A Low Cost Fall Detection Device Base on Accelerometer Sensor and Notifications for Vertigo and Syncope Patient

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Abstract: In this study we propose a low-cost portable device to monitor the vertigo and syncope patients whether normal, dizziness or falls. The purpose of this study is design and manufactures a device using an accelerometer sensor to determining the condition of patients who are at risk of vertigo and syncope. The patient's condition is detected by accelerometer which read the values of the x, y and z axes to determine condition normal, dizzy, or fall. This device also uses a real time clock to remind the patient to take medication three times a day. The device outputs are LCD Oled, Voice, and SMS notification. If the patient condition is falls an SMS notification will be sent, the dizzy condition vertigo patient will press the panic button first and then an SMS notification will be sent. The test results of this device, 30 times falls detection, obtained a sensitivity value for dizziness activity is 83.3% and a sensitivity value for falling activity is 90%. The system takes an average of 8 seconds after a drop in activity to send SMS notifications to phone number users, and it also takes an average of 5 to 6 seconds after a dizzy activity to make phone calls to phone number users.

1 INTRODUCTION

The balance system is an important system for human life. This system enables humans to be aware of their position in the surrounding space. Balance is an integrated system, namely the visual, vestibular, propioseptic and cerebellar systems. Disorders of the balance system will cause various complaints, including a spinning sensation which is often called vertigo. Vertigo is a common complaint described as a spinning sensation, shakiness, instability (giddiness, unsteadiness) and dizziness (Sura, 2010),(Gnerre, 2015),(Thompson, 2005) . Vertigo is a real public health problem. The patient has difficulty expressing the onset of symptoms. According to a survey from the Department of Epidemiology, Robert Koch Institute Germany in the general population in Berlin in 2007, the prevalence of vertigo in 1 year was 0.9%, vertigo due to migraine was 0.89%, for BPPV 1.6%, vertigo due to Meniere's Disease 0.51% . In Indonesia, case data in R.S. Dr. Kariadi Semarang stated vertigo cases were in the 5th rank of most cases treated in the neurological ward. The effect of vertigo on a person is sudden loss of nerve function and experiencing dizziness so that a person can fall and faint. Not only vertigo, the cause of fainting or syncope in the medical world can be caused by, low blood pressure or dilated blood vessels, irregular heartbeat, hypoglycemia and neurological diseases (Kidd, 2016). Because the symptoms of vertigo and syncope appear suddenly, it is necessary to take an action in the form of supervision for someone who has experienced it, because if it is not done quickly action can cause more severe symptoms such as stroke and even death (Müller, 2019), (Moya, 2009).

Supervision is very important to avoid the not desirable action. The families always accompany and supervise what patient. So, if something happens it can be immediately handled and did not have fatal consequences. However, this is not an easy thing to do because families also have their own activities. Anxiety arises when families cannot monitor what is happening to vertigo patients. To supervise and monitor vertigo patients whether there are incidents of dizziness, falls or not, a device is needed to determine the position of the patient from a short distance or far away. Several studies related to health monitoring have been carried out including for monitoring heart rate (Irmansyah, 2018) and body temperature (Kalaithasan, 2018) based on IoT. Research conducted can also make a diagnosis using a smartphone (Trivedi, 2017) and website-based (Hameed, 2016). The sensor used in this study uses a

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pulse sensor and a DS18b20 sensor. The results of this study have an average error of 1%. All research conducted only focuses on monitoring using internet network communication which of course adds to costs, besides that there is no notification either to the doctor or the patient's family at risk if something happens to the patient. In this research we built the small portable device to monitor vertigo and syncope patient condition for normal, dizzy or fall. Some methods had been designed and implemented in this area especially for fall condition (Jefiza, 2017).

The fall detection approaches are categorized into three classes, namely: (i) wearable sensor based, (ii) ambience sensor based and (iii) vision based (Mubashir, 2013). In this study we used a wearable sensor based approach category, the advantages of this approach remain in the cost efficiency of the device, the installation and arrangement of the design are also not complicated. Therefore, the device is relatively easy to operate. (Hakim, 2017). In addition, this tool is also equipped with a panic button and RTC (Real Time Clock) to remind patients to take medication if they are taking regular medication with a sound output. The purpose of this research is to design and make a device using accelerometer sensor which is useful for knowing the condition of vertigo and syncope patients. Perhaps, this tool can monitoring in patients with vertigo and syncope easily while they are have activity especially moving.

