Korespondensi / Proses Review

Reviewer #1:

1. Add impact on your abstract

Response to the Reviewer #1:

The impact of the research has been added to the abstract section. Thank you for the revision given.

Reviewer #1

2. Move the impact to your abstract and add purpose and method in the last paragraph of introduction

Response to the Reviewer #1:

The impact has been moved to the abstract section. The last paragraph in the introduction has added a purpose and method. Thank you for the revision given.

Reviewer #1

3. Add discussion before Figure

Response to the Reviewer #1:

We already added additional information and discussion before the figure. Thank you for the revision given.

Reviewer #1

4. Combine all these paragraph into one

Response to the Reviewer #1:

We already combined these sentences into one paragraph. Thank you for the revision given.

Reviewer #1

5. Add discussion before all Tables

Response to the Reviewer #1:

We already added additional information and discussion before all tables. Thank you for the revision given.

Reviewer #1

6. Check your grammar in all parts of paper

Response to the Reviewer #1:

We already double checked the grammar of the paper/manuscript

Reviewer #1

7. Use illustration for the Figure

Response to the Reviewer #1:

We already added additional information and use illustration for that figure. Thank you for the revision given.

Reviewer #1

8. Delete nomenclatures

Response to the Reviewer #1:

Thank you for the advice given. We cannot delete the nomenclature section, because the camera ready JESTEC template has a nomenclature section.

Reviewer #1

9. Adjust the reference to the JESTEC format

Response to the Reviewer #1:

Thank you for reminding us. We already adjust the reference to the JESTEC camera ready template. We already double chek about the reference.

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DRIVING SAFETY APPLICATION USING WEARABLE DEVICE AND MOBILE TECHNOLOGY

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Abstract

This research conducted to help motorbike riders to avoid accidents caused by drowsiness. The wearable device technology used is smartband and accelerometer from an android smartphone. Smartband in this research is used to get heart rate data to detect drowsiness experienced by motorbike riders. An accelerometer uses to detect if an accident occurs so that it can send information to the driver's family when an accident is detected. The method in this research is quantitative research and development. The results obtained that the accuracy of detecting drowsiness equal to 80% and the accident detection test gets an accuracy of 100% accuracy. The accuracy of drowsiness detection during the day getting value 75%, and testing at night have the accuracy rate is 90%. Functional suitability test results obtained a value of 100%, compatibility aspects have 100%, usability aspects of 84.7%, and performance aspects in terms of response time are in the range of satisfaction equal to 3.88 seconds. The results of tests conducted on a Likert scale formula shows that the application can use, and the driving safety application has reached its desired purpose. This research have an impact on driving safety that must prioritize and prioritize safety, both for self and for others.

Keywords: Safety ride, Motorbike driver, Drowsiness, Smartband, Accelerometer.

1. Introduction

Based on data released by the NTSC Indonesia from 2010 to 2016, there have been 41 accident investigations that caused as many as 443 fatalities. One of the causes of accidents comes from driver error. There were 69.7% of motor vehicle accidents caused by sleepy motorists [1]. Drowsiness is a condition where someone feels like sleeping. Drowsiness can happen at the wrong time, for example, when working, while studying, or while driving. Sleepiness usually characterized by fatigue, loss of consciousness, falling asleep, and interference with activity [2] and forgetting [3]. Besides being able to hurt self sleepy while driving, it can also harm another motorbike driver.

Drowsiness can trigger various problems, such as disturbing driving performance [4], productivity, affecting one's emotions, disturbing social interactions, and the most fatal is that it can cause accidents both on the road and in the work environment [5]. Accidents can occur not only because of human factors but also because of road or vehicle factors. Accident handling is if the driver is still conscious and then asks for help or a family who knows when the accident occurred. There are cases of late accident handling because no family knows [6]. Accelerometer sensor can use to detect the tilt or change the position of an object [7] so that can know the information about accidents.

Several studies have conducted related to this research. Such as wearable device technology use for drowsiness detection [8]. SMS use to control smartphones remotely [9]. Accelerometer data use to identify idling times of a vehicle [10] and assess road quality [11]. In this research, to detect drowsiness is the Mi Band 3 smartband because it can track the user's activities such as heart rate [12], sleep quality [13], and activity trackers [14].

