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Implementation of Inertial Measurement Unit (IMU) Sensor for Monitoring System Motion Monitoring System for Pregnant Women (SIMBUMIL)

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Abstract: Pregnancy is an important period of life until the birth of the baby in the womb. One of the biggest concerns in the first trimester of pregnancy is the occurrence of miscarriage caused by excessive activity. This research examines the implementation of an Inertial Measurement Unit (IMU) Sensor using IMU MPU-6050 for pregnant women's movement monitoring system (SIMBUMIL). The movement data of pregnant women is monitored in the form of movements from daily activities. The SIMBUMIL prototype device is attached to the arms and legs to obtain real-time movement data. Based on the test results, it shows that the device can detect any angle changes experienced by pregnant women during activities. The average amount of data sent and stored in the database is 7 movement data per second per device. The SIMBUMIL application also successfully displays the movement data of pregnant women's activities visually in the form of graphs.

Keywords: *IMU, Pregnant Women, Monitoring, Realtime, MPU-6050*

1. Introduction

The period of pregnancy in pregnant women is important in life until the birth of a baby in the womb which takes up to 280 days or 40 weeks [1]. During pregnancy, pregnant women are usually inseparable from various daily activities. This is due to the demands of routine inside and outside the home, causing pregnant women to actively move. The number of activities carried out by pregnant women depends on the gestational age. Especially young pregnancy, especially in the first trimester or when the fetus enters the first three months of pregnancy. One of the biggest concerns in the first trimester of pregnancy is miscarriage. Based on research from the Central Statistics Agency (BPS) [2]. In 2015, out of 237,642,326 Indonesians, the estimated birth rate was 5 million per year and the miscarriage rate was 3.5 million per year [3]. It is estimated that between 10% to 20% of pregnancies end in miscarriage and most of these events occur within the first trimester [4]. Many factors cause miscarriage, one of which is the activity of movement in pregnant women. The movement in question is the number of activities that make the pregnant woman's stomach move up and down or left and right. Although the fetus in the womb has been protected, the frequency of excessive movement will be able to affect the condition of the pregnancy. One of the causes of shaking that is often experienced by pregnant women is when doing household chores with a lot of movement. These activities, if done excessively, will cause pregnant women to experience fatigue, worry, anxiety and even stress. The frequency of shocks that are too often experienced by pregnant women will be dangerous for the development of pregnancy. One of the impacts that often arise is trauma to the pregnancy, bleeding, pain in the abdomen, hips and waist, and even the risk of miscarriage. To be able to control the movement of pregnant women, a study of the movement behaviour of pregnant women during work activities both inside and outside the home is needed [1].

Accelerometer sensors are acceleration measurement devices that are commonly used in industry and science. This sensor is very sensitive and used to detect and monitor vibration or movement such as a system for stabilizing cameras in videography applications where accelerometers are used to stabilize the position of the camera so that the resulting image is not blurred [5], gesture control as a quadcopter control where the accelerometer is implemented on the quadcopter to detect changes in tilt angle and vibration caused by propeller rotation or wind speed so that it can fly stably [6], Accelerometer as a wheelchair movement control through head movement detection to help users who have limited legs [7].

This research uses the MPU6050 type accelerometer sensor which has a thin size, ultra-low power, 3-axis (XYZ) with a maximum 16-bit high resolution. Its digital output data is formatted in 16-bit form which can be accessed using SPI or I2C digital interface. The MPU6050

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has an accelerometer sensitivity with an adjustable scale ranging from 2g, 4g, 8g and 16g. The module series that will be used in this research is GY-521 which has an operational voltage limit of 3.0 to 5.0 volts. In the accelerometer device, there are piezoelectric components and capacitance sensors, there are microscopic crystals that will produce micro-voltage when acceleration occurs. This micro-voltage will be interpreted into velocity and orientation [8].

The movement activity behaviour of pregnant women to be measured are movement speed and movement attitude. Movement speed uses an accelerometer sensor while movement attitude is measured using a gyroscope sensor [8]. The monitoring system is carried out in real-time through sensors to obtain data on the movement activities of pregnant women, which will then be sent to the server and stored in the database [9] [10].

2. Research Method

The motion activity monitoring device for pregnant women is carried out with 3 main stages, namely (1) designing SIMBUMIL hardware to read and collect motion data based on the activities of pregnant women, (2) designing the integration of SIMBUMIL hardware and software to ensure that the sensor successfully reads and sends data to SIMBUMIL software and, (3) designing SIMBUMIL software as an interface between SIMBUMIL and users

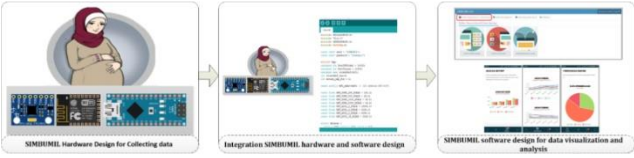

Fig 1. Stages of the Pregnant Women Movement Activity Monitoring Device

2.1 SIMBUMIL Hardware Design

Hardware Design can be described as Fig 2 below.

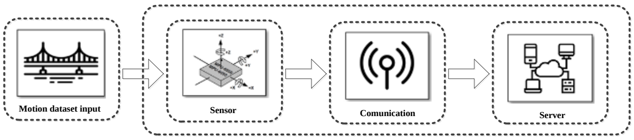

Fig 2. SIMBUMIL Hardware Design Stages

The SIMBUMIL hardware design stage consists of 3 parts, namely the sensor section functions to detect changes in acceleration, orientation and rotation of objects. The sensor plays a role in reading motion data input from pregnant women's activities. The sensor used to detect object movement is the MPU-6050 chip from InvenSense. This chip is small in size 4x4x0.9mm, highly accurate, and resistant to shock with low power consumption. The MPU-6050 is a device with 6 motion detection axes, 3 gyroscope axes, 3 accelerometer axes and a Digital Motion Processor (DMP) section. The MPU-6050 has three 16-bit ADCs (analog-to-digital converter) as digitized gyroscope outputs and three 16-bit ADCs as digitized accelerometer outputs with an additional air temperature sensor unit [5] [11].

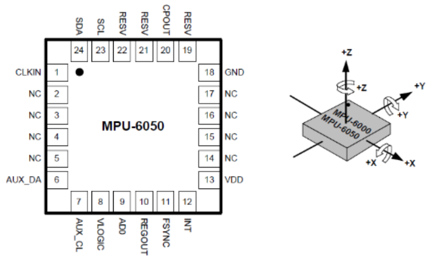

Fig. 3. MPU-6050 Shape and Orientation

Motion tracking remains precise during fast and slow movements. The gyroscope can be programmed in full-scale ranges of ±250, ±500, ±1000 and ±2000 degrees/second and the accelerometer can be programmed in full-scale ranges of ±2g, ±4g, ±8g and ±16g.

The communication part is the data communication part that will carry motion data to the server. In the motion data communication section, using WiFi technology based on the ESP-12E chip from the AI-Thinker Team with the ESP-8266 core processor. ESP-12E is a 32-bit microcontroller with very low power consumption. It supports clock speeds of 80 MHz, and 160 MHz, integrated with Wi-Fi MAC/BB/RF/PA/LNA and equipped with an onboard antenna**.** [6] [7] [8]. The ESP-12E module supports the IEEE802.11 b/g/n standard with a complete TCP/IP protocol stack.

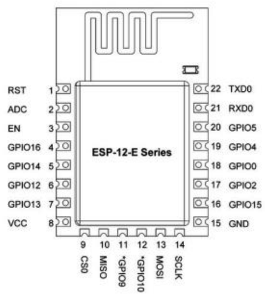

Fig. 4. Block Diagram of ESP-12E

ESP-12E consists of 22 pins with 17 GPIO pins, 4 PWM pins and 1 10-bit ADC pin. Support programming with MicroPython, LUA and Arduino C++ languages.

The server part functions to receive data, and store and process movement data. In the server section, the pregnant women's movement activity monitoring system is installed as a motion data receiver with the UDP protocol, listening on port 11000 which is programmed using the Python programming language. The received data is then saved to the MySQL database to be processed as needed. MySQL was chosen because this database server is free and can be configured for high availability like expensive paid database servers. The SIMBUMIL hardware process flow can be depicted in the following flowchart:

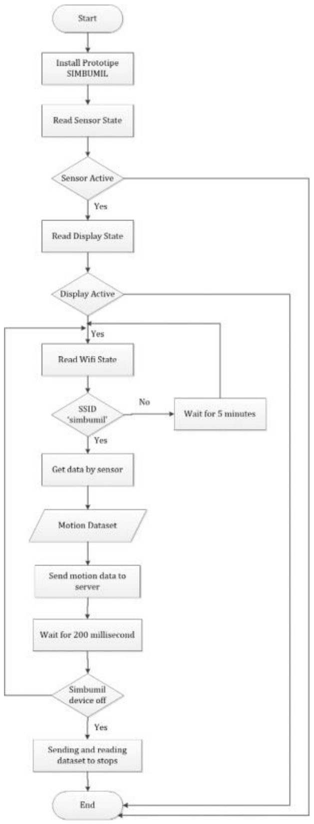

Fig. 5. SIMBUMIL Hardware Flowchart

2.2 SIMBUMIL Hardware and Software Integration Design

This process is carried out to ensure that the sensor successfully reads and sends data to the SIMBUMIL software. The mechanism of hardware integration with SIMBUMIL software is done by capturing motion data of pregnant women using hardware through sensors and sending motion data of pregnant women to the server in real-time through the internet network. [12]. The data is then permanently stored in the SIMBUMIL database. Visualization of motion data will be displayed through SIMBUMIL software in graphical form. The following flowchart integrates the hardware with the SIMBUMIL software.

