DEVELOPMENT OF FALL DETECTION APPLICATION OVER ELDERLY BASED ON ANDROID

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ABSTRACT

Fall is one of the moving condition that prove about action from the person on that condition. Age is one of decrease factor that someone has a fall. When elder has been fall and doesn't detected on a period time will bring many possibilities that happened. The fall incident will bring effect to physically and mentally. If first fall treatment comes late, so the injured conduce a disability, paralyzed and death. However, a family role is very important as the supporting system for elder, but sometimes doesn't work well because of the obstacles. So, the application develops of the fall detection over elder can be one of solution for the problems. The application that develop in implementation using threshold-based fall detection algorithm that utilize accelerometer censor, gyroscope and GPS in Android smartphone. The purpose of fall detection application over elder is to make much easier on detection especially fall detection over elder on daily activity and it makes easy for others family member to access the information when the elder fall.

Keywords: fall detection, elder, accelerometer, gyroscope, threshold-based fall detection, Android.

1. INTRODUCTION

1.1 Background of The Study

Fall is one of the moving condition that prove about action from the person on that condition. Age is one of decrease factor that someone has a fall. It is older more movement limited or aging.

Based on the survey result has been done towards the 60 respondent that have a parents between 45-74 years old, it can be found 96,7% elder respondent that has been fallen with various causes such as slip, stumble, and vehicle accident that 65,5% causes by severe injury. The members' family respondent is 98,3% feel worry, if the parents has fallen, moreover 80% respondent has been difficult to find helper when they fall. Based on the explain above, it can be concluding that the respondent feels difficult to find an information when the parents fall. So as, it need monitoring by the family members or relative towards the changes and the stability movement on elder.

The monitoring can be watch through various aspect include through the smartphone. Nowadays, smartphone has already had with all people include elder. Recently, smartphones already pinned by sensors such as accelerometer, gyroscope and GPS. The combination between accelerometer sensor and gyroscope can be detected fall movement with the various advantage on algorithm fall detection movement, which one of the algorithm is threshold-based fall detection.

1.2 Research Questions

Based on the background of the study, so the writer identify a few problems that raised from this case.

1. The difficulty when detected the movement especially fall movement on elder daily activity.
2. The family members are difficult to get the information when the elder fall.

1.3 Objectives

The objectives of research are to build the fall detected application based on android. This application can be detected the fall movement on elder and also can give a notification to the family member when the elder fall. The purpose of the build the fall application on elder is.

1. Makes easier detected a movement especially fall movement on elder daily activity.
2. Makes easier the family to get the information when the elder fall.

2. FRAMEWORK OF THEORY

2.1 Elder

The elder is group age on the human that has been reach the last phase in the life. According to the experts, the age limitation is covered by elder age such as [1].

a. According to *Undang-Undang Nomor 13 Tahun* 1998 on the *Bab 1 Pasal 1 ayat 2*, elder is someone that reach the 60 years old or more.
b. According to the World Health Organization (WHO) elder divided into four section that middle age is, 45-59 years old, elderly is 60-74, old is 75-90 years old, very old is 90 years old.
c. According to Dra Jos Masani (UI psychologist) it contains four phases that is: First is inventus phase, that is 25-40 years old. Second is

virilities phase, that is 40-55 years old. Third is presenium phase, that is 55-65 years old. Four is senium phase, that is 65 till death.

d. According to Dr. Koesoemato Setyonegoro, the getiatric age can be divided into 3 group age such as, young old between 70-75 years old. Old between 75-80 years old and very old is more than 80 years old.

2.2 Threshold

On this research, this threshold can be used as the acceleration value threshold and angular velocity threshold from accelerometer censor and gyroscope censor.

The threshold is used to differentiate the fall movement and un-movement. If the accelerate value and angular velocity value is more than threshold that already has been set so that fall has detected. Whereas, the finding of threshold value is done with analyze all the accelerate value and angular velocity from the movement on daily activity. All of the accelerate data and angular velocity can be pick the maximum value to become the threshold [2].