In contrast to Aloul's research [15] which uses smartphones to detect car accidents, this research use smartphone and wearable device to detect motorbike driver accident. A smartband retrieved the motorbike driver's heart rate data and sent it to a smartphone to calculate the average heart rate which, if declared sleepy, the smartband will vibrate, and the smartphone will sound an alarm. When an accident driving is detected using the accelerometer sensor on an android smartphone, the location, and time data when the accident occurred sent to the family. This research aims to build a driving safety application and uses a software development life cycle method during the system development process.

2. Method

This research consists of several stages. The initial stage is to carry out case analysis to obtain accident-related data, analyze sleepiness and accidents up to the implementation stage and system testing. Fig. 1 is the stages carried out in this research.

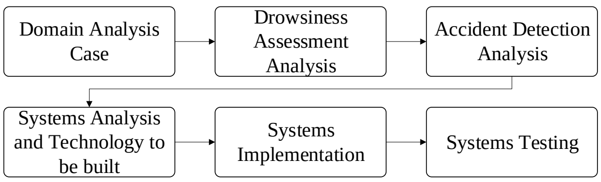


Fig. 1. Stage of Research Method

2.1. Domain Analysis Case

At this stage, an analysis of cases is carried out in the form of an analysis of common problems when driving accidents. Amounting to 69.7% of motor vehicle accidents caused by rider drowsiness. Every day many riders are passing by on the highway. Due to data from BPS Indonesia (Central Bureau of Statistics) recorded until 2017, there were 138,556,699 units of motor vehicles in Indonesia. This number is increasing every time so that it can cause higher accident rates.

Drowsiness while riding can occur due to several factors such as fatigue or the urge to sleep at night [16], travel that far, less fit body condition. Drowsy while also riding can-do harm to other riders. Drowsiness is a condition in which a person feels like to sleep. It can happen at the most opportune times, such as at work while studying or while riding. Thus, the results of the domain analysis case stage in this study are getting that driving accidents can be caused by several reasons, one of which is sleepy.

2.2. Drowsiness Assessment Analysis

At this stage, an analysis of the data obtained heartbeat from the smartband will be calculated based on previous studies to determine if someone is drowsy or not. Drowsiness usually occurs because of a lack of sleep. Everyone has different sleep needs, depending on age and daily activities. Ideally, adults need 7-9 hours of sleep during hours per day, children and teenagers need 9 hours, toddlers need 10-12 hours, and the newborn takes 16-18 hours. The following workflow of drowsiness assessment in this research can see in Fig. 2.

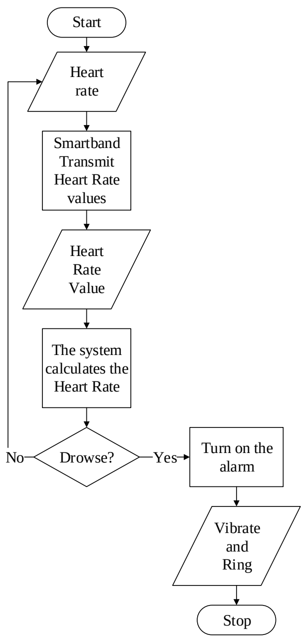


Fig. 2. Drowsiness Assessment Workflow

Drowsiness detection applications built using tools that smartband. The smartband can use on the left or right wrist that will use to detect the amount of blood. Mi Band 3 uses a green LED light that is paired with a light-sensitive photodiode to detect the amount of blood flowing through the wrist. When the heartbeats, the blood flowing in the wrist will reflect light, and its reflections readable by a photodiode, the blood does not reflect light means a higher blood volume. Through the observation of view, the sensor analyzes the data and calculates the heart rate. By blinking LED lights hundreds of times per second, Mi Band 3 can calculate the frequency of the heartbeat.

The hear rate is the number of heartbeat per unit of time, usually expressed in beats per minute or beats per minute (bpm) [17]. In adults, the normal heart rate is 60-100 bpm [18] with the heart rate maximum is 220 - age. Table 1 included a normal heartbeat.