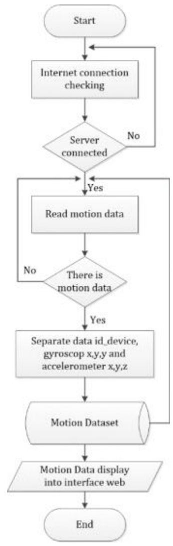

Fig. 6. Flowchart of Hardware Integration with SIMBUMIL Software

2.3 SIMBUMIL Software Design

In the SIMBUMIL interface with the user that aims to visualize and analyze the movement data of pregnant women. SIMBUMIL software development applies the RAD (Rapid Application Development) method. The stages carried out start from needs analysis, system design, development and implementation. System requirements analysis can be categorized into 3 (three) parts, namely:

A. Data requirements that are input to the system include:
1. Basic data on pregnant women is data that contains complete data on pregnant women that requires data references such as nationality data and regional data.
2. Client data is data that contains client data from pregnant women, this data requires data references such as relationship data, relationship status data, nationality data and regional data.
3. Client relationship data, which contains the relationship status between pregnant women data and client data.
4. User data, namely data that contains access rights authorization data from the system
5. Device data is data containing device data for pregnant women because 1 (one) pregnant woman will use 2 devices at once, so the data obtained from each device can be known.
6. Motion data is data obtained from devices installed on the arms and legs of pregnant women.
7. Data of pregnant women, namely data obtained from processing pregnant women's data and device data.

B. The processes that will be carried out through the system include:

1. The process of recording basic data on pregnant women consists of 3 (three) processes that will be carried out, namely.
    a. Recording pregnant women's data is used to manage the input of pregnant women's data stored in the pregnant women's data store.
    b. Family relationship recording is used to manage the input of family relationship data and pregnant women's data which is then stored in the family relationship data store.
    c. The pregnant women data store and family relationship data store are used for the process of creating information on pregnant women and families that will be displayed to admins and doctors.
2. The device data collection process consists of 2 (two) processes that will be carried out, namely.
    a. Device data collection is used to manage input device data and pregnant women's data stored in the device data store.
    b. Device and pregnant women data collection is used to process pregnant women and device data.
    c. Device information generation is used to generate device information from device data and pregnant women's data. The information generated in this process will be presented to doctors and pregnant women.
3. The process of creating user data consists of 2 (two) processes that will be carried out, namely,
    a. User data recording is used to manage user data derived from pregnant women's data and family relationship data and then stored in the user data store.
    b. The creation of user data information comes from user data that will be given to pregnant women, family admins and doctors.
4. The motion data analysis process consists of 3 (three) processes that will be carried out, namely
    a. The motion data recording process is used to manage device data and pregnant women's data and motion data sourced from pregnant women and then stored in the motion data store.
    b. The motion data analysis process requires motion data from pregnant women and then stored in the motion analysis data store.
    c. Motion information generation and motion data analysis are derived from motion analysis data and then processed to generate motion information that will be provided to families and doctors.

C. The outputs that will be generated from the system include:

1. Information on pregnant women, which presents complete information related to basic data on pregnant women
2. Client relationship information, which presents information related to the relationship status of client data with pregnant women.
3. User information, namely presenting user information and system access authorization rights
4. Device information, which presents device information that will be used by pregnant women.
5. Motion analysis information, which presents information on the results of motion data analysis of pregnant women.

A detailed description of the SIMBUMIL data flow for the design, development and implementation stages of the system can be seen in Fig. 7 of the following system flowchart:

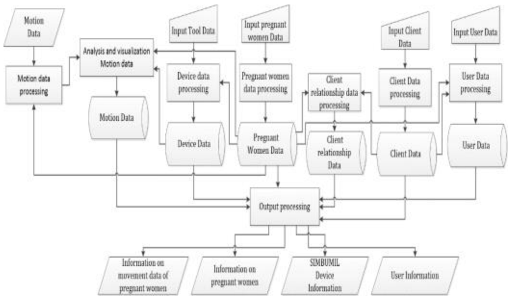

Fig 7. SIMBUMIL Data Flow Diagram

3. Results and Discussion

3.1. System Architecture

The SIMBUMIL hardware and software architecture model can be seen in Fig. 8 below.

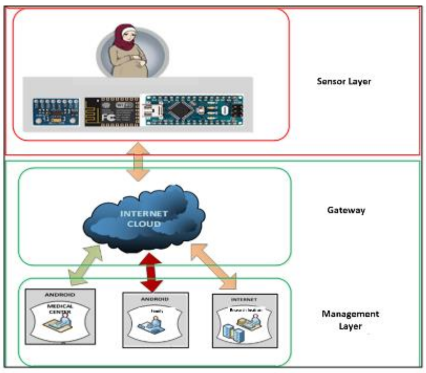

Fig. 8 System Architecture Model

The SIMBUMIL architecture model consists of two parts. **The first part** is a hardware model that is used by pregnant women on the arms and legs using a comfortable strap. This device consists of an MPU6050 accelerometer sensor as a vibration and shock detector. Arduino Mini [13] as a controller, and WiFI ESP8266 module as a connection module to the WiFi internet network to send data on the movement of pregnant women's activities in real-time [12]. Furthermore, embedding the system is embedding software or programs in the SIMBUMIL hardware that has been installed to drive the SIMBUMIL hardware and ensure that the SIMBUMIL device can function to capture motion data through the MPU6050 accelerometer sensor and send the motion data to the server via WiFI ESP8266 to be stored in the database. **The second part** is the SIMBUMIL software model. The software is designed into 3 (three) parts, namely (1) software for reading movement data, (2) website-based SIMBUMIL software for movement data management information systems managed by administrators, (3) Android-based SIMBUMIL software for movement data management information systems that can be accessed by users such as pregnant women, families or doctors

3.2 SIMBUMIL FIGUREHardware Design

The design of the SIMBUMIL device begins with (1) designing a schematic diagram (2) designing a SIMBUMIL PCB (Printed Circuit Board), and (3) designing SIMBUMIL device products. **The creation of the SIMBUMIL prototype** was carried out with 3 main stages. **The first stage** is the drawing of the SIMBUMIL prototype schematic diagram. The schematic diagram of the SIMBUMIL device illustrates 3 (three) important parts. consisting of 3 (three) parts including a 3.7 Volt battery charger with protection, an Inertia Measurement Unit (IMU) sensor and an ESP-12F WiFi module. The 3.7 Volt battery charger section with protection consists of IC TP4056 which is a battery charger IC for 1A Lithium Ion (Li-Ion) type batteries. This IC was chosen because TP4056 has constant current linear power and constant voltage and is suitable for portable devices. TP4056 is connected to a mini USB as a voltage source for battery charging. This part of the battery charger module is also equipped with dual N-Channel Power Mosfet FS8205 and IC DW01A as protection against excess battery charging which can cause battery damage. The output voltage of this battery charger is 4.2 Volts which is connected directly to a 3.7 Volt 800 mAh battery. Before the voltage is used for the IMU sensor and ESP-12F WiFi module, the voltage is reduced to 3.3V using IC RT9013 so that the output voltage matches the needs of the device. **The Inertia Measurement Unit (IMU) sensor** section on the top right of the schematic diagram shows the MPU-6050 IMU sensor from InvenSense. The MPU-6050 is a 6-axis MotionTracking device that is a combination of a 3-axis gyroscope and a 3-axis accelerometer. The MPU-6050 has 3 16-bit analog-to-digital (ADC) converter units for digitized gyroscope data output and 3 16-bit ADC units for digitized accelerometer data output. Data reading is done using the Inter-Integrated Circuit (I2C) protocol through SDA pin 24 and SCL pin 23 ports. **The ESP-12F WiFi Module part** consists of an ESP8266 core processor and is integrated with a Tensilica L106 32-bit MCU from Ai-Thinker Technology. The pins used for data reading from the MPU-6050 sensor are the GPIO4 pin for the SDA pin and GPIO5 for the SCL pin. **The second stage** of SIMBUMIL prototyping is designing the PCB using the EasyEDA device, besides being free of charge, this software is easy to use. In addition to functioning as a circuit board design tool, EasyEDA can also function as a circuit simulator. Figure (2) in the SIMBUMIL prototype creation drawing is the result of routing from EasyEDA for the SIMBUMIL hardware schematic diagram. The PCB layout consists of 2 layers or dual-layer. The top of the PCB houses the ESP-12F chip, the pins of the 0.96-inch OLED display module with 128x64 pixel resolution, and the mini USB port. The bottom of the PCB houses the power supply, battery charger and MPU-6050 IMU sensor. The technology used is Surface Mount Device (SMD) with SMD 0603 component sizes such as resistors, capacitors and LEDs.

The third stage of SIMBUMIL prototyping is SIMBUMIL PCB prototype production. Figure (3) of SIMBUMIL prototype manufacturing displays the SIMBUMIL PCB 3D engineering results generated by EasyEDA software. The engineering results are PCB manufacturing with two-layer FR-4 material and a thickness of 1.6 mm.

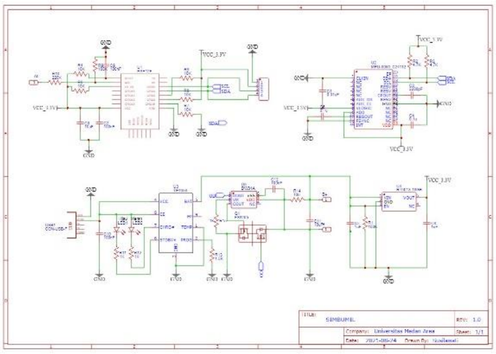

Fig. 9 Schematic Diagram of SIMBUMIL Hardware Module

As shown in Fig. 9, the SIMBUMIL hardware module consists of the MPU-6050 accelerometer sensor, ESP-12E which functions as a micro-controller with WiFi features and a regulator. In the scheme, there is a 3.3-volt AMS1117 IC as a regulator for the power supply of the MPU-6050 chip and ESP-12E module. MPU-6050 pin ADO is set HIGH by connecting it to VCC 3.3V with the aim that the I2C (Inter-Integrated Circuit) address is open at 0x69. The SCL (Serial Clock) and SDA (Serial Data) pins are connected to the GPIO5 and GPIO4 pins respectively. The GPIO0, GPIO2 and GPIO15 pins are connected to the header pins towards the LED and buzzer. The PCB design for the previous schematic is shown in Figure with a physical size of 43 x 48 mm. Fig. 10 shows the PCB design of the SIMBUMIL hardware module.