2 RESEARCH METHOD

The method used in this research is making prototype tools starting from literature studies, system design, hardware design, software design, hardware testing, software and analysis of test results. The stages of research on Microcontroller-Based Monitoring Tools for Vertigo and Syncope Patients can be seen in Figure 1.

2.1 System Design

This tool uses an accelerometer sensor to determine the tilt angle of the sensor placed on the prototype box so that the condition of the vertigo patient can be known. The accelerometer sensor is determined to be 3 conditions, namely, fine, dizzy (accidentally dropped) and falling. When conditions are fine it will run normally and for this normal condition a push button is also provided for a panic button that vertigo sufferers can use if they need help. Furthermore, in the second condition, namely dizziness, the patient experiences dizziness and falls accidentally moving the body because the balance of the body is disturbed so that the accelerometer sensor will read the movements of the patient's body who is experiencing dizziness. When dizzy, DF-Player will first ask if the patient is okay, if the patient's condition is not good, the patient can press the push button to ask for help by sending an SMS notification and activating the DF-Player. In the last condition, namely a fall, the tilt sensor will detect the slope of the patient who fell, whether he fell left, right, backward and forward. The design of a monitoring device system for people with vertigo and syncope based on a microcontroller can be seen in Figure 2.

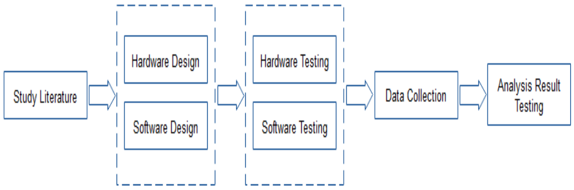

Figure 1: Research methodology.

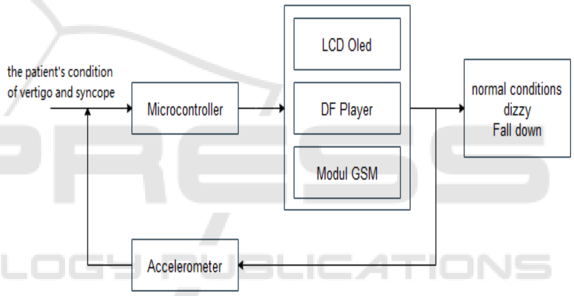

Figure 2: Framework of system design.

Furthermore, the microcontroller will process the condition that the patient has fallen. Then the DF-Player will ask the patient's condition first whether the patient is okay, if there is no response from the patient, the SIM800L GSM Module will send an SMS

2.2 Hardware System

This series consists of a tilt angle detector using the MPU6050 accelerometer, push button, RTC, DF Player, GSM SIM800L module, battery connected to 5V and GND pins, Arduino nano functions as a microcontroller as shown in Figure 3. MPU6050 accelerometer sensor is connected to pin A4 , A5 on the microcontroller detects the slope of the patient's position who is placed on the prototype bag when experiencing a change in position which is divided into several conditions. To determine the patient's condition on the accelerometer sensor can be seen in the table 2.

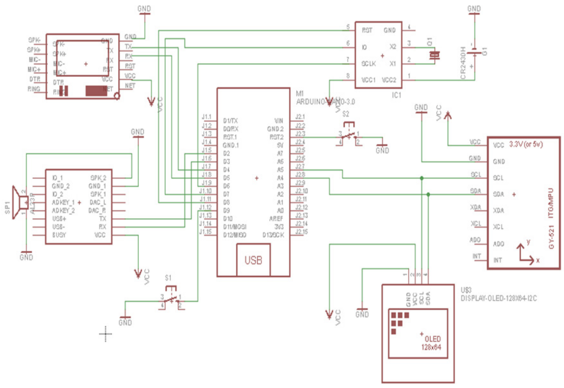

Figure 3: The electronic circuit for the fall detection device.

Table 1: Accelero sensor value for fall detection.