Table 1. Normal Heart Rate.

Age	Normal Heart Rate
1-2 years	80-130
2-6 years	70-120
6-10 years	70-110
Ten years and over	60-100

The time body relaxes either at rest, drowsiness, or sleep, and heart rate is relatively slower than when doing the activity. In general, the decline ranges from 10-20% of the current state of operation. This value has validated by expert Doctor.

2.3. Accident Detection Analysis

At this stage, an analysis of the data value of the slope of the smartphone, which will be calculated based on the data values from previous studies to determine the position of the motor falls to the left or the right. A smartphone today generally already has an accelerometer sensor for various needs, such as changing the display from portrait to landscape by tilting the body of the phone, this happens because of a change to the coordinates x, y, and z smartphone. The x-axis is the form of a horizontal line, a vertical line forming the y-axis and z-axis pointing to the front and rear of the display device. Accelerometer values can see in Table 2.

Table 2. Accelerometer Axis Value.

Position	X	Y	Z
Vertical	0	1	0
Vertical reversed	0	-1	0
Left landscape	1	0	0
Right landscape	-1	0	0
Flat	0	0	1
Flat reversed	0	0	-1

The calculation of the value of the accelerometer will be focused on the x-axis because the amount of x to determine the slope of the smartphone, which is placed on speedometers overall effect accelerometer to detect an accident. The following workflow drowsiness ratings can see in Fig. 3.

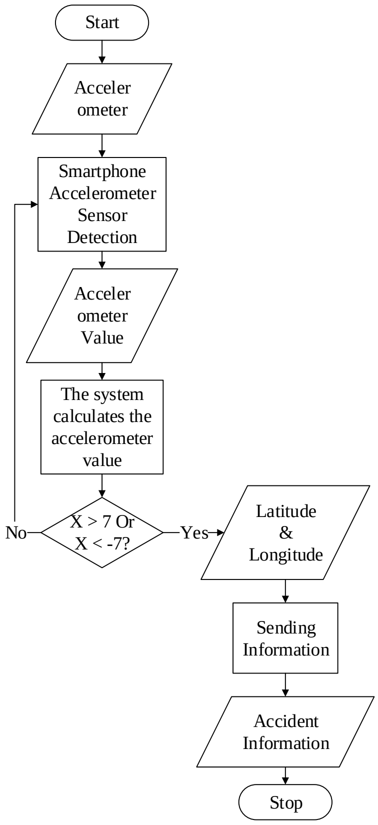


Fig. 3. Accident Detection Workflow

2.4. Tools and Technology

Some of the technology used in this research is :

a. Smartband
This technology used to get the heart rate value that detects drowsiness. The smart band is a device or application to monitor and keep track of fitness-related metrics such as walking or running distance, calorie consumption, heart rate, and sleep quality.

b. Accelerometer
This technology used to get the value of the slope of the smartphone to identify a crash. In this research, the accelerometer in the android smartphone used as a detector of the wave of the vehicle due to holes or damaged roads. The accelerometer in a smartphone can change the display from portrait to landscape by tilting the body smartphone because that reads three axes from different directions [19].

c. Google Maps API
This technology used to get the latitude and longitude values [20] to determine the accident's current location is detected.

d. SMS Gateway
This technology used to provide and send information to a predetermined destination number when detected accidents [21].

2.5. System Implementation

At this stage of the application development, along with the implementation of technology, it has been analyzed previously. At this stage, the start of implementation drowsiness assessment, implementation of crash detection, smart band linking implementation, and the implementation of the SMS Gateway.

2.6. System Testing

The results at the testing stage of the system by testing process analysis technique based on functional suitability, compatibility, usability, and efficiency. The functional suitability test assessed by the Guttman scale. After getting the test results in the form of points, then analyzed using criteria in the document quality for android applications can see in Table 3.

Table 3. Functional Quality Standards Suitability.

