator of imminent labour, and prompt monitoring is essential to spot difficulties and ensure a safe delivery. This study aims to track contractions in pregnant women to improve prenatal and labour care. Real-time monitoring, recording and analysis of uterine contractions. This research is a type of R&D research with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation. The result of this tool is that it can precisely track contraction activity and send information to the IoT network. Through an easy-to-use mobile app, this information can be accessed by medical staff caring for pregnant women and pregnant women themselves. To provide continuous monitoring, provide early notification of alarming changes, and facilitate rapid medical response, this monitoring system utilizes IoT technology. This can ease the burden on medical institutions, lower the possibility of difficulties during labour, and provide a sense of security for pregnant women. As an innovative and effective tool, the Internet of Things-based Maternal Contraction Monitoring System is anticipated to improve prenatal and delivery healthcare, reduce maternal and infant mortality, and monitor contractions in pregnant women. The healthcare of pregnant women around the world could be significantly improved with the successful implementation of this approach.

Keywords: monitoring contractions of pregnant women; iot technology

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1 Introduction

Maternal health is an important subject in public health care [1]. Pregnancy is an important period in a woman's life, and proper pregnancy monitoring is essential to ensure maternal health and healthy fetal growth[2]. Uterine contractions are an important component of pregnancy monitoring[3] [4]. Contractions are a natural sign of pregnancy that occurs as the body prepares for labor [5][6]. However, to detect unusual or potentially harmful contractions, careful monitoring is essential [7].

In general, the birthing process will take place when the fetus has reached 37 to 42 weeks of age[8]. Childbirth is a normal process in a woman's life designed to bring a baby into the world[9]. Although this process is usually not dangerous, there are risks associated with childbirth, such as complications during labor that require supervision, assistance, and health services with adequate health facilities [10]. Maternal health efforts are implemented to encourage all deliveries to be attended by trained health personnel, namely obstetricians and gynecologists, general practitioners, and midwives, and to be conducted in healthcare facilities [11].

Some Internet-of-Things (IoT) devices that can be used to track pregnant women's contractions use sensors that can be attached to the pregnant woman's abdomen to track uterine contractions [12] [13]. Once processed, analyzed, and shared in a way that is easily understood by pregnant women and healthcare professionals, the data collected by these sensors can be used to improve healthcare [14]. Utilizing IoT technology for contraction monitoring not only produces more accurate data but also enables real-time and integrated monitoring [15].

An electromyograph (EMG) is a device that captures signals from muscles as they perform contraction and relaxation movements [16] [17]. When a muscle contracts and relaxes, it produces an electrical potential [18] [19]. This electrical potential will be captured by the electromyograph and used to monitor the activity of the muscle[18]. This tool can monitor the contractions of pregnant women who are about to give birth so that medical personnel do not need to check the condition of the mother's stomach every time, the design of this monitoring tool uses WeMos D1 Mini which functions as a controller in the hardware control system and to the IoT platform.

As such, designing an Internet of Things-based system to track pregnancy-related contractions is a possible breakthrough in improving care for pregnant women use of this technology can facilitate better access to appropriate care when needed and make it easier for pregnant women to monitor their health issues [20]. In addition, the information obtained through contraction monitoring can help medical practitioners better plan patient care and spot potential health issues before they become more significant problems.

Given this, the creation of an IoT-based system to monitor women's perinatal contractions will not only improve prenatal care but also have a good effect on the health and well-being of both mother and fetus. With this strategy, we can improve the standard of care provided to pregnant women and possibly also decrease the number of problems during pregnancy that are not identified as soon as they arise. It is hoped that this tool will be able to monitor the contractions of pregnant women who are about to give birth so that medical personnel do not need to check every time. The design of this monitoring tool uses WeMos D1 Mini which functions as a controller in the hardware control system and to the IoT platform.

2 Method

The type of method used in this research is research and development (R&D), By following the ADDIE steps in the development of a contraction monitoring system, this research aims to ensure that the resulting solution meets practical needs, can be implemented properly, and provides significant benefits in monitoring the health of pregnant women.