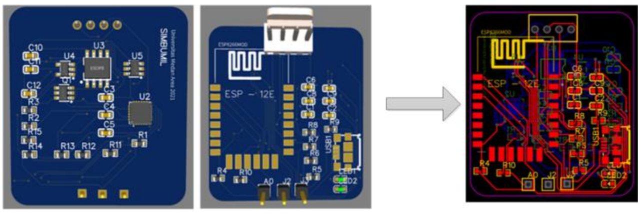

Fig. 10. SIMBUMIL Hardware Module PCB

The ESP-12E is programmed to read the accelerometer and gyroscope data by sending register code 0x3B as the initial value of ACCEL_XOUT_H to the MPU-6050. Furthermore, the MCU requests raw data of 14-byte register values containing 7 pieces of information with each value in 2 bytes (integer). These values are the accelerometer X, Y, Z, air temperature, gyroscope X, Y and Z values. The raw data values still have to be reprocessed to get the change values of acceleration, orientation and rotation. Raw data conversion is done by sending the initial register code 0x1B to read the accelerometer and gyroscope scale values on the MPU-6050. For gyroscope scale values 0 to 3, scales of 131.0, 65.5, 32.8 and 16.4 apply respectively. For accelerometer scale values of 0 to 3, scale values of 16384.0, 8192.0, 4096.0 and 2048.0 apply, respectively. The scale values obtained for the gyroscope and accelerometer are used as dividers of the raw data values to obtain the data conversion results.

3.3 Product Design of SIMBUMIL Device

This design was carried out with 2 main stages, as shown in the following figure.

Fig. 11. SIMBUMIL Product Design

SIMBUMIL product design is carried out in several stages, namely (a) programming the ESP8266 chip with the Arduino IDE using the C++ programming language [14], (b) designing the prototype box case using SketchUp software according to the PCB size and prototype display then printed it on a 3D printer, (c) Arrange all electronic components such as ESP8266, SMD (Surface mount device) capacitors and resistors with SMD component size 0603, LCD, 3.7v 800mAh LiPo battery and ON/OFF switch in the case box neatly until finished, (d) ensuring the ESP8266 chip program is running properly, shown in Fig. 12 part 1, and finally installing a comfortable strap on the box casing so that it can later be attached to the arms and legs of pregnant women, shown in Fig. 12 part 2.

3.4 SIMBUMIL Prototype Product Usage

The use of the product is carried out with 3 main stages, as shown in the following figure

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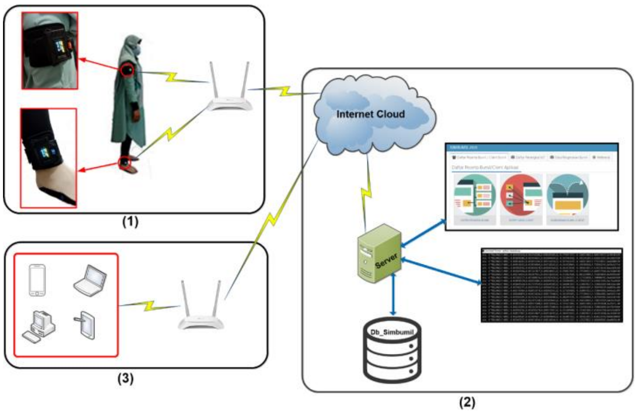

Fig. 12. SIMBUMIL Product Usage

The use of the SIMBUMIL prototype product consists of three parts, namely the first part in Fig. 12 section 1 shows the installation of the device on the body of a pregnant women. Some of the activities carried out are (a) preparing an access point router device that has internet connection capabilities using a sim card with a 4G internet provider, (b) installing the SIMBUMIL prototype on the arms and forearms of pregnant women, then ensuring that the device can be connected to the access point router device and can function to capture motion data through the SIMBUMIL prototype device and send the motion data to the server via the internet to be stored in the database. In the second part, prepare a cloud computing-based server to receive, store and process movement data of pregnant women. Some of the preparation activities carried out on the server are preparing a domain as the official address for accessing the SIMBUMIL application, preparing a VPS (virtual private server) as application and database hosting, and installing the software needed on the server such as the Linux operating system, Apache server, MySQL server, and Python. On the server, the SIMBUMIL database, motion data receiver application, and web-based monitoring application are installed as shown in Fig. 12 part 2 [15]

[16]. **The third section** describes information access in the SIMBUMIL application on the client side. Accessing information by the client through an access point router that has internet connection capabilities using PCs, laptops, smartphones and other devices.

The results of this research can be seen from the successful integration of reading and storing motion data through sensors installed on the device with the application of monitoring the movements of pregnant women in real-time. For this reason, testing the reading of motion data from the device is carried out to see that the sensor can read the data, as well as send and store the data on the server properly.

3.5 Data Reading and Storage Testing

This test is carried out to see if all the data is received and stored in the database on the server properly. In the server section, there is a server application written in the Python programming language which aims to read as well as receive and store motion data of pregnant women in real-time. The data generated through the SIMBUMIL device is in the form of accelerometer value data on the X, Y, and Z axes and X, Y Z axis gyroscope value data. The motion data will then be separated into data such as device ID, gyroscope X, Y, Z axis and accelerometer X, Y, Z axis. The separated data will be saved to the MySQL database in the motion data table on the server. The following is a sample of raw data of real-time movement data through the SIMBUMIL device received by the server application.


```
data: b'*RD;UMA-005;-0.2896446884;0.2564701438;-0.5037472844;0;9.8353805542;-4.5130701065;0.8212111592;100;v1.10;0x63cc0660#'
data: b'*RD;UMAIoT-0001;0.1557473242;-0.1513506919;-0.1989142448;0;9.6270847321;1.2761094570;-1.9608511925;0xa2f30998#'
data: b'*RD;UMA-005;2.4634456635;-0.1530826986;-0.4805650711;0;9.7060937881;-2.0159177780;-0.9864110947;100;v1.10;0x5202a8ab#'
data: b'*RD;UMAIoT-0001;0.3527963459;0.1761316955;-0.3759785593;0;9.4834327698;1.6232687235;-1.9847931862;0x737ede8f#'
data: b'*RD;UMA-005;2.4218773842;-0.2424808443;-0.0014655436;0;10.6805334091;0.5770025849;-0.9911994934;100;v1.10;0xc5033711#'
data: b'*RD;UMAIoT-0001;0.2612664402;0.2844487131;-0.2042434961;0;9.5983543396;2.2146365643;-1.0702081919;0xd92b8967#'
data: b'*RD;UMA-005;1.7525237799;0.2985712290;0.6781470180;0;10.6901102066;0.9337386489;-0.6895300746;100;v1.10;0x9bed76bd#'
data: b'*RD;UMAIoT-0001;0.0269127097;0.1397595704;-0.0021316998;0;9.2847137451;2.4085669518;-1.1875240803;0xa378dc08#'
data: b'*RD;UMA-005;0.2844487131;0.1502848417;1.4805988073;0;10.6230726242;-0.1915361285;-0.5458779931;100;v1.10;0xdd99a72f#'
data: b'*RD;UMAIoT-0001;-0.0494287908;0.1334977001;0.1458882093;0;9.3972415924;2.2816741467;-1.1899182796;0x0670de6d#'
data: b'*RD;UMA-005;-0.1598774791;-0.2379509956;0.6912036538;0;9.7587661743;-2.3894133568;-0.1436520964;100;v1.10;0xd25b73d6#'
data: b'*RD;UMAIoT-0001;-0.1418912709;0.3124272525;0.1373614073;0;9.6725749969;2.0949265957;-1.0845733881;0x9081c57c#'
data: b'*RD;UMA-005;-0.5675650835;-0.0884655416;-0.2815175951;0;10.2112703323;-1.8267759085;-0.6703764796;100;v1.10;0xf7533503#'
data: b'*RD;UMAIoT-0001;-0.1029877514;0.5563736558;0.2123706043;0;9.6917285919;1.8890250921;0.0718260482;0xeb3ab4ae#'
data: b'*RD;UMA-005;-0.3714486957;0.1953170002;-0.9916401505;0;9.3014736176;-4.1754879951;0.4716577232;100;v1.10;0xf9df7248#'
data: b'*RD;UMAIoT-0001;-0.0075941808;1.1853582859;-0.5114747286;0;12.1601505280;0.1197100878;0.7350199223;0x693cc878#'
data: b'*RD;UMA-005;-0.2555375099;0.3325451612;-0.7023950815;0;10.1322612762;1.9704279900;0.8331822157;100;v1.10;0xbe528230#'
data: b'*RD;UMAIoT-0001;0.9183629155;1.5164380074;-0.9355497956;0;9.5049810410;4.6232032776;-0.2394201756;0x98da22d8#'
data: b'*RD;UMA-005;-1.5448162556;0.7699432969;-0.3823736608;0;10.6757450104;-0.1029506698;1.5346833467;100;v1.10;0xa48399c9#'
data: b'*RD;UMAIoT-0001;1.8036845922;0.4942878783;0.7193154693;0;7.2951326370;2.1523873806;-0.3950432837;0xb1285d55#'
data: b'*RD;UMA-005;-0.4659096301;0.2656630874;-0.1593445688;0;9.6246910095;-0.3567360640;1.1899182796;100;v1.10;0xd51d8322#'
data: b'*RD;UMAIoT-0001;2.8458192348;-0.6252542138;1.7982220650;0;9.4092130661;2.3127987385;-1.6448165178;0x13d7d3fa#'
data: b'*RD;UMA-005;0.2451454699;0.1441561878;-0.0351730473;0;9.7994670868;-1.2545616627;1.9800047874;100;v1.10;0x5395bfbc#'
data: b'*RD;UMAIoT-0001;1.0165543556;-1.6797795296;2.7365698814;0;11.6860980988;0.9361328483;-2.3774423599;0xfff80e55#'
data: b'*RD;UMA-005;0.1585451663;0.1771975458;0.0512940250;0;9.2392244339;-0.6488286853;1.8962076902;100;v1.10;0xac9cf5bc#'
data: b'*RD;UMAIoT-0001;-0.4657764137;-1.4199786186;1.9310535192;0;11.5975131989;2.7174189091;1.5993267298;0xa13fd594#'
data: b'*RD;UMA-005;0.3581255674;0.1187090278;0.0544915758;0;9.5983543396;-0.6224924326;2.0901381969;100;v1.10;0x47722f67#'
data: b'*RD;UMAIoT-0001;-0.8538790345;-0.5531761050;0.1303001493;0;7.7284832001;-12.6078662872;-13.5368165970;0x33a9849d#'
data: b'*RD;UMA-005;0.3019019961;-0.0370382816;-0.0103920363;0;10.7667245865;-0.7541735172;2.1475989819;100;v1.10;0xe4917f9c#'
data: b'*RD;UMAIoT-0001;-0.0584885143;-0.0039969371;-0.7595512867;0;8.7053174973;-0.8475474119;-3.4213142395;0xb2272ab5#'
data: b'*RD;UMA-005;0.9583323002;-0.2912434936;0.4463246465;0;8.9830446243;1.6519991159;1.6160861254;100;v1.10;0x63fcef1f#'
data: b'*RD;UMAIoT-0001;-0.1823935658;0.1979816258;-0.8397564888;0;9.5696239471;-0.0550666377;-3.5027170181;0xc25a0e2d#'
data: b'*RD;UMA-005;0.6652235389;-0.2828499079;1.1078177691;0;10.7858781815;1.9033904076;0.7589619160;100;v1.10;0xbcbe0992#'
data: b'*RD;UMAIoT-0001;-0.1974486858;0.2777871490;-0.3751791716;0;9.3613290787;0.7254431248;-2.9472622871;0xee8e8438#'
```