Rankings	Warning	Critical
No error	0 points	0 points
An easy mistake	1 point	-
Errors that are difficult	2 points	-
Fatal error	4 points	-
The test fails	-	5 points

Compatibility analysis conducted by operationally test series with the commencement of the installation of applications on different versions of operating systems and various specifications of smartphones based on the Android platform [22]. The next stage of calculating the percentage score test results to determine the quality level of compatibility aspects, namely:

$$\text{Percentage of Eligibility} = \frac{\text{Score obtained}}{\text{Maximum Score}} \text{ x } 100\ \% \qquad (1)$$

The usability aspect testing is using a Likert scale as the scale of measurement. The instruments use questionnaire contains 30 questions to be answered by the user to show the attitude towards ease of use application [23]. After finding the results of the calculations score in the obtained, then make a comparison with the criteria in Table 4 for the interpretation of scores [24].

Table 4. Criteria Interpretation Score.

Percentage (%)	Interpretation
0% - 20%	Very unfit
21% - 40%	Less worthy
41% - 60%	fairly decent
61% - 80%	worthy
81% - 100%	very decent

Analysis of quality in the performance aspect of efficiency done by calculating the average response time of each activity that executed using the program function trace view [25]. Tests on the performance aspect performed at least five times the amount calculated average response time when an application retrieves data from the server and then shown into the system [26]. The results are then compared Table 5 user satisfaction with the response time [27].

Table 5. User Satisfaction Predicate.

Response Time (seconds)	Predicate
<3	Very satisfied
3-9	Satisfied
9-12	Quite happy
> 12	Not satisfied

3. Results and Discussion

These stages include results from testing assessment and discuss the results obtained for the implementation of further research.

3.2. Drowsiness Assessment

Calculation of heart rate obtained will be sent to a smartphone using bluetooth 4.0 connection from Mi Band 3. Data received smart heartbeat band reprocessed to get the average heart rate. Here is the value of heart rate normal conditions of 5 samples 21-23 age range. The calculation of the average cost of each sample obtained heart rate while relaxing, during activity, sport, or at rest can see in Table 6.

Table 6. Calculation of Heart Rate Average (BPM).

Sample	Age	Relaxing	Activity	Sport	Rest
1st sample	23	65	85	105	56
2nd sample	21	72	91	112	64
3rd sample	22	64	82	102	60
4th sample	22	62	80	98	54
5th sample	22	68	88	101	58

A summary from Table 6 is the average heart rate when relaxing=66 BPM, during activity =85 BPM, sport=104 BPM and rest=58 BPM. Based on Table 6 can be concluded if the average heart rate of each person is different, then taken the theory from an expert doctor who claims that if a person experiences drowsiness, heart rate will decrease by approximately 10% to 20%. Calculation of the average heart rate done for 15 seconds. The example of drowsiness assessment, a rider aged 22 years is in a fit condition and has a regular heart rate of 80 BPM. Using the theory is when a person experiences drowsiness heart rate decreases of 10-20% from the current normal circumstances, this formula determines the heart rate when the drowsy.

$$H_{beat} = N_{beat} - \frac{20}{100} \text{ x } N_{beat} \quad (2)$$

If $N_{beat} = 80$, then :
$H_{beat} = 80 - 16$
$H_{beat} = 64$ BPM

When the value of a rider heart rate less than 64 BPM or 64 BPM otherwise drowsy.

3.3. Detection Accident Assessment

In this case, the smartphone will affix to the top of the speedometer of the motorbike. Table 7 shows the standard minimum values, and maximum values accelerometer in normal position.

Table 7. Testing Standard Value Accelerometer.

Axis	Minimum (m/s^2)	Maximum (m/s^2)
X	-0.13	0.16
Y	3.12	3.23
Z	8.70	9.65

Table 8 show the minimum and maximum value from the accelerometer when receiving shocks when riding. The shocks that occurred were small to moderate shocks.

Table 8. Testing Shock Value Accelerometer While Riding.

Axis	Minimum (m/s^2)	Maximum (m/s^2)
X	-2.91	3.48
Y	2.61	5.44
Z	4.69	12.68

The occurrence of sudden braking also causes shocks. Table 9 show the minimum and maximum values from the accelerometer when receiving shocks when a sudden brake is applied.

Table 9. Testing Value Accelerometer When Brakes Sudden Shocks.