Test value			Patient's Condition Left and right	Patient's Condition Front and back
X	Y	Z		
< -35	-125 to 125	-125 to 125	Good (0° – 50°) =Y (40° – 90°) = X	Good (0° – 50°) = Z (40° – 90°) = X
(-35) to (- 10)	-150 to - 125 125 to 150	-150 to - 125 125 to 150	Dizzy (50° – 70°) = Y (40° – 20°) = X	Dizzy (50° – 70°) = Z (40° – 20°) = X
> -10	-150 < Y >150	-150 < Y >150	Falldown (70° – 90°) = Y (20° – 0°) = X	Falldown (70° – 90°) = Z (20° – 0°) = X

The accelerometer sensor uses I2C connections (SDA and SCL) where SDA is connected to pin A4 and SCL to pin A5 of the microcontroller. The battery as a mobile voltage source for this system is connected to + 5V and GND microcontroller and + 4V to the GSM SIM800L module. To get a voltage of + 4VDC, a DC-DC converter is needed. The panic button is connected to pin 9, the reset button is connected to the RST and GND pins on the microcontroller. Pins 2, and 3 are used as the input lines for the output data to send SMS to the SIM800L. RX and TX pins are used as output data entry points to activate DF-Player. The device made will be placed on the patient's belt. The design of the tool box can be seen in Figure 4.

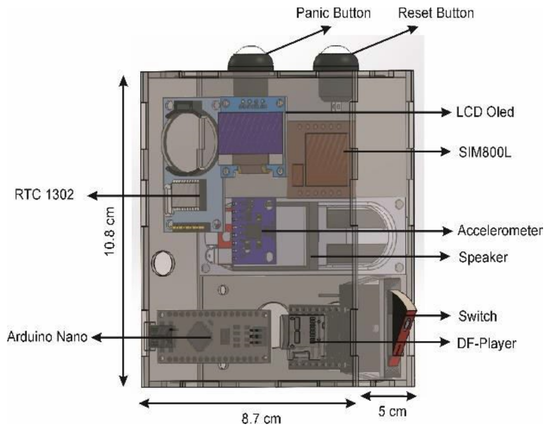

Figure 4: Tool design for the fall detection device.

2.3 Software Design

Flowchart of vertigo patient monitoring tool with SMS notification can be seen in Figure 5. The process starts from the initialization of I/O. In Good condition, LCD will display the time and date, when the panic push button is pressed the DF Player will sound for help, the LCD will display the words "TOLONG" and SIM800L will send an SMS.

In Dizziness condition, LCD will display “???” and DF Player will ask the patient's condition, if the panic push button is pressed DF Player will ask for help and SIM800L will send an SMS, and if the push button reset is pressed the DF Player will not sound and SIM800L will not send SMS, the LCD will display the time and date. In Drop condition, LCD will display “???” and the DF Player will ask the patient's condition, for 10 seconds there is no response, the SMS will be sent. The LCD will display "FALL" and the DF Player will sound. If the patient presses the push button reset at the time of the fall, the SMS will be canceled and the patient is declared fine. When OK DF Player will remind you to take medication 3 times a day and the LCD display "WAKTUNYA MINUM OBAT".