Fig. 13. Readable data

The data in Fig. 13 shows that the device has successfully read the data. The data has been normalized by separating the device id, gyroscopex, gyroscopey, gyroscopez and accelerometerx, accelerometery and accelerometerz. The normalized data is then successfully stored in the database at almost the same time.

kodeperangkat	accx	accy	accz	gyrox	gyroy	gyroz	acctotal	gyrototal	tanggalupdate
UMA-005	-4,36572	3,71569	-3,04473	17,3244	-3,54821	6,5242	11,1261	27,3969	2021-11-12 20:13:52
UMAIoT-0001	0,498951	0,441129	0,116711	8,82503	1,98958	2,45406	1,05679	13,2687	2021-11-12 20:13:52
UMA-005	1,89228	1,37375	-3,40939	9,3302	4,20422	2,03507	6,67542	15,5695	2021-11-12 20:13:52
UMAIoT-0001	0,130433	0,114312	0,0464977	8,05409	2,727	2,43969	0,291243	13,2208	2021-11-12 20:13:52
UMA-005	0,889052	-1,21374	-0,113113	1,40779	-7,74524	2,92093	2,2159	12,074	2021-11-12 20:13:52
UMAIoT-0001	-0,35706	-0,144156	-0,0215835	9,1674	1,93691	2,66714	0,522799	13,7714	2021-11-12 20:13:52
UMA-005	2,20684	-2,10878	4,18479	13,7834	-1,2809	2,61207	8,50042	17,6764	2021-11-12 20:13:52
UMAIoT-0001	-0,188655	-0,252073	-0,152683	9,38288	1,9824	2,33914	0,593412	13,7044	2021-11-12 20:13:52
UMA-005	2,62825	-0,207175	4,36559	16,5272	-1,07739	3,69186	7,20102	21,2964	2021-11-12 20:13:52
UMAIoT-0001	0,113646	-0,482697	-0,0700796	8,12831	2,62165	1,71425	0,666423	12,4642	2021-11-12 20:13:52
UMA-005	-1,63115	0,293908	2,46131	6,82108	-3,36864	2,85868	4,38637	13,0484	2021-11-12 20:13:52
UMAIoT-0001	-0,377844	-0,77927	0,130433	9,16261	1,56581	0,773327	1,28755	11,5017	2021-11-12 20:13:52
UMA-005	0,774473	-0,128835	-0,666423	6,00466	-2,63602	2,98557	1,56973	11,6262	2021-11-12 20:13:52
UMAIoT-0001	-0,210639	-0,785398	0,103254	10,5728	1,2809	0,215478	1,09929	12,0692	2021-11-12 20:13:52
UMA-005	-2,45612	0,703061	-2,71565	9,60075	-3,40934	2,53307	5,87483	15,5432	2021-11-12 20:13:52
UMAIoT-0001	0,0410352	-0,58675	-0,0688806	9,31105	1,91057	-1,54187	0,696666	12,7635	2021-11-12 20:13:53
UMA-005	0,37811	1,9986	-4,1303	14,5759	-2,20985	5,60722	6,50701	22,393	2021-11-12 20:13:53
UMAIoT-0001	0,195051	-0,201046	0,0944609	9,63906	2,17633	-1,80762	0,490557	13,623	2021-11-12 20:13:53
UMA-005	-1,45195	2,48823	-3,48666	11,2456	0,246603	2,76291	7,42684	14,2551	2021-11-12 20:13:53
UMAIoT-0001	-0,0643507	-0,00839357	0,11711	9,48104	1,78847	-1,9824	0,189855	13,2519	2021-11-12 20:13:53
UMA-005	-1,73853	-0,374247	-0,403824	5,46357	-4,53222	1,60412	2,5166	11,5999	2021-11-12 20:13:53
UMAIoT-0001	0,0912634	0,856943	-0,250475	10,1945	1,35272	0,80924	1,19868	12,3565	2021-11-12 20:13:54
UMA-005	-0,886654	0,618459	-2,42094	8,90882	-6,07409	2,78206	3,92606	17,765	2021-11-12 20:13:54
UMAIoT-0001	0,364121	0,854545	-0,105919	9,27274	2,70066	1,33836	1,32458	13,3118	2021-11-12 20:13:54
UMA-005	-0,0626187	1,63368	-3,31719	10,5752	-5,48512	2,12366	5,01349	18,184	2021-11-12 20:13:54
UMAIoT-0001	0,178397	0,42674	0,194384	8,74602	2,40138	2,76291	0,799521	13,9103	2021-11-12 20:13:54
UMA-005	-1,60197	0,291776	-3,81721	13,7595	3,61046	2,72221	5,71096	20,0921	2021-11-12 20:13:54
UMAIoT-0001	0,131632	0,0646171	0,0125237	8,69574	2,4756	2,71263	0,208773	13,884	2021-11-12 20:13:54
UMA-005	-0,142691	0,0723446	-1,16631	5,75806	-5,02064	2,25055	1,38134	13,0292	2021-11-12 20:13:54
UMAIoT-0001	-0,0342404	-0,116711	-0,083536	8,10437	3,03824	2,9736	0,234487	14,1162	2021-11-12 20:13:54
UMA-005	1,39613	-1,00123	1,90268	8,43238	-1,06781	2,8084	4,30004	12,3086	2021-11-12 20:13:54
UMAIoT-0001	-0,321487	-0,333211	-0,139626	9,23683	2,24097	2,7246	0,794325	14,2024	2021-11-12 20:13:54
UMA-005	3,04793	-0,407155	3,70663	14,4011	-1,23541	2,41336	7,16171	18,0499	2021-11-12 20:13:54
UMAIoT-0001	-0,284049	-0,623389	-0,290444	9,00459	2,67432	1,90818	1,19788	13,5871	2021-11-12 20:13:54
UMA-005	-0,163075	0,605802	2,962	10,4627	-2,90417	2,37026	3,73087	15,7371	2021-11-12 20:13:54
UMAIoT-0001	0,141492	-0,631916	0,102855	8,7532	3,52426	0,169988	0,876262	12,4475	2021-11-12 20:13:55
UMA-005	0,202112	-0,20038	1,45715	6,65828	-5,05416	2,46842	1,85964	14,1809	2021-11-12 20:13:55
UMAIoT-0001	-0,0824701	-0,895181	0,497885	8,87052	3,06937	-0,402226	1,47554	12,3421	2021-11-12 20:13:55
UMA-005	0,214636	-0,0147887	-0,814976	5,77242	-2,27449	2,90177	1,0444	10,9487	2021-11-12 20:13:55
UMAIoT-0001	0,193052	-0,580755	-0,0382374	10,3214	1,84593	-1,46046	0,812044	13,6278	2021-11-12 20:13:55
UMA-005	-1,01202	0,672418	-2,95254	10,2304	-5,23373	3,14119	4,63698	18,6053	2021-11-12 20:13:55
UMAIoT-0001	0,171469	-0,340806	0,157213	9,64863	2,40617	-1,65439	0,669487	13,7092	2021-11-12 20:13:55

Fig. 14. Data Stored on Database Server

The snapshot in Fig. 14 shows that the motion data has been stored in the database. All sent data was successfully stored and nothing was missed. The data was taken from the hardware with ID UMA-005 attached to the arm and device ID UMAIoT-0001 attached to the leg.

In addition, this test also shows the average data that can be sent to be stored per second from each device. After observing the data for five minutes, the average data that can be sent to be stored per second is shown in the following figure.