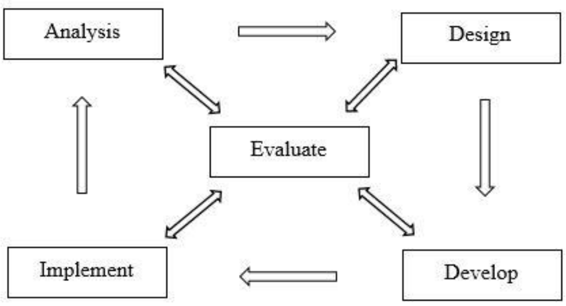


Fig. 1. ADDIE development models

The development process is an overview of the steps taken in carrying out the research. Based on the development model used in this research is the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). First step is analysis, this step is used to determine the fundamental problems that occur or are being faced by medical personnel or midwives. The analysis process can be carried out when the tool is able to overcome the problems being faced, has the support of facilities to be applied, and the application of the tool. Second step is design, this stage is intended to design the concept of the tool to be used. The process of designing and designing tools must be clearly and accurately stated because at this stage it affects further development. Third step is development, this stage is an important part of ADDIE development research because the previous framework which is still conceptual is then realized into a tool product that is ready to be applied. And at this stage it is necessary to make an instrument to measure the performance of the tool. Fourth step is implementation, implementation is carried out with reference to the product design that has been made. The ADDIE research model aims to obtain initial feedback to implement or apply solutions from users to the tools created and developed. Fifth step is evaluation, In the evaluation stage, the purpose of ADDIE development research is to determine the effectiveness and performance of the tool as well as obtain feedback from users and determine whether the desired objectives have been met.

2.1 Problem identification

Problem identification is done by observing and evaluating the current problems or handling of midwives and health workers. Some things that become points of consideration are manual checking of the abdomen of pregnant women who are about to give birth, manual recording of contraction results, and midwives or medical personnel must often check the abdomen of mothers who are about to give birth.

2.2 Literature study

A literature study was conducted to obtain the basic concept of the hardware and software working system of the proposed tool. Some of the concerns are the hardware design process using a combination of electronic components that are available on the market. The literature taken comes from several scientific journal articles and scientific seminars.

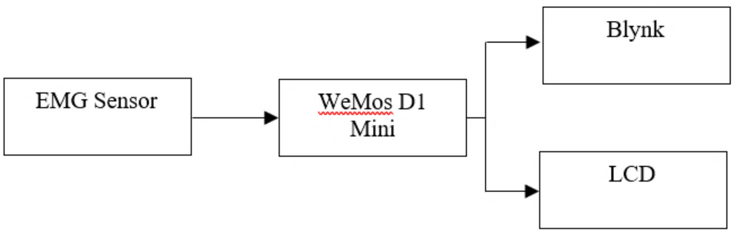


Fig. 2. Circuit diagram of the device

This monitoring system has an EMG (Electromyograph) sensor input which functions to capture signals from the abdominal muscle tension of mothers who will give birth or contraction of the abdomen, the data will then be processed by the WeMos D1 Mini microcontroller and the I2C LCD will display the muscle tension value and the data from the sensor will be sent to the Blynk application on the smartphone.

a. Contraction

Contractions are one of the signs that a pregnant woman is about to give birth to her baby in addition to the rupture of membranes and the opening of labour. The pain during contractions is like abdominal muscles tightening and then loosening repeatedly. Labour is a process in which a woman gives birth to a baby that begins with regular uterine contractions and culminates in the expulsion of the baby until the expulsion of the placenta and its membranes where the labour process will last for 12 to 14 hours [21].

b. EMG sensors (electromyography)

Electromyography (EMG) is the process of recording the electrical activity of muscles, to determine whether it is contracting or not[22]. EMG signal measurement is done with an instrument called electromyograph, and while the recording results are called an electromyogram [23].

Fig. 3. EMG sensors

c. Electrodes

To capture the voltage signal generated by the muscle, an electrode is needed as an antenna. The electrode installation technique used in this research is the intramuscular EMG installation technique. This method was chosen because it is more practical and easier because it simply uses a gel-type electrode that is attached to the skin layer where the muscle voltage signal will be detected. The voltage signal captured by the electrode will be forwarded to the muscle sensor module and the data will be processed by the microcontroller [22].

Fig. 4. Electrodes

d. WeMos D1-Mini

WeMos D1 mini is an ESP266-based mini wifi board that is known to be economical and reliable. This ESP8266 can connect microcontroller devices such as Arduino with the internet via wifi. with the internet via Wi-Fi. WeMos D1 Mini can create mini projects without using arduino as a microcontroller. using arduino as the microcontroller, because the WeMos D1 mini module can work alone or stand-alone. module can work alone or stand-alone to process every stanza code or coding that comes in or incoming coding [24].

WeMos has Digital and Analogue Pins:

Digital Pins are used for digital signal Input/Output. This digital signal has two logics, namely HIGH and LOW or 1 and 0. Analogue pins are used as Analogue signal Input/Output. Analogue signal This has a value of 0 - 1023, where the analogue value of 1023 is 5 Volts DC. In its implementation, the analogue pin is connected to sensors such as the LM35 temperature sensors, DHT11 and DHT 22 temperature and humidity sensors, and others.