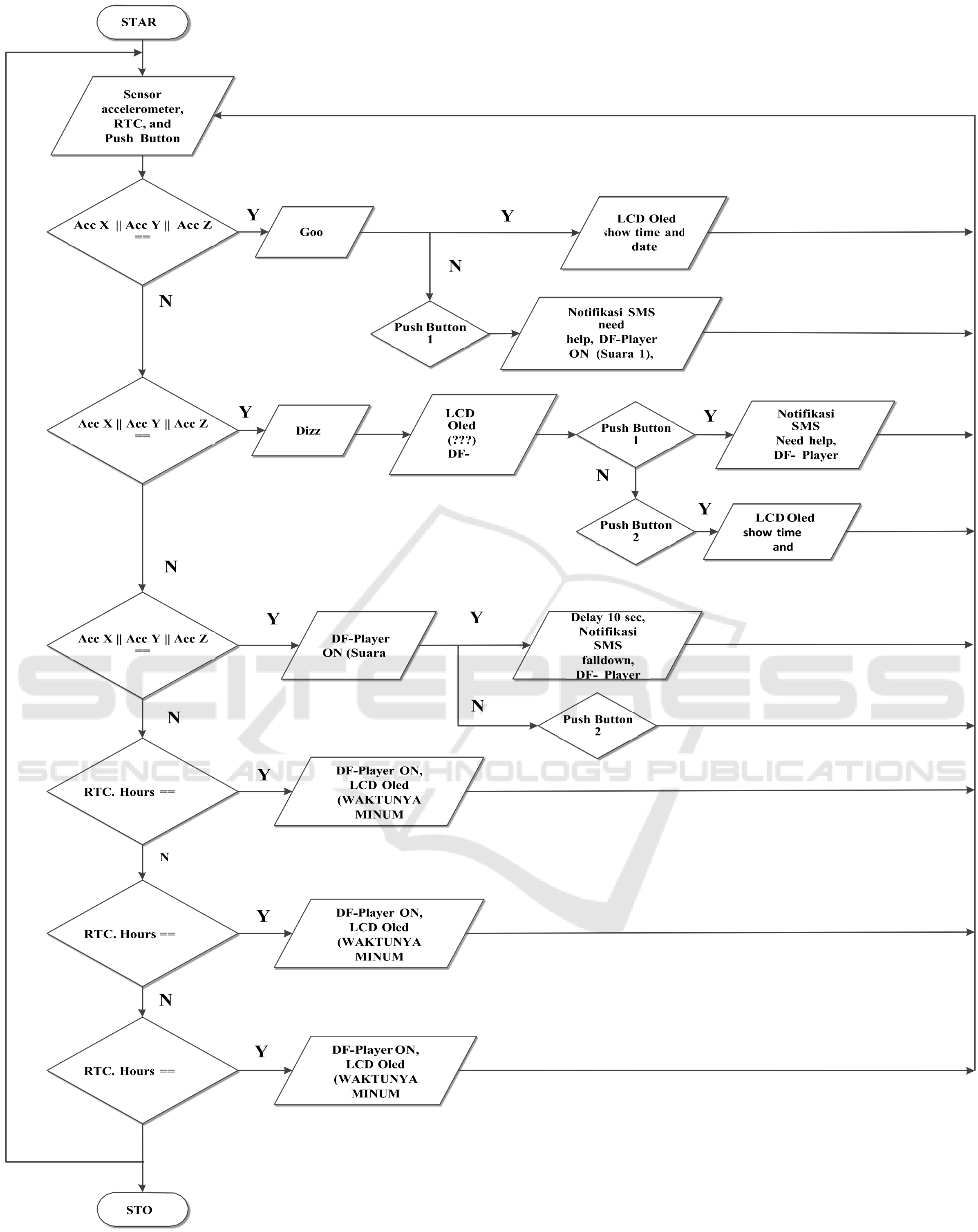

Figure 5: Flowchart of the fall detection device.

2.4 Testing of Control Tools for Vertigo and Syncope based on Microcontroller

The next step is testing a monitoring tool for people with vertigo and syncope based on a microcontroller, this test aims to determine the advantages and disadvantages of the system that has been created. The test is carried out in two stages. First, testing system performance, second, testing tool notifications. This bag prototype-shaped device is then attached to the patient, as seen in Figure 6.

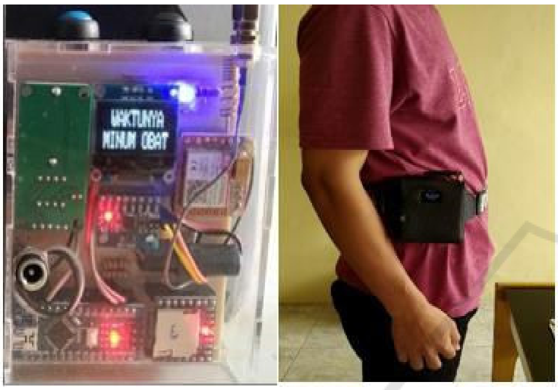

Figure 6: Installation of fall detection device on the body.

3 EXPERIMENT RESULT

3.1 Testing the Performance System

This test is carried out to determine the performance of the device, whether the patient is in a dizzy state, normal activities and fall detection.

Figure 7: The implementation and testing of fall detection of vertigo ang syncope patient.

Starting by testing the tilt sensor on the accelerometer, we take the output data on the X, Y and Z axes to detect the state of the patient. The data taken is based on the slope of the angle 0_o, 50_o, 70_o, and 90_o back and to the left then the sensor data is displayed on the serial monitor, so that the results are in accordance with table 2.Based on table 2 when the patient's condition is fine the accelerometer sensor is tilted 0_o - 50_o on the Y axis and 90_o - 40_o on axis X, the sensor value shows -125 s / d 125 on the Y axis, the sensor value is <-35 on the X axis. For dizzy conditions the sensor value taken is at a slope of 50_o - 70_o at the Y axis and 40_o - 20_o on the X axis, the sensor values show -150 to -125 and 125 to 150 on the Y axis, the sensor value -35 to -10 on the X axis. For falling conditions the sensor values are taken is at a slope of 70_o - 0_o on the Y axis and 20_o - 0_o on the X axis, the sensor value shows -150 <Y> 150 on the Y axis, the sensor value> -10 on the X axis, for the left and right directions with the rotating point on the Z axis , and if the direction of the front and back of the Y axis will be replaced with the Z axis and tit The rotary angle is on the Y axis.