Description	device SIMBUMIL	(t1)	s1	(t2)	s2	(t3)	s3	(t4)	s4	(t5)	s5
Arm Device	UMA-005	12/11/2021 20:15:00	7	12/11/2021 20:16:00	7	12/11/2021 20:17:00	7	12/11/2021 20:18:00	7	12/11/2021 20:19:00	7
	UMA-005	12/11/2021 20:15:01	7	12/11/2021 20:16:01	7	12/11/2021 20:17:01	7	12/11/2021 20:18:01	7	12/11/2021 20:19:01	7
	UMA-005	12/11/2021 20:15:02	7	12/11/2021 20:16:02	7	12/11/2021 20:17:02	7	12/11/2021 20:18:02	8	12/11/2021 20:19:02	7
	UMA-005	12/11/2021 20:15:03	7	12/11/2021 20:16:03	7	12/11/2021 20:17:03	7	12/11/2021 20:18:03	7	12/11/2021 20:19:03	7
	UMA-005	12/11/2021 20:15:04	7	12/11/2021 20:16:04	7	12/11/2021 20:17:04	7	12/11/2021 20:18:04	7	12/11/2021 20:19:04	7
	UMA-005	12/11/2021 20:15:05	7	12/11/2021 20:16:05	7	12/11/2021 20:17:05	7	12/11/2021 20:18:05	7	12/11/2021 20:19:05	8
	UMA-005	12/11/2021 20:15:06	7	12/11/2021 20:16:06	7	12/11/2021 20:17:06	7	12/11/2021 20:18:06	7	12/11/2021 20:19:06	6
	UMA-005	12/11/2021 20:15:07	7	12/11/2021 20:16:07	7	12/11/2021 20:17:07	7	12/11/2021 20:18:07	7	12/11/2021 20:19:07	8
	UMA-005	12/11/2021 20:15:08	6	12/11/2021 20:16:08	6	12/11/2021 20:17:08	7	12/11/2021 20:18:08	7	12/11/2021 20:19:08	7
	UMA-005	12/11/2021 20:15:09	8	12/11/2021 20:16:09	7	12/11/2021 20:17:09	6	12/11/2021 20:18:09	7	12/11/2021 20:19:09	7
	UMA-005	12/11/2021 20:15:10	7	12/11/2021 20:16:10	8	12/11/2021 20:17:10	8	12/11/2021 20:18:10	7	12/11/2021 20:19:10	7
	UMA-005	12/11/2021 20:15:11	7	12/11/2021 20:16:11	7	12/11/2021 20:17:11	7	12/11/2021 20:18:11	7	12/11/2021 20:19:11	7
	UMA-005	12/11/2021 20:15:12	6	12/11/2021 20:16:12	7	12/11/2021 20:17:12	6	12/11/2021 20:18:12	6	12/11/2021 20:19:12	7
	UMA-005	12/11/2021 20:15:13	8	12/11/2021 20:16:13	7	12/11/2021 20:17:13	8	12/11/2021 20:18:13	8	12/11/2021 20:19:13	7
	UMA-005	12/11/2021 20:15:14	7	12/11/2021 20:16:14	7	12/11/2021 20:17:14	7	12/11/2021 20:18:14	7	12/11/2021 20:19:14	7
	UMA-005	12/11/2021 20:15:15	7	12/11/2021 20:16:15	7	12/11/2021 20:17:15	7	12/11/2021 20:18:15	6	12/11/2021 20:19:15	7
	UMA-005	12/11/2021 20:15:16	7	12/11/2021 20:16:16	7	12/11/2021 20:17:16	7	12/11/2021 20:18:16	6	12/11/2021 20:19:16	7
	UMA-005	12/11/2021 20:15:17	7	12/11/2021 20:16:17	7	12/11/2021 20:17:17	7	12/11/2021 20:18:17	7	12/11/2021 20:19:17	6
	UMA-005	12/11/2021 20:15:18	7	12/11/2021 20:16:18	7	12/11/2021 20:17:18	7	12/11/2021 20:18:18	7	12/11/2021 20:19:18	8
	UMA-005	12/11/2021 20:15:19	7	12/11/2021 20:16:19	7	12/11/2021 20:17:19	7	12/11/2021 20:18:19	7	12/11/2021 20:19:19	7
	UMA-005	12/11/2021 20:15:20	7	12/11/2021 20:16:20	7	12/11/2021 20:17:20	7	12/11/2021 20:18:20	7	12/11/2021 20:19:20	7
	UMA-005	12/11/2021 20:15:21	7	12/11/2021 20:16:21	7	12/11/2021 20:17:21	7	12/11/2021 20:18:21	7	12/11/2021 20:19:21	7
	UMA-005	12/11/2021 20:15:22	7	12/11/2021 20:16:22	7	12/11/2021 20:17:22	7	12/11/2021 20:18:22	7	12/11/2021 20:19:22	7
	UMA-005	12/11/2021 20:15:23	8	12/11/2021 20:16:23	7	12/11/2021 20:17:23	7	12/11/2021 20:18:23	7	12/11/2021 20:19:23	7
	UMA-005	12/11/2021 20:15:24	7	12/11/2021 20:16:24	7	12/11/2021 20:17:24	7	12/11/2021 20:18:24	7	12/11/2021 20:19:24	7
	UMA-005	12/11/2021 20:15:25	7	12/11/2021 20:16:25	8	12/11/2021 20:17:25	7	12/11/2021 20:18:25	7	12/11/2021 20:19:25	7
	UMA-005	12/11/2021 20:15:26	6	12/11/2021 20:16:26	7	12/11/2021 20:17:26	7	12/11/2021 20:18:26	7	12/11/2021 20:19:26	7
	UMA-005	12/11/2021 20:15:27	8	12/11/2021 20:16:27	7	12/11/2021 20:17:27	7	12/11/2021 20:18:27	7	12/11/2021 20:19:27	7
	UMA-005	12/11/2021 20:15:28	7	12/11/2021 20:16:28	6	12/11/2021 20:17:28	7	12/11/2021 20:18:28	7	12/11/2021 20:19:28	7
	UMA-005	12/11/2021 20:15:29	7	12/11/2021 20:16:29	7	12/11/2021 20:17:29	7	12/11/2021 20:18:29	7	12/11/2021 20:19:29	7
	UMA-005	12/11/2021 20:15:30	6	12/11/2021 20:16:30	7	12/11/2021 20:17:30	8	12/11/2021 20:18:30	7	12/11/2021 20:19:30	7
	UMA-005	12/11/2021 20:15:31	7	12/11/2021 20:16:31	7	12/11/2021 20:17:31	6	12/11/2021 20:18:31	7	12/11/2021 20:19:31	7
	UMA-005	12/11/2021 20:15:32	8	12/11/2021 20:16:32	7	12/11/2021 20:17:32	8	12/11/2021 20:18:32	8	12/11/2021 20:19:32	7
	UMA-005	12/11/2021 20:15:33	7	12/11/2021 20:16:33	7	12/11/2021 20:17:33	7	12/11/2021 20:18:33	6	12/11/2021 20:19:33	7
	UMA-005	12/11/2021 20:15:34	6	12/11/2021 20:16:34	6	12/11/2021 20:17:34	7	12/11/2021 20:18:34	7	12/11/2021 20:19:34	7
	UMA-005	12/11/2021 20:15:35	8	12/11/2021 20:16:35	7	12/11/2021 20:17:35	7	12/11/2021 20:18:35	8	12/11/2021 20:19:35	7
	UMA-005	12/11/2021 20:15:36	7	12/11/2021 20:16:36	8	12/11/2021 20:17:36	7	12/11/2021 20:18:36	7	12/11/2021 20:19:36	7
	UMA-005	12/11/2021 20:15:37	7	12/11/2021 20:16:37	7	12/11/2021 20:17:37	7	12/11/2021 20:18:37	6	12/11/2021 20:19:37	7
	UMA-005	12/11/2021 20:15:38	7	12/11/2021 20:16:38	6	12/11/2021 20:17:38	6	12/11/2021 20:18:38	8	12/11/2021 20:19:38	8
	UMA-005	12/11/2021 20:15:39	7	12/11/2021 20:16:39	8	12/11/2021 20:17:39	7	12/11/2021 20:18:39	7	12/11/2021 20:19:39	6
	UMA-005	12/11/2021 20:15:40	7	12/11/2021 20:16:40	7	12/11/2021 20:17:40	6	12/11/2021 20:18:40	7	12/11/2021 20:19:40	7
	UMA-005	12/11/2021 20:15:41	7	12/11/2021 20:16:41	7	12/11/2021 20:17:41	7	12/11/2021 20:18:41	7	12/11/2021 20:19:41	8
	UMA-005	12/11/2021 20:15:42	7	12/11/2021 20:16:42	7	12/11/2021 20:17:42	8	12/11/2021 20:18:42	7	12/11/2021 20:19:42	7
	UMA-005	12/11/2021 20:15:43	7	12/11/2021 20:16:43	7	12/11/2021 20:17:43	7	12/11/2021 20:18:43	7	12/11/2021 20:19:43	6
	UMA-005	12/11/2021 20:15:44	7	12/11/2021 20:16:44	7	12/11/2021 20:17:44	7	12/11/2021 20:18:44	7	12/11/2021 20:19:44	8
	UMA-005	12/11/2021 20:15:45	7	12/11/2021 20:16:45	7	12/11/2021 20:17:45	7	12/11/2021 20:18:45	7	12/11/2021 20:19:45	7
	UMA-005	12/11/2021 20:15:46	7	12/11/2021 20:16:46	7	12/11/2021 20:17:46	7	12/11/2021 20:18:46	7	12/11/2021 20:19:46	6
	UMA-005	12/11/2021 20:15:47	7	12/11/2021 20:16:47	7	12/11/2021 20:17:47	7	12/11/2021 20:18:47	7	12/11/2021 20:19:47	8
	UMA-005	12/11/2021 20:15:48	7	12/11/2021 20:16:48	7	12/11/2021 20:17:48	7	12/11/2021 20:18:48	7	12/11/2021 20:19:48	7
	UMA-005	12/11/2021 20:15:49	7	12/11/2021 20:16:49	7	12/11/2021 20:17:49	7	12/11/2021 20:18:49	7	12/11/2021 20:19:49	7
	UMA-005	12/11/2021 20:15:50	7	12/11/2021 20:16:50	7	12/11/2021 20:17:50	7	12/11/2021 20:18:50	7	12/11/2021 20:19:50	7
	UMA-005	12/11/2021 20:15:51	7	12/11/2021 20:16:51	7	12/11/2021 20:17:51	7	12/11/2021 20:18:51	7	12/11/2021 20:19:51	7
	UMA-005	12/11/2021 20:15:52	7	12/11/2021 20:16:52	7	12/11/2021 20:17:52	7	12/11/2021 20:18:52	7	12/11/2021 20:19:52	7
	UMA-005	12/11/2021 20:15:53	8	12/11/2021 20:16:53	7	12/11/2021 20:17:53	7	12/11/2021 20:18:53	7	12/11/2021 20:19:53	7
	UMA-005	12/11/2021 20:15:54	6	12/11/2021 20:16:54	7	12/11/2021 20:17:54	7	12/11/2021 20:18:54	7	12/11/2021 20:19:54	7
	UMA-005	12/11/2021 20:15:55	7	12/11/2021 20:16:55	7	12/11/2021 20:17:55	7	12/11/2021 20:18:55	7	12/11/2021 20:19:55	6
	UMA-005	12/11/2021 20:15:56	8	12/11/2021 20:16:56	7	12/11/2021 20:17:56	7	12/11/2021 20:18:56	7	12/11/2021 20:19:56	8
	UMA-005	12/11/2021 20:15:57	7	12/11/2021 20:16:57	7	12/11/2021 20:17:57	7	12/11/2021 20:18:57	7	12/11/2021 20:19:57	7
	UMA-005	12/11/2021 20:15:58	7	12/11/2021 20:16:58	8	12/11/2021 20:17:58	7	12/11/2021 20:18:58	7	12/11/2021 20:19:58	6
	UMA-005	12/11/2021 20:15:59	7	12/11/2021 20:16:59	7	12/11/2021 20:17:59	7	12/11/2021 20:18:59	7	12/11/2021 20:19:59	8
	movement average value		7		7		7		7		7
Leg Device	UMAIoT-0001	12/11/2021 20:15:00	7	12/11/2021 20:16:00	7	12/11/2021 20:17:00	7	12/11/2021 20:18:00	7	12/11/2021 20:19:00	7