2.3 System Design

In general, the proposed system has a simple workflow process battery function to supply EMG sensor power then the sensor reads muscle tension or abdominal muscle activity. The data that has been read by the sensor will be sent to the WeMos D1 Mini microcontroller and will be read by the LCD and Blynk on the smartphone.

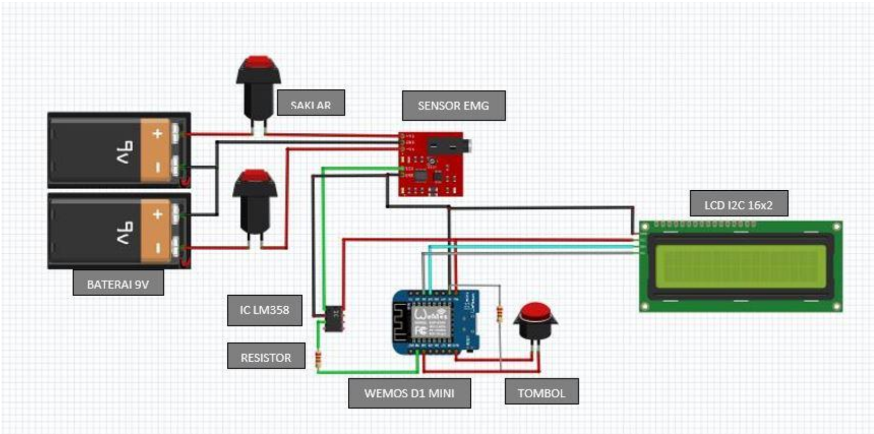


Fig. 5. Schematic circuit

Table 1. Port Usage of WeMos D1 Mini

Number	Port WeMos D1 Mini	Usage
1	D0	PUSH BUTTON
2	D1	SCL
3	D2	SDA
4	A0	DATA
5	3.3V	POWER
6	5V	VCC
7	GND	GND

From Figure 5 and Table 1, an explanation of the device monitoring system is obtained. The following is an explanation of the above circuit:

1. 9v battery as a voltage source from the EMG sensor.
2. VCC and GND from WeMos D1 mini is the source for LCD I2C, EMG sensor, IC.
3. The red cable is the source of the mains voltage (+) from the battery which will supply the voltage to the EMG sensor.
4. The black wire is the source of the mains voltage (-) from the battery that will supply voltage to the EMG sensor 4.
5. The light blue input wire from pin D2 on the WeMos D1 mini is connected to pin SDA on the LCD I2C.
6. The grey input wire from pin D1 on the WeMos D1 Mini is connected to the SCL pin on the LCD I2C.
7. The green input wire from pin A0 on the WeMos D1 Mini is connected to the data pin on the EMG sensor.
8. The red input wire from pin 3.3V on the WeMos D1 Mini is connected to the push button and goes to pin D0 on the WeMos D1 Mini.

2.4 Tool Design

The design of the prototype is carried out by the concept and design that has been designed on a breadboard measuring 5 x 10 cm by connecting the WEMOS D1 mini with other components and placing it on the breadboard using jumper cables by soldering according to the circuit in the fritzing software. In this circuit, a switch is added to disconnect and connect the electric current as a supply to the EMG sensor. the electrical circuit requires a signal amplifier circuit to make the sensor reading more stable and accurate (Op-Amp). Furthermore, after the sensor reads the muscle tension, the Wemos D1 Mini microcontroller will process the data and will give commands to the I2C LCD to display the value of the abdominal muscle tension and the data will be sent to the IoT platform in the form of Blynk to display graphs, values and counters.

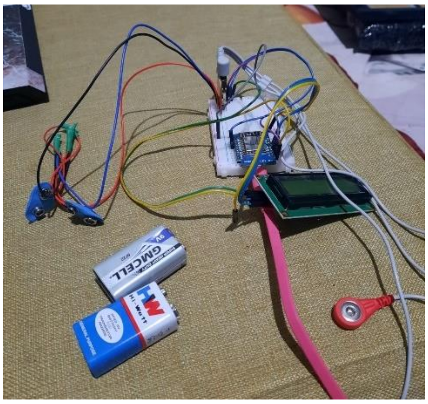


Fig. 6. Tool Design

The picture above is a monitoring system made with materials used such as, Wemos D1 Mini, EMG Sensor, LCD, 9V Battery, and breadboard then the components are arranged in a square black box.