2.3 Threshold-Based Fall Detection Algorithm

Threshold-based fall detection algorithm is one of the algorithm that used to detect the fall movement. On the fall detection, threshold-based fall detection algorithm firstly need the accelerate data form the x,y,z that can be through accelerometer censor and the angular velocity from x,yx,z that can be through gyroscope censor. The fall detection divided into a few stage such as.

1. The first stage is to compare the accelerate magnitude value and velocity with the each of threshold.
2. The second is to compare the angular value and angular value threshold.
3. The last is checked the movement after long lay with compare the accelerate value and threshold long lay value. This stage is used to increases the accuracy value when fall is detected [3].

3. RESEARCH METHOD

The research method that used is quantitative approach with using descriptive method, that is do a comparative study with compare the phenomena that find and made a classify from the standard of source [4].

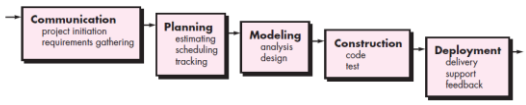
3.1 Collecting Data Method

The collecting data method that used is:

1. Survey (questionnaire)
   Collecting the data is done by online.
2. Literature study
   The collect of data is done with find, analyze, study and research the sources that have a direct interact with the research such as book, scientific journal and other sources.

3.2 Software Development Method

The software development method used is waterfall method by Roger S. Pressman [5].



Picture 1. *Waterfall* method

4. THE RESULT AND DISCUSSION

4.1 System Analyze

System analyze involves problem analyze, architecture system analyze, technology analyze, non-functional need analyze and functional need analyze.

4.1.1 Problem Analysis

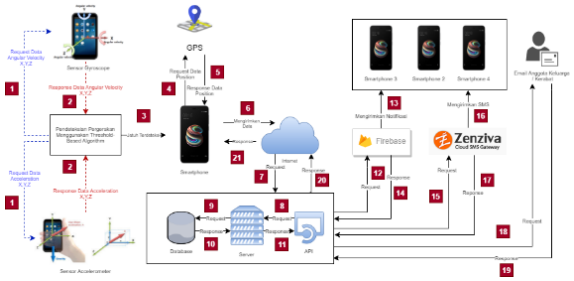
The purpose of problem analysis is to help the application development. This research is related to body movement on human, it can be a few problems that always happened and experienced by the elder and family. The first problem is the difficulties to detect the fall especially fall movement on elderly on daily activity. Besides, it needs a supporting device such as accelerometer censor, gyroscope and GPS, the calculation is used also to calculate the fall movement.

The fall happening, when someone lose the stability of the body, so there are several things that causes someone experienced interference stability of the body including aging effect, crashed and disease factor. However, from all of that causes, the aging effect is the main factor for postural stability disorder on elder. The regression or the marfologist change on elder causes by the changes of functional muscle and the rate for doing of activity also can be causes the decrease capability to maintain the balance of the body [6]. The elder is more than 60 years old include man or woman which can do activity and working or they can be find the jobs their self-made the elder expelled or depend on the family to fulfil the living [7].

The family is supporting system for elder that hope always be ready to give a help towards elder if it need [6]. The problem happening when family can be always accompanying elder to watch directly. The providing information while elder fall will make family is more give a help to elder. So that the application that develop will must be compete to detect the movement on elder and also give an information when the elder fall.

4.1.2 System Architecture Analysis

System architecture analysis is used to describe the system that interact such as the illustration below.



Picture 2. System Architecture Analysis

4.1.3 Technology Analysis

The purpose is to explained in more detail all of things that used in system development. It is the technology that used on develop this application.

1. Sensor Fusion

Sensor Fusion is the merging two kinds of censor that different that have a characteristic mostly same to get the new function. The one of function from the fusion censor gets the comparation between twi censor that combine [8].