	UMAIoT-0001	12/11/2021 20:15:01	7	12/11/2021 20:16:01	7	12/11/2021 20:17:01	7	12/11/2021 20:18:01	7	12/11/2021 20:19:01	7
	UMAIoT-0001	12/11/2021 20:15:02	7	12/11/2021 20:16:02	7	12/11/2021 20:17:02	7	12/11/2021 20:18:02	7	12/11/2021 20:19:02	7
	UMAIoT-0001	12/11/2021 20:15:03	8	12/11/2021 20:16:03	7	12/11/2021 20:17:03	7	12/11/2021 20:18:03	7	12/11/2021 20:19:03	8
	UMAIoT-0001	12/11/2021 20:15:04	7	12/11/2021 20:16:04	7	12/11/2021 20:17:04	7	12/11/2021 20:18:04	7	12/11/2021 20:19:04	7
	UMAIoT-0001	12/11/2021 20:15:05	7	12/11/2021 20:16:05	8	12/11/2021 20:17:05	7	12/11/2021 20:18:05	7	12/11/2021 20:19:05	7
	UMAIoT-0001	12/11/2021 20:15:06	7	12/11/2021 20:16:06	7	12/11/2021 20:17:06	7	12/11/2021 20:18:06	7	12/11/2021 20:19:06	7
	UMAIoT-0001	12/11/2021 20:15:07	7	12/11/2021 20:16:07	7	12/11/2021 20:17:07	7	12/11/2021 20:18:07	7	12/11/2021 20:19:07	7
	UMAIoT-0001	12/11/2021 20:15:08	6	12/11/2021 20:16:08	6	12/11/2021 20:17:08	8	12/11/2021 20:18:08	7	12/11/2021 20:19:08	7
	UMAIoT-0001	12/11/2021 20:15:09	8	12/11/2021 20:16:09	7	12/11/2021 20:17:09	6	12/11/2021 20:18:09	7	12/11/2021 20:19:09	7
	UMAIoT-0001	12/11/2021 20:15:10	7	12/11/2021 20:16:10	8	12/11/2021 20:17:10	8	12/11/2021 20:18:10	7	12/11/2021 20:19:10	7
	UMAIoT-0001	12/11/2021 20:15:11	7	12/11/2021 20:16:11	7	12/11/2021 20:17:11	7	12/11/2021 20:18:11	7	12/11/2021 20:19:11	7
	UMAIoT-0001	12/11/2021 20:15:12	7	12/11/2021 20:16:12	6	12/11/2021 20:17:12	6	12/11/2021 20:18:12	7	12/11/2021 20:19:12	7
	UMAIoT-0001	12/11/2021 20:15:13	7	12/11/2021 20:16:13	8	12/11/2021 20:17:13	8	12/11/2021 20:18:13	8	12/11/2021 20:19:13	7
	UMAIoT-0001	12/11/2021 20:15:14	7	12/11/2021 20:16:14	7	12/11/2021 20:17:14	7	12/11/2021 20:18:14	7	12/11/2021 20:19:14	8
	UMAIoT-0001	12/11/2021 20:15:15	7	12/11/2021 20:16:15	7	12/11/2021 20:17:15	7	12/11/2021 20:18:15	6	12/11/2021 20:19:15	7
	UMAIoT-0001	12/11/2021 20:15:16	7	12/11/2021 20:16:16	7	12/11/2021 20:17:16	7	12/11/2021 20:18:16	7	12/11/2021 20:19:16	7
	UMAIoT-0001	12/11/2021 20:15:17	8	12/11/2021 20:16:17	7	12/11/2021 20:17:17	7	12/11/2021 20:18:17	7	12/11/2021 20:19:17	6
	UMAIoT-0001	12/11/2021 20:15:18	7	12/11/2021 20:16:18	8	12/11/2021 20:17:18	7	12/11/2021 20:18:18	8	12/11/2021 20:19:18	8
	UMAIoT-0001	12/11/2021 20:15:19	7	12/11/2021 20:16:19	7	12/11/2021 20:17:19	7	12/11/2021 20:18:19	7	12/11/2021 20:19:19	7
	UMAIoT-0001	12/11/2021 20:15:20	7	12/11/2021 20:16:20	7	12/11/2021 20:17:20	7	12/11/2021 20:18:20	7	12/11/2021 20:19:20	7
	UMAIoT-0001	12/11/2021 20:15:21	7	12/11/2021 20:16:21	7	12/11/2021 20:17:21	8	12/11/2021 20:18:21	7	12/11/2021 20:19:21	7
	UMAIoT-0001	12/11/2021 20:15:22	7	12/11/2021 20:16:22	7	12/11/2021 20:17:22	7	12/11/2021 20:18:22	7	12/11/2021 20:19:22	7
	UMAIoT-0001	12/11/2021 20:15:23	7	12/11/2021 20:16:23	7	12/11/2021 20:17:23	7	12/11/2021 20:18:23	7	12/11/2021 20:19:23	7
	UMAIoT-0001	12/11/2021 20:15:24	7	12/11/2021 20:16:24	7	12/11/2021 20:17:24	7	12/11/2021 20:18:24	8	12/11/2021 20:19:24	7
	UMAIoT-0001	12/11/2021 20:15:25	7	12/11/2021 20:16:25	7	12/11/2021 20:17:25	7	12/11/2021 20:18:25	7	12/11/2021 20:19:25	7
	UMAIoT-0001	12/11/2021 20:15:26	7	12/11/2021 20:16:26	7	12/11/2021 20:17:26	7	12/11/2021 20:18:26	7	12/11/2021 20:19:26	7
	UMAIoT-0001	12/11/2021 20:15:27	7	12/11/2021 20:16:27	7	12/11/2021 20:17:27	7	12/11/2021 20:18:27	7	12/11/2021 20:19:27	8
	UMAIoT-0001	12/11/2021 20:15:28	8	12/11/2021 20:16:28	7	12/11/2021 20:17:28	7	12/11/2021 20:18:28	7	12/11/2021 20:19:28	7
	UMAIoT-0001	12/11/2021 20:15:29	6	12/11/2021 20:16:29	7	12/11/2021 20:17:29	7	12/11/2021 20:18:29	7	12/11/2021 20:19:29	7
	UMAIoT-0001	12/11/2021 20:15:30	7	12/11/2021 20:16:30	8	12/11/2021 20:17:30	7	12/11/2021 20:18:30	7	12/11/2021 20:19:30	7
	UMAIoT-0001	12/11/2021 20:15:31	7	12/11/2021 20:16:31	7	12/11/2021 20:17:31	7	12/11/2021 20:18:31	7	12/11/2021 20:19:31	7
	UMAIoT-0001	12/11/2021 20:15:32	8	12/11/2021 20:16:32	7	12/11/2021 20:17:32	7	12/11/2021 20:18:32	7	12/11/2021 20:19:32	7
	UMAIoT-0001	12/11/2021 20:15:33	7	12/11/2021 20:16:33	7	12/11/2021 20:17:33	8	12/11/2021 20:18:33	7	12/11/2021 20:19:33	7
	UMAIoT-0001	12/11/2021 20:15:34	6	12/11/2021 20:16:34	6	12/11/2021 20:17:34	7	12/11/2021 20:18:34	7	12/11/2021 20:19:34	7
	UMAIoT-0001	12/11/2021 20:15:35	8	12/11/2021 20:16:35	7	12/11/2021 20:17:35	6	12/11/2021 20:18:35	7	12/11/2021 20:19:35	7
	UMAIoT-0001	12/11/2021 20:15:36	7	12/11/2021 20:16:36	8	12/11/2021 20:17:36	8	12/11/2021 20:18:36	7	12/11/2021 20:19:36	7
	UMAIoT-0001	12/11/2021 20:15:37	7	12/11/2021 20:16:37	7	12/11/2021 20:17:37	7	12/11/2021 20:18:37	7	12/11/2021 20:19:37	7
	UMAIoT-0001	12/11/2021 20:15:38	7	12/11/2021 20:16:38	6	12/11/2021 20:17:38	6	12/11/2021 20:18:38	8	12/11/2021 20:19:38	7
	UMAIoT-0001	12/11/2021 20:15:39	7	12/11/2021 20:16:39	8	12/11/2021 20:17:39	7	12/11/2021 20:18:39	7	12/11/2021 20:19:39	7
	UMAIoT-0001	12/11/2021 20:15:40	7	12/11/2021 20:16:40	7	12/11/2021 20:17:40	6	12/11/2021 20:18:40	7	12/11/2021 20:19:40	7
	UMAIoT-0001	12/11/2021 20:15:41	8	12/11/2021 20:16:41	7	12/11/2021 20:17:41	8	12/11/2021 20:18:41	7	12/11/2021 20:19:41	8
	UMAIoT-0001	12/11/2021 20:15:42	7	12/11/2021 20:16:42	7	12/11/2021 20:17:42	8	12/11/2021 20:18:42	7	12/11/2021 20:19:42	7
	UMAIoT-0001	12/11/2021 20:15:43	7	12/11/2021 20:16:43	8	12/11/2021 20:17:43	7	12/11/2021 20:18:43	7	12/11/2021 20:19:43	6
	UMAIoT-0001	12/11/2021 20:15:44	7	12/11/2021 20:16:44	7	12/11/2021 20:17:44	7	12/11/2021 20:18:44	7	12/11/2021 20:19:44	8
	UMAIoT-0001	12/11/2021 20:15:45	7	12/11/2021 20:16:45	7	12/11/2021 20:17:45	7	12/11/2021 20:18:45	7	12/11/2021 20:19:45	7
	UMAIoT-0001	12/11/2021 20:15:46	7	12/11/2021 20:16:46	7	12/11/2021 20:17:46	8	12/11/2021 20:18:46	7	12/11/2021 20:19:46	6
	UMAIoT-0001	12/11/2021 20:15:47	7	12/11/2021 20:16:47	7	12/11/2021 20:17:47	7	12/11/2021 20:18:47	7	12/11/2021 20:19:47	8
	UMAIoT-0001	12/11/2021 20:15:48	7	12/11/2021 20:16:48	7	12/11/2021 20:17:48	7	12/11/2021 20:18:48	7	12/11/2021 20:19:48	7
	UMAIoT-0001	12/11/2021 20:15:49	7	12/11/2021 20:16:49	7	12/11/2021 20:17:49	7	12/11/2021 20:18:49	7	12/11/2021 20:19:49	7
	UMAIoT-0001	12/11/2021 20:15:50	7	12/11/2021 20:16:50	7	12/11/2021 20:17:50	7	12/11/2021 20:18:50	8	12/11/2021 20:19:50	7
	UMAIoT-0001	12/11/2021 20:15:51	7	12/11/2021 20:16:51	7	12/11/2021 20:17:51	7	12/11/2021 20:18:51	7	12/11/2021 20:19:51	7
	UMAIoT-0001	12/11/2021 20:15:52	7	12/11/2021 20:16:52	7	12/11/2021 20:17:52	7	12/11/2021 20:18:52	7	12/11/2021 20:19:52	7
	UMAIoT-0001	12/11/2021 20:15:53	8	12/11/2021 20:16:53	7	12/11/2021 20:17:53	7	12/11/2021 20:18:53	7	12/11/2021 20:19:53	8
	UMAIoT-0001	12/11/2021 20:15:54	6	12/11/2021 20:16:54	7	12/11/2021 20:17:54	6	12/11/2021 20:18:54	7	12/11/2021 20:19:54	7
	UMAIoT-0001	12/11/2021 20:15:55	7	12/11/2021 20:16:55	7	12/11/2021 20:17:55	8	12/11/2021 20:18:55	7	12/11/2021 20:19:55	6
	UMAIoT-0001	12/11/2021 20:15:56	8	12/11/2021 20:16:56	8	12/11/2021 20:17:56	7	12/11/2021 20:18:56	7	12/11/2021 20:19:56	8
	UMAIoT-0001	12/11/2021 20:15:57	7	12/11/2021 20:16:57	6	12/11/2021 20:17:57	7	12/11/2021 20:18:57	7	12/11/2021 20:19:57	7
	UMAIoT-0001	12/11/2021 20:15:58	7	12/11/2021 20:16:58	8	12/11/2021 20:17:58	7	12/11/2021 20:18:58	6	12/11/2021 20:19:58	6
	UMAIoT-0001	12/11/2021 20:15:59	7	12/11/2021 20:16:59	7	12/11/2021 20:17:59	8	12/11/2021 20:18:59	8	12/11/2021 20:19:59	8
	movement average value		7		7		7		7		7