Axis	Minimum (m/s^2)	Maximum (m/s^2)
X	-3.52	3.86
Y	0.38	8.02
Z	0.28	20.20

Table 10 show the minimum and maximum values from the accelerometer when receiving a shock when an accident occurs with the motorbike position fell to the right. While riding, it will declare in a motorbike accident in which position fell to the right.

Table 10. Accelerometer Shock Value Current Testing Accident Occurs

Axis	Minimum (m/s^2)	Maximum (m/s^2)
X	-23.06	9.87
Y	-4.38	10.67
Z	-17.20	24.74

For the example assessment of the accident, a 22-year-old motorbike driver suffered an accident that caused the motor to fall to the right and give the accelerometer value on the x-axis of -7.56 m/s. After several experiments conducted in this research, it can ensure that the motorbike is said to have fallen when the value of the axis $x>7$ m / s or $x<-7$ m/s. To determine whether an accident occurred or not with a logical formula:

$A_{BL} = X_{axis} > 7 \lor X_{axis} < -7$
If $X_{axis} = -7.56$, then:
$A_{BL} = -7{,}56 > 7 \lor -7{,}56 < -7$
A_{BL} = false ∨ true
A_{BL} = true
When A_{BL} is true, then it will be detected an accident.

3.4. System Architecture

The system architecture in this research can see in Fig. 4. The smartband used to detect motorbike driver heartbeat. When the system detects drowsiness, it will sound an alarm and vibrate to riders. If an accident occurs, the system will detect and take the scene and then sends the location information using SMS to the family of the crash or the destination number that has registered in the application.

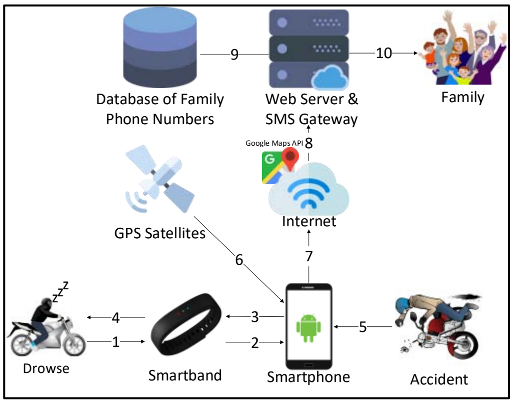


Fig. 4. System Architeture

The system procedure describes the activity process from the side of the driver, the system, and the family. A description of a system procedure in this research can see in Fig. 5.

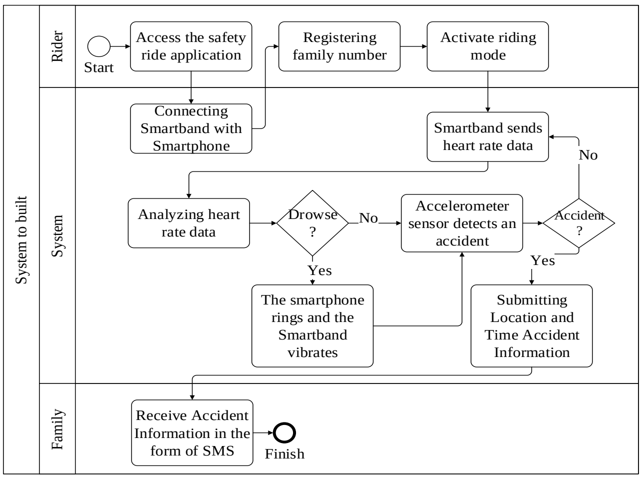
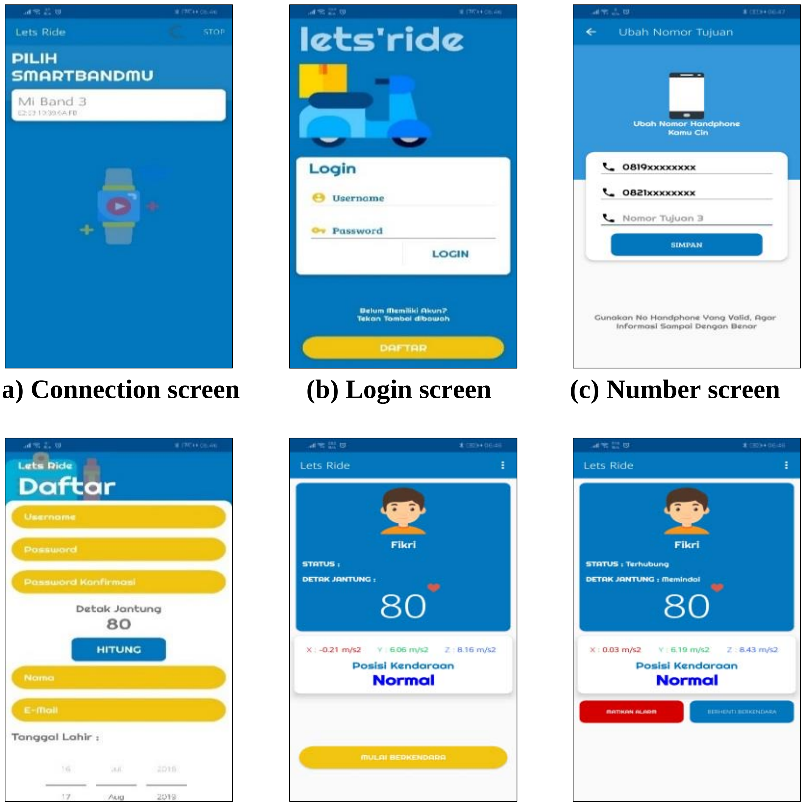