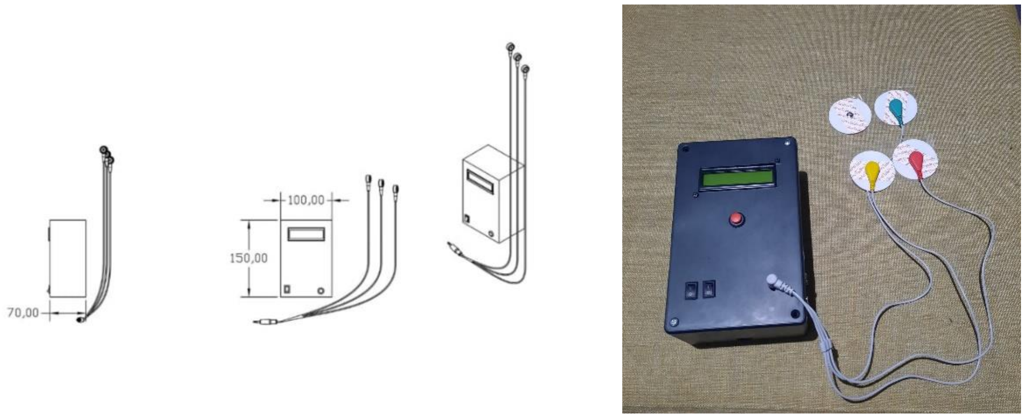
2.5 System Testing and Analysis

The prototype is tested by reading on the LCD and IoT platform (Blynk) from the muscle activity recorded by the EMG (electromyography) sensor. The counter will count 1 if there is a contraction in the abdomen of a pregnant women with a muscle tension value that exceeds the tool's setting limit and will record the contraction results in the form of how many seconds of contraction time occurs. The LCD on the prototype serves to display the value of muscle tension and bring up the counter value that occurs when there is a contraction.

3 Results and Discussion

3.1 3D prototype design

The 3D design of the IoT-based contraction monitoring system for pregnant women is made in such a way based on the concept design that has been made. Here are the differences between 3D design images used for monitoring contractions in pregnant women and IoT-based 3D designs.

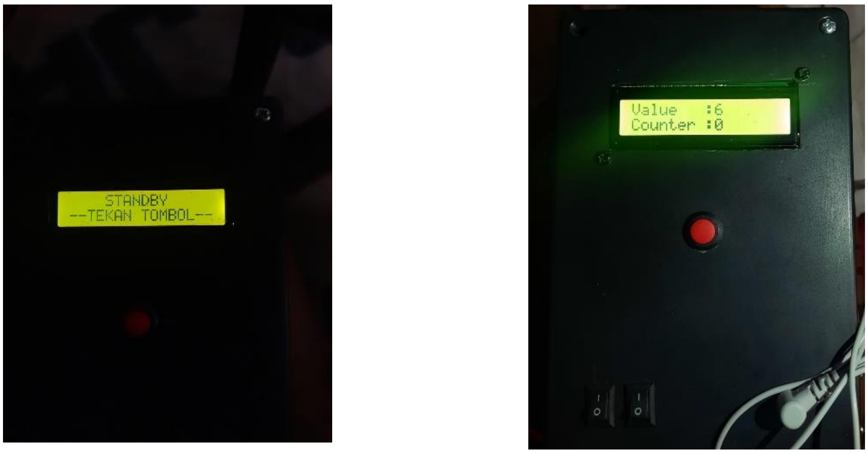


(a) (b)

Fig. 7. (a) 3D design of IoT-based contraction monitoring device for pregnant women, (b) prototype of contraction monitoring device.

3.2 Design of an IoT-based monitoring system for pregnant women

The hardware of the prototype has been completed by the existing design. The prototype LCD is programmed to display the results of abdominal muscle tension so that medical staff can know the condition of the pregnant woman's abdomen.



(a) (b)

Fig. 8. LCD on the prototype

Figure 8 (a) is the initial condition of the prototype after being switched on which will bring up a command to press the red button under the LCD. Figure 8 (b) is the sensor reading mechanism displayed through 2 responses, namely normal conditions, and contraction conditions. Each response performed will be displayed on the LCD screen, where the response to the normal abdominal state only displays the value of abdominal muscle tension with a value of less than 70, while in the contraction state the LCD screen will display the abdominal condition with a value above 70, and the counter will count the number of contractions that occur during the tool is used. The following is a picture of the prototype of monitoring contractions in pregnant women.