Description: (t) is the test time and (s) is the number of movements

Fig. 15. Average Movement Results for 5 Minutes

Fig. 15 shows the average result per second of movement that can be transmitted and stored through the hand device and foot device. The average result of the movements obtained is 7 movements per second per device. With the maximum number of movements being 8 movements per second per device.

3.6 Testing the Presentation of Realtime Motion Data on the SIMBUMIL Interface

The motion data that has been stored in the database will then be displayed visually in graphical form through the SIMBUMIL interface. Data visualization can be seen in the SIMBUMIL interface that has been designed as shown below :

Fig. 16. Average Data for 5 Minutes of Motion Data Collection

After observing the visualization of motion data, it can be concluded that the SIMBUMIL application interface successfully displays real-time data of motion data captured through the SIMBUMIL device, then stored in the database. At the same time, the data can be displayed visually in graphical form. Fig. 16 shows the graphical representation of the stored motion data. The X-axis value representation is blue, the Y-axis is red and the Z-axis is green. The X-axis value will change when there is a movement to the left and right. The Y-axis value will change if there is a continuous upward and downward movement. The Z-axis value will change when there is movement in the forward and backward directions.

3.7 Movement Speed and Movement Attitude

Fig. 17 shows the data graph when the SIMBUMIL hardware is placed in a flat place with the indicator LED facing up. It can be seen that the accelerometer data of the three axes is stable, the X-axis accelerometer value is around 0, the Y-axis is around 0.5 and the Z-axis is -0.2. From this display, it can be concluded that the data received by the sensor sent by the hardware and received by the server is stable.

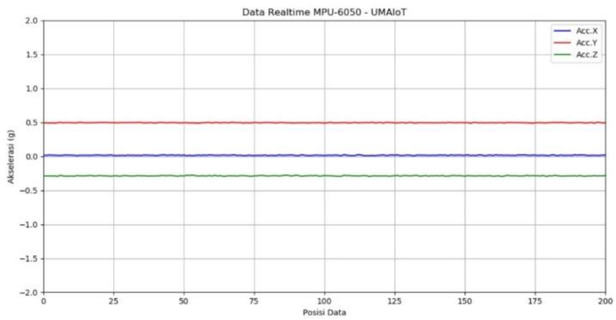

Fig. 17 Data When There is No Acceleration

Fig. 18 shows a graphical display of real-time data when the hardware is given movement in the X-axis direction, namely moving left and right.

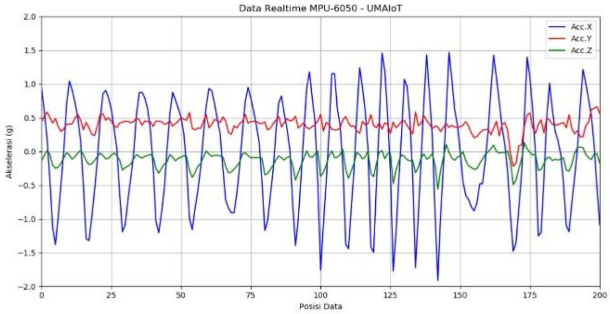

Fig. 18 Acceleration Data X-Axis

Fig. 19 shows the graphical display of real-time data when given movement in the direction of the Y-axis, namely moving up and down continuously.

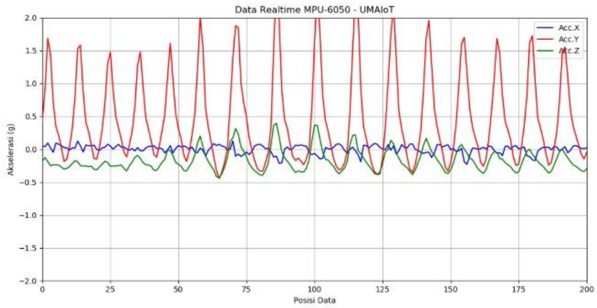

Fig. 19 Acceleration Data Y-Axis

Fig. 20 shows a graphical display of real-time data when given movement in the Z-axis direction, namely moving forward and backwards.

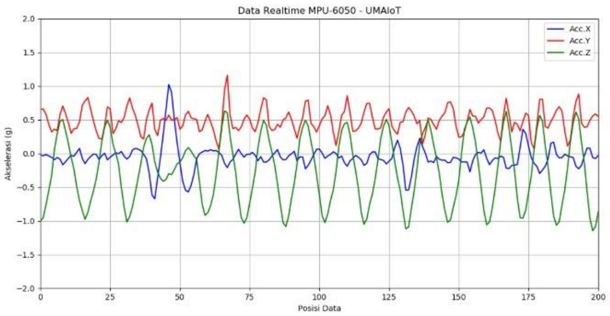

Fig. 20 Acceleration Data Y-Axis

Based on the data description of the three acceleration axes, it can be seen that movement occurs when the graph of an X, Y or Z axis undergoes a drastic change from plus to minus values or vice versa. Excessive movement occurs when the change in value is rapid over a long period, from a few tens of seconds to minutes. When the X, Y and Z axis values stabilize at a certain value, it can be concluded that the SIMBUMIL hardware is not moving.

Fig. 21 shows when the acceleration direction is irregular, mixed between the X, Y and Z axes. The movement of pregnant women's limbs such as hands usually has acceleration data mixed on all three axes.

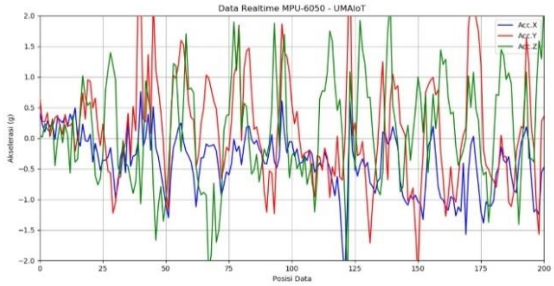

Fig. 21 Acceleration Data X, Y, Z Axis

In addition to receiving and storing data in real-time to the MySQL database, the server application also filters the data to look for data that is considered excessive movement and stores it on the database to be informed to the family, doctor or other interested parties.

id	idperangkat	accx	accy	accz	ipasal	portasal	ipserver	portserver	tgl_update
1,809	UMAIoT-0001	0.018	0.498	-0.281	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:45
1,810	UMAIoT-0001	0.022	0.498	-0.289	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:45
1,811	UMAIoT-0001	0.02	0.492	-0.286	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:45
1,812	UMAIoT-0001	0.022	0.499	-0.281	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:45
1,813	UMAIoT-0001	0.017	0.495	-0.29	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:45
1,814	UMAIoT-0001	0.018	0.496	-0.284	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:46
1,815	UMAIoT-0001	0.017	0.499	-0.289	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:46
1,816	UMAIoT-0001	0.009	0.501	-0.289	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:46
1,817	UMAIoT-0001	0.018	0.491	-0.284	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:46
1,818	UMAIoT-0001	0.016	0.494	-0.288	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:46
1,819	UMAIoT-0001	0.013	0.494	-0.282	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,820	UMAIoT-0001	0.018	0.494	-0.276	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,821	UMAIoT-0001	0.015	0.494	-0.29	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,822	UMAIoT-0001	0.017	0.498	-0.285	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,823	UMAIoT-0001	0.016	0.494	-0.285	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,824	UMAIoT-0001	0.015	0.492	-0.279	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:47
1,825	UMAIoT-0001	0.017	0.496	-0.284	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:48
1,826	UMAIoT-0001	0.017	0.494	-0.281	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:48
1,827	UMAIoT-0001	0.019	0.495	-0.286	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:48
1,828	UMAIoT-0001	0.017	0.497	-0.283	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:48
1,829	UMAIoT-0001	0.014	0.492	-0.288	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:49
1,830	UMAIoT-0001	0.022	0.498	-0.286	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-18 16:48:49

Fig. 22. Acceleration Data Silent in MySQL

Fig. 22 shows the real-time data that has been stored in the MySQL database when the SIMBUMIL hardware is stationary. There is very little difference in the accX, accY and accZ columns compared row by row. The difference in some of the values between rows can be seen in Fig. 23, so that the smallest and largest difference values can be found, namely on the X-axis at least 0, maximum 0.009, Y-axis at least 0, maximum 0.01 and Z-axis at least 0, maximum 0.014.