While elder does the movement with carrying smartphone in its pocket so the each accelerate value will change. The accelerate value and angular velocity depends on the movement pattern. The accelerate value and angular velocity that resulting can be conclude below.

$$Ax = \{ Ax_1, Ax_2, Ax_3, \ldots\ldots\ldots, Ax_n \} \quad (1)$$

$$Ay = \{ Ay_1, Ay_2, Ay_3, \ldots\ldots\ldots, Ay_n \} \quad (2)$$

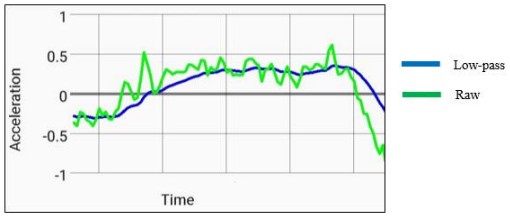
$$Az = \{ Az_1, Az_2, AZ_3, \ldots\ldots\ldots, Az_n \} \quad (3)$$

$$Gx = \{ Gx_1, Gx_2, Gx_3, \ldots\ldots\ldots, Gx_n \} \quad (4)$$

$$Gy = \{ Gy_1, Gy_2, Gy_3, \ldots\ldots\ldots, Gy_n \} \quad (5)$$

$$Gz = \{ Gz_1, Gz_2, GZ_3, \ldots\ldots\ldots, Gz_n \} \quad (6)$$

The accelerate value that resulting directly from the accelerometer will have noise and on the value will influence by the gravity value much more 9.8 m/s2 that adding on each value in certain condition. So this case to decrease the impact from the noise and eliminated the influence of the gravity on the data so it can be do the filtering on that value [9]. The filtering will use to design the software on this research that is low-pass filtering. The low pas-filtering is filtering is used to smoothing the data and maintain the low value data [9]. On the android developing documentation occurs one of the low pass-filtering that then used to predict the linier accelerate. It is the differences of data that does not use after the low pass filtering.



Picture 3. Accelerate Filtering Value

After the accelerate value is done by filtering, a magnitude value will count with use accelerate value and angular velocity from each coordinate on accelerometer censor and gyroscope censor. The mangnitude value will count using this calculation:

$$AT_t = \sqrt{Ax^2 + Ay^2 + Az^2} \quad (7)$$

$$GT_t = \sqrt{Gx^2 + Gy^2 + Gz^2} \quad (8)$$

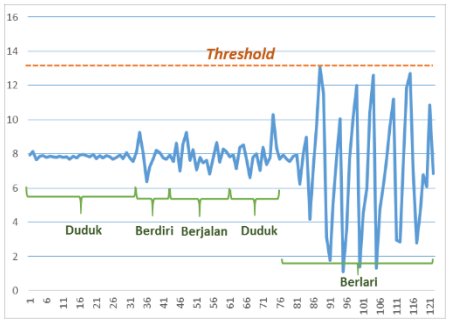
Besides, the magnitude value is be found the slope value that will used as the add parameter which call as pitch, roll and yaw [10][11]. The all third found with the calculation below:

$$Pitch = \left(\frac{180}{\pi}\right) * \text{atan}\left(\frac{-Ax}{\sqrt{Ay^2+Az^2}}\right) \quad (9)$$

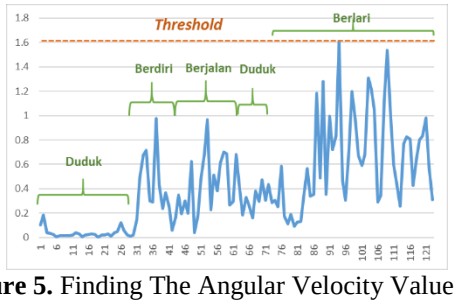
$$Roll = \left(\frac{180}{\pi}\right) * \text{atan}\left(\frac{Ay}{\sqrt{Ax^2+Az^2}}\right) \quad (10)$$

$$Yaw = \left(\frac{180}{\pi}\right) * \text{atan}\left(\frac{\sqrt{Ay^2+Ax^2}}{Az}\right) \quad (11)$$