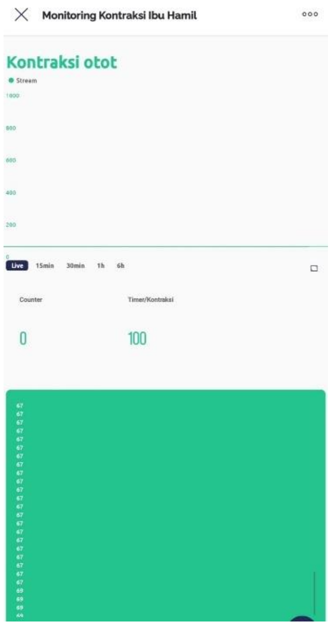


Fig. 9. View on blynk

Figure 9 above is the display of the Blynk application. Blynk itself is an IoT platform used to control hardware devices, display, process, store and visualize sensor data that is read. In this experiment, there are three data trials, the top position is a graph widget that functions to display a graph of abdominal muscle activity, then there is a counter widget that functions to count the number of contractions, and the value widget functions to display the exact value of muscle tension.

Fig. 10. Electrode installation position

The rounded top of the uterus is called the fundus uteri. This is where egg implantation occurs during pregnancy. The fundus uteri are the area most often used to measure the height of the uterus during pregnancy, to evaluate fetal growth, and it is where the abdominal muscles contract or harden. it is important to monitor the growth and position of the fundus uteri as health professionals can identify potential health concerns and provide appropriate care to support maternal and fetal health.

The EMG (Electromyography) sensor has 3 electrode wires with different colors: red indicates the positive electrode or connected to the positive pole, yellow indicates the negative electrode or connected to the negative pole and green indicates the ground electrode or reference electrode. The bipolar insertion technique is used to attach the electrodes at three different locations within the abdominal muscle.

3.3 Result

The results in this study concern testing the function of the device, including hardware and software testing. Hardware testing (devices that have been assembled) and software testing (devices that have uploaded the program), where the device has been tested on pregnant women with 37-42 weeks of pregnancy. Testing using the Blynk application to monitor data on the abdominal muscle tension of pregnant women using the EMG V3 sensor as a contraction detector.

Table 2. Trial Mrs. D 5th child 42 weeks gestation

Condition	Muscle state of relaxation	State of muscle contraction
1	55	70
2	53	72
3	58	75
4	60	80
5	61	82
Average	57,4	75,8

Table 3. Trial Mrs. R 2nd child 39 weeks gestation

Condition	Muscle state of relaxation	State of muscle contraction
1	62	72
2	69	76
3	67	71
4	58	82
5	57	84
Average	62,5	77

Table 4. Trial Mrs. B 2nd child 39 weeks gestation

Condition	Muscle state of relaxation	State of muscle contraction
1	63	70
2	67	79
3	58	80
4	62	73
5	64	86
Average	62,8	77,4

From Table 3 the results of testing the Electromyograph (EMG) sensor obtained data results from experiments that have been carried out 3 times on pregnant women with a gestational age of 37-42 weeks, the data collection process is carried out at the clinic, and accompanied by a village midwife to make sure whether there is a contraction or not. The normal abdominal muscle tension value of pregnant women is between 50-70mV while in the condition of contraction abdominal muscles are above 70mV with an average muscle tension reaching 75-90mv.

4 Conclusions

The monitoring system being referred to appears to be effective and reliable in its performance. It is described as working optimally and being user-friendly, suggesting that it meets the intended objectives and provides a satisfactory user experience. The use of EMG sensors in the system is mentioned as having some drawbacks. Specifically, it is noted that the stability of these sensors is less than ideal, and they require an op-amp circuit for proper operation. Additionally, it is suggested that there are better EMG sensor alternatives available that could potentially improve the system's performance and stability. In summary, the monitoring system is commendable for its optimal functionality and ease of use, but there is room for improvement by exploring alternative EMG sensors to enhance stability and reliability.

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7 Authors

Sahrul Romadhoni is a student who is currently undergoing education in the electrical engineering study programme at the Faculty of Science and Technology, Universitas Muhammadiyah Sidoarjo with a bachelor's degree (email: sahrulromadhoni0312@gmail.com)

Indah Sulistiyowati is a lecturer at the Department of Electrical Engineering, Faculty of Science and Technology, University of Muhammadiyah Sidoarjo. She received the M. Eng degree in Electrical Engineering from Sepuluh November Institute of Technology (email: indah_sulistiyowati@umsida.ac.id).

Mar'ati Amalia rizqiyah is a student who is currently undergoing education in the midwife profession education study program at the Faculty of Health Sciences, University of Muhammadiyah Sidoarjo with a bachelor's degree (email: amaliaputrinasir@gmail.com).