1812	UMAIoT-0001	0.022	**0.002**	0.499	**0.007**	-0.281	**0.005**
1813	UMAIoT-0001	0.017	**0.005**	0.495	**0.004**	-0.29	**0.009**
1814	UMAIoT-0001	0.018	**0.001**	0.496	**0.001**	-0.284	**0.006**
1815	UMAIoT-0001	0.017	**0.001**	0.499	**0.003**	-0.289	**0.005**
1816	UMAIoT-0001	0.009	**0.008**	0.501	**0.002**	-0.289	**0**
1817	UMAIoT-0001	0.018	**0.009**	0.491	**0.01**	-0.284	**0.005**
1818	UMAIoT-0001	0.016	**0.002**	0.494	**0.003**	-0.288	**0.004**
1819	UMAIoT-0001	0.013	**0.003**	0.494	**0**	-0.282	**0.006**
1820	UMAIoT-0001	0.018	**0.005**	0.494	**0**	-0.276	**0.006**
1821	UMAIoT-0001	0.015	**0.003**	0.494	**0**	-0.29	**0.014**
1822	UMAIoT-0001	0.017	**0.002**	0.498	**0.004**	-0.285	**0.005**
1823	UMAIoT-0001	0.016	**0.001**	0.494	**0.004**	-0.285	**0**
1824	UMAIoT-0001	0.015	**0.001**	0.492	**0.002**	-0.279	**0.006**
1825	UMAIoT-0001	0.017	**0.002**	0.496	**0.004**	-0.284	**0.005**
1826	UMAIoT-0001	0.017	**0**	0.494	**0.002**	-0.281	**0.003**
1827	UMAIoT-0001	0.019	**0.002**	0.495	**0.001**	-0.286	**0.005**
1828	UMAIoT-0001	0.017	**0.002**	0.497	**0.002**	-0.283	**0.003**
1829	UMAIoT-0001	0.014	**0.003**	0.492	**0.005**	-0.288	**0.005**
1830	UMAIoT-0001	0.022	**0.008**	0.498	**0.006**	-0.286	**0.002**
1831	UMAIoT-0001	0.016	**0.006**	0.493	**0.005**	-0.284	**0.002**
		Min	0		0		0
		Max	0.009		0.01		0.014

Fig. 23 Difference in Value between Rows of Data at Rest

Fig. 24 shows the real-time data that has been stored in the database when SIMBUMIL hardware moves on the X, Y and Z axes. There is a considerable difference in value on each line. Fig. 25 shows the difference between rows as well as the minimum and maximum values of the difference in the X, Y and Z axes.

id	idperangkat	accx	accy	accz	ipasal	portasal	ipserver	portserver	tgl_update
527	UMAIoT-0001	0.079	-0.178	-0.302	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
528	UMAIoT-0001	0.023	-0.221	-0.334	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
529	UMAIoT-0001	-0.037	-0.218	-0.354	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
530	UMAIoT-0001	-0.132	-0.182	-0.395	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
531	UMAIoT-0001	-0.152	-0.095	-0.408	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
532	UMAIoT-0001	-0.177	0.004	-0.451	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
533	UMAIoT-0001	-0.271	0.189	-0.537	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:50
534	UMAIoT-0001	-0.403	0.406	-0.673	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
535	UMAIoT-0001	-0.217	0.837	-0.545	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
536	UMAIoT-0001	0.008	1.276	-0.273	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
537	UMAIoT-0001	-0.008	1.086	-0.53	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
538	UMAIoT-0001	-0.091	1.618	-0.305	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
539	UMAIoT-0001	0.033	2.117	0.156	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
540	UMAIoT-0001	0.142	1.73	-0.01	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:51
541	UMAIoT-0001	0.21	1.328	-0.283	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
542	UMAIoT-0001	0.224	1.078	-0.316	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
543	UMAIoT-0001	0.071	1.035	-0.332	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
544	UMAIoT-0001	-0.042	0.841	-0.401	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
545	UMAIoT-0001	-0.12	0.577	-0.488	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
546	UMAIoT-0001	-0.13	0.322	-0.492	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:52
547	UMAIoT-0001	-0.094	0.098	-0.536	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:53
548	UMAIoT-0001	-0.081	-0.171	-0.554	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:53
549	UMAIoT-0001	-0.052	-0.283	-0.518	192.168.43.221	11,000	192.168.43.61	11,000	2020-01-17 15:00:53

Fig. 24. Mobile Acceleration Data on MySQL

530	UMAIoT-0	-0.132	**0.095**	-0.182	**0.036**	-0.395	**0.041**
531	UMAIoT-0	-0.152	**0.02**	-0.095	**0.087**	-0.408	**0.013**
532	UMAIoT-0	-0.177	**0.025**	0.004	**0.099**	-0.451	**0.043**
533	UMAIoT-0	-0.271	**0.094**	0.189	**0.185**	-0.537	**0.086**
534	UMAIoT-0	-0.403	**0.132**	0.406	**0.217**	-0.673	**0.136**
535	UMAIoT-0	-0.217	**0.186**	0.837	**0.431**	-0.545	**0.128**
536	UMAIoT-0	0.008	**0.225**	1.276	**0.439**	-0.273	**0.272**
537	UMAIoT-0	-0.008	**0.016**	1.086	**0.19**	-0.53	**0.257**
538	UMAIoT-0	-0.091	**0.083**	1.618	**0.532**	-0.305	**0.225**
539	UMAIoT-0	0.033	**0.124**	2.117	**0.499**	0.156	**0.461**
540	UMAIoT-0	0.142	**0.109**	1.73	**0.387**	-0.01	**0.166**
541	UMAIoT-0	0.21	**0.068**	1.328	**0.402**	-0.283	**0.273**
542	UMAIoT-0	0.224	**0.014**	1.078	**0.25**	-0.316	**0.033**
543	UMAIoT-0	0.071	**0.153**	1.035	**0.043**	-0.332	**0.016**
544	UMAIoT-0	-0.042	**0.113**	0.841	**0.194**	-0.401	**0.069**
545	UMAIoT-0	-0.12	**0.078**	0.577	**0.264**	-0.488	**0.087**
546	UMAIoT-0	-0.13	**0.01**	0.322	**0.255**	-0.492	**0.004**
547	UMAIoT-0	-0.094	**0.036**	0.098	**0.224**	-0.536	**0.044**
548	UMAIoT-0	-0.081	**0.013**	-0.171	**0.269**	-0.554	**0.018**
549	UMAIoT-0	-0.052	**0.029**	-0.283	**0.112**	-0.518	**0.036**
		Min	**0.01**		**0.003**		**0.004**
		Max	**0.225**		**0.532**		**0.461**

Fig. 25 Difference in Value between Lines of Data on the Move

4. Conclusion

From the results of the research that has been carried out, the following 3 conclusions are obtained:

1. The implementation of the Inertial Measurement Unit (IMU) sensor for pregnant women's movement monitoring system (SIMBUMIL) using MPU-6050 sensor shows the result that the sensor can detect any angle change experienced by pregnant women
2. Based on the results of the motion data obtained, it shows that the process of reading and storing data works well. The data obtained from the device is successfully transmitted and stored in the database at almost the same time. In addition, the results of the average number of movements sent are 7 movement data per second per device.
3. Based on the results of the data presentation, it shows that the SIMBUMIL application interface successfully displays movement data in real-time. At the same time, the data can be displayed visually in graphical form. Any change in the angle of movement affects the graphical visualisation of motion data.

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Author Contributions

All Authors contributed equally to this work.

Conflicts of interest

The authors declare no conflicts of interest.

References

[1] I. B. G. Manuaba, *Ilmu Kebidanan Penyakit Kandungan dan Keluarga Berencana*. EGC, 1998.

[2] Badan Pusat Statistik, *Proyeksi Penduduk Indonesia 2010-2035*. Badan Pusat Statistik, 2013.

[3] M. Ekoriano and M. Anggraeni, "Policy brief: Upaya meningkatkan pemakaian alat kontrasepsi (KB) Pasca Persalinan dan Pasca Keguguran di Rumah Sakit." BKKBN, 2010.

[4] H. Farrer, *Perawatan Maternitas*. EGC, 1999.

[5] Analog Devices, "Digital Accelerometer ADXL345." Analog Devices Inc, 2015.

[6] M. Schwartz, *Internet of Things with ESP8266*. Packt Publishing, 2016.

[7] AI-Thinker Team, *ESP-12E WiFi Module, Version 1.0*. Shenzhen: Shenzhen Anxinke Tech., 2015.

[8] Espressif Systems, *Espressif Smart Connectivity Platform : ESP8266. ESP8266 802.11 bgn Smarrt Device*. Espressif Systems Inc., 2013.

[9] P. Bansal, I. S. R. Vedaraj, and P. Student, "Monitoring and Analysis of Vibration Signal in Machine Tool Structures," *International Journal of Engineering Development and Research (IJEDR)*, vol. 2, pp. 2310–2317, 2014.

[10] H. Guanglin and X. Hongyu, "Design and Simulation of The Vibration Monitoring System Based on Wireless Sensor Network," presented at the International Conference on Information Management, Innovation Management and Industrial Engineering (ICIII), 2012, pp. 12–16.

[11] InvenSense, *MPU-6000 and MPU-6050 Product Spesification Revision 4.2*. InvenSense Inc, USA, 2013.

[12] A. Simakov, "Wireless Internet of Things device for vibration monitoring." Department of control

engineering, Czech Technical University in Prague, 2017.

[13] Arduino, “Arduino Nano.” Accessed: Feb. 09, 2018. [Online]. Available: https://store.arduino.cc/usa/arduino-nano

[14] J. SwarnaPrabha, “Accelerometer Based Gesture Controlled Robot Using Arduino,” *International Journal Of Engineering Sciences & Research Technology (IJESRT)*, vol. 4, no. 4, pp. 469–475, 2015.

[15] C. Bell, *MySQL for the Internet of Things*. Lake Zurich: Apress, 2016.

[16] L. Aggarwal, V. Gaur, and P. Verma, “Design and Implementation of Wireless Gesture Controlled Robotic Arm with Vision,” *International Journal of Computer Application*, vol. 79, no. 13, pp. 39–43.