Fig. 5. System Procedure

3.5. System Implementation

These applications require installation on an android smartphone device with minimum version 5.1 (Lolipop). Fig. 6 show the system implementation result. The interface for the coupling smartband and smartphone shown in figure (a). On this page, there is a list of devices that can be connected. The login screen sees in figure (b), in which this page use to log in. Figure (c) shows the destination number that will send information about the location and the time when the accident occurred. Figure (d) used to register a new account. The main screen show in figure (e). This page indicator displayed the heart rate and accelerometer value equal to the image (f) only in this figure when started riding.



a) Connection screen (b) Login screen (c) Number screen

(d) Register screen (e) Main screen (f) Riding screen

Fig. 6. Application display results

3.6. Results of Drowsiness Detection Test

Drowsiness detection testing by calculating the heart rate of 30 respondents. Here are the test results, which can see in Table 11. The test results presented that the accuracy of sleepiness detection calculations reached 80% following the formula stated by the expert doctor. The accuracy rate when testing during the day only getting an accuracy value of 75%. The accuracy when testing at night is 90%.

Table 11. Result of Drowsiness Detection Test

No	Age	Time	Normal Heart Rate	Heartbeats While Drowsy	Result
1	21	10:13	80	59	Corresponding
2	22	10:15	81	63	Corresponding
3	21	10:17	82	69	Not Corresponding
4	23	10:20	79	57	Corresponding
5	22	10:22	80	67	Not Corresponding
6	22	12:43	75	67	Not Corresponding
7	22	12:46	82	65	Corresponding
8	22	12:48	87	66	Corresponding
9	20	12:50	86	58	Corresponding
10	24	12:54	85	59	Corresponding
11	22	13:05	86	62	Corresponding
12	24	13:08	75	68	Not Corresponding
13	21	13:11	80	66	Not Corresponding
14	23	13:13	81	63	Corresponding
15	23	13:16	87	56	Corresponding
16	21	15:25	83	57	Corresponding
17	21	15:27	82	55	Corresponding
18	22	15:30	88	70	Corresponding
19	23	15:33	81	61	Corresponding
20	20	15:36	89	60	Corresponding
21	20	19:45	78	60	Corresponding
22	22	19:49	82	61	Corresponding
23	22	19:54	89	57	Corresponding
24	22	19:58	84	60	Corresponding
25	24	20:05	88	60	Corresponding
26	22	03:04	80	69	Not Corresponding
27	21	03:07	86	60	Corresponding
28	20	03:09	83	61	Corresponding
29	23	03:13	79	58	Corresponding
30	24	03:16	87	55	Corresponding

3.7. Results of Drowsiness While Riding Test

We are testing drowsiness while riding a motorbike by cyclically calculating the heart rate with a regular heart rate of 80. The test result can found in Table 12, from the test results as many as five times, when detected vibration on smartband drowsiness and alarm on the smartphone turns on which function well.