Changes in the angle value will affect the value of the accelerator sensor. The greater the angle change, the greater the value of the accelero sensor. So when the accelero sensor value shows a value> 150 or more, it can be said that people with vertigo have fallen. Then the DF-Plyer will sound and within 10 seconds there is no response from the patient, the SIM800L will send an SMS. Furthermore, motion testing is carried out in three positions to detect sudden dizziness experienced by the patient. The test results can be seen in table 2.

Table 2: Dizziness detection tests on regular activities.

Position	Numbe r of experi me nt	Dizzy Notifications via phone call		Accu racy %	Detection %	
		Yes	No		Yes	No
Sit-Stand	10	8	2	80		
Standing -Walking	10	8	2	80	83.3	16.6 7
Walking-Sit	10	9	1	90		
Total	30	25	5			

Table 3: Detection test falls on the system.

Category	Number of experiment	Notification Fall		Accuracy %	Detection %	
		Yes	No			
Face down	10	9	1	90	Yes	No
Recumbent	10	9	1	90	90	10
Total	20	18	2			

For thirty times the trial results testing in Table 2, 83% of the devices can detect patient dizziness during normal activities, with an accuracy rate of about 80%

to 90%. Furthermore, testing the detection of tools for falls and prone incidents is carried out. The test results can be seen in table 3. Based on the experiments in table 3, some falling activities such as falling on your back and falling on your stomach can be detected by the system as falling activities with an accuracy rate of 90%.

3.2 Testing the Notification of Tool

This test is done to find out whether the device can send SMS notifications and phone calls if the patient is dizzy and falls. In this tool, the SIM800 GSM module is used for sending SMS and telephone calls as shown in Figure 8. Table 4 is the test results of phone calls conducted ten times.

Based on the experiment in table 4, it takes SIM800L to make a phone call with a duration of 5 to 6 seconds. Then performed testing of tools for sending sms. The following is a table of the results of testing the SMS delivery which was carried out ten times

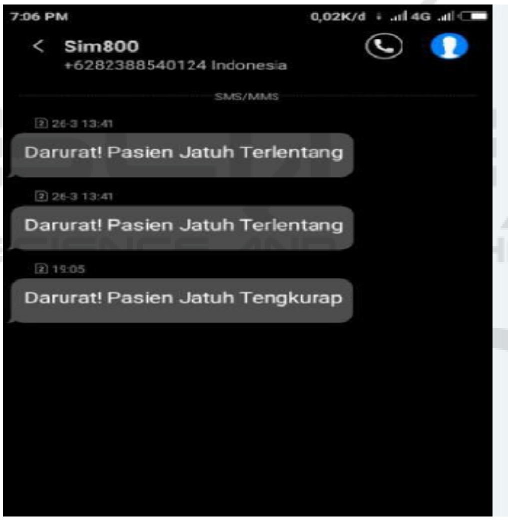

Figure 8: Testing Notification Tools for sending sms.

Table 4: Testing SIM800L timeout test to make phone calls.

Experiment	Phone call	Time period (second)
1	Yes	5
2	Yes	5
3	Yes	5
4	Yes	6
5	Yes	6
6	Yes	5
7	Yes	5
8	Yes	5
9	Yes	5
10	Yes	6

Table 5: Testing the time period for sending SMS notifications.

Experiment	Phone call	Time period (second)
1	Yes	8
2	Yes	9
3	Yes	8
4	Yes	8
5	Yes	7
6	Yes	9
7	Yes	10
8	Yes	8
9	Yes	9
10	Yes	8

Based on the experiment in table 5 the time it takes for SIM800L to send an SMS notification with a duration of 8 seconds. When SIM800L makes a phone call, it cannot send SMS notifications at the same time. If done together, the SIM800L will be an error.

4 CONCLUSIONS

In this study, we made a low-cost portable device to monitor and monitor patients at risk of vertigo whether dizziness, falls or not occurred. The results of tests carried out on the device to detect falls as much as 30 times, obtained a sensitivity value for dizziness activity of 83.3% and a sensitivity value for falling activity by 90%, meaning that the system is able to detect dizziness and fall activity quite well. an average of 8 seconds after the activity falls to send SMS notifications to phone number users, and it also takes an average of 5 to 6 seconds after a dizzy activity to make phone calls to phone number users.

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