Table 12. Testing Result Drowsiness While Riding

	Heart Rate	Vibrate Smartband	Vibration and Sound Phone
Test 1	59	Yes	Yes
Test 2	61	Yes	Yes
Test 3	57	Yes	Yes
Test 4	60	Yes	Yes
Test 5	65	Yes	Yes

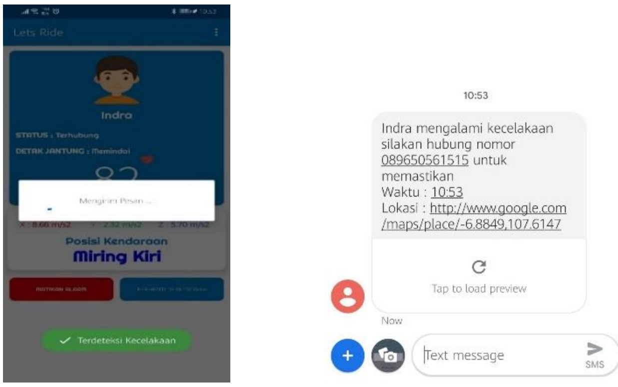
3.8. Results of Accident Detection Test

Accident test detection by calculates the accelerometer sensor in a smartphone. Fig. 7 (a) show the position a smartphone stored at the motorbike speedometer to obtain motor vehicle accelerometer data, and (b) show a driver has an accident so that the application sends information an accident has occurred to the rider's family.

(a) smartphone position **(b) accident position**

Fig. 7. Accident Detection Test

When an accident is detected, the application will send information in the form of a short message service to the destination number that has registered. The information sent contains detailed information such as the name detected in the accident, the number that can contact, and the time and coordinates of the accident's location. Fig. 8 (a) is the display when the application sends a message, while Fig. 8 (b) is the result of the short message service that has sent.



(a) Sending message **(b) Message content**

Fig. 8. Sending Information When Accident

Tests accident detection conducted six times that can seen in Table 13.

Table 13. Accident Detection Tests

Position	Accelerometer Value	Message	Information
Tilt Left	X-axis: 8.66 m / s	sent	Detected Leaning Left
Tilt Right	X-axis: -7.79 m / s	sent	Detected Leaning Right
Tilt Left	X-axis: 7.56 m / s	sent	Detected Leaning Left
Tilt Right	X-axis: -8.16 m / s	sent	Detected Leaning Right
Tilt Left	X-axis: 8.66 m / s	sent	Detected Leaning Left
Tilt Right	X-axis: -8.17 m / s	sent	Detected Leaning Right

The experiment detected the accident and information messages sent to the destination number. These results mean that the level of accuracy in accident detection gets an accuracy rate of 100%. The overall results of the tests conducted on the application of functional aspects of suitability testing, compatibility, usability, and efficiency criteria can see in Table 14.

Table 14. Software Testing Result

	Score	Result
Suitability	100 %	Very decent
Compatibilty	100 %	Very decent
Usability	84.71 %	Very decent
Efficiency	3.88 seconds	Satisfied

4. Conclusion

This research has successfully used accelerometer sensors on smartphone android and wearable devices to detect and prevent motorbike driver accidents. The results of tests carried out show that the accuracy of detecting drowsiness is equal to 80%, and the accident detection test gets an accuracy of 100 %. From the results of software testing also get good grades, seen from the criteria of suitability, compatibility, usability, and efficiency. The difference in accuracy when detecting drowsiness during the day and night becomes a subject for further research.

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Nomenclatures

H_{beat}	Heartbeats value when drowsy
N_{beat}	Normal heartbeats value
A_{BL}	Boolean value when the tilt motorcycle
X_{axis}	Value on the x-axis accelerometer

Abbreviations

JESTEC	Journal of Engineering Science and Technology
NTSC	National Transportation Safety Committee
SMS	Short Message Services
BPS	Badan Pusat Statistik
LED	Light Emitting Diode
UNIKOM	Universitas Komputer Indonesia
BPM	Beats Per Minute

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