This research has a stages, first search the accelerate data, angular velocity on elder daily activity, determine threshold value and identify the fall movement. The first stage is search the accelerate data and angular velocity to get the accelerate value pattern and angular velocity from all daily activity through the accelerometer censor and gyroscope censor and used as the reference in find the fall threshold value. As for the results from this research is to determine and find the accelerate value also angular velocity on elder daily activity then next step is to determine the threshold value below:



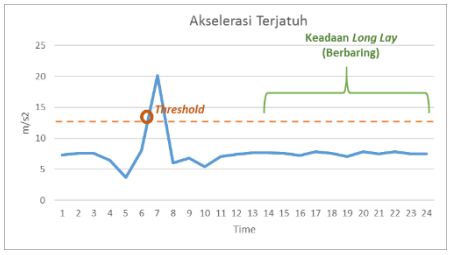
Picture 4. Finding Accelerate Threshold Value



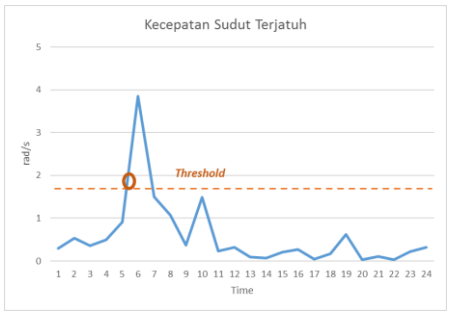
Picture 5. Finding The Angular Velocity Value

The stage results show that the accelerate threshold value obtained is 13,081 m/s^2 and the angular velocity threshold obtained is 1,605 rad/s. So that, the accelerate threshold and the angular velocity from the fallen is the highest accelerate and angular velocity from the elder daily activity is the

accelerate value and the angular velocity on running activity. While the angular threshold value used is 60 degrees. To prove the accelerate threshold value and the angular velocity is true, researcher done fall incident (assumed that this incident is fall incident with current position is move forward and lay down) and compare the threshold value that determined.



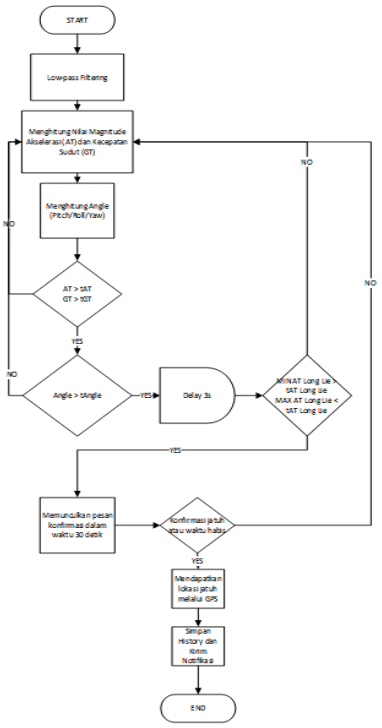
Picture 6. Proving The Accelerate Threshold Value



Picture 7. Proving The Angular Velocity Threshold Value

The falling incident can get that the accelerate value and angular velocity on fallen that has higher threshold value. It cannot be without the long lay detection after the fallen detected make the possibilities the positive false value will bigger. This situation become more dangerous cause the elder will fall without detected by the system. So that, to improve both of it that is the true positive rate and the false rate, the additional layer of inspection is added after the fall incident detected. This checking will verify if the elder back to the normal activity after fall. This case, if the elder does not show the symptoms after three second fall so it is possible that the fall incident is detected because the fall when laying down is called long lay. On falling cases with a long lay, it shows the balance value after the elder does not do an activity [3].

The minimum accelerate threshold on long lay incident is 6,0 m/s^2, moreover the maximum value is 9,0 m/s^2. So, it shows the fall incident detected process is used a sensor fusion that describes below:



Picture 8. The Fallen Detected Flowchart

2. GPS

This research is to fulfil the functionality need for the application to determine the elder fall location so that, it need a GPS technology. Using the GPS technology is expected to help the system that bulid to find the fall current location and the elder fall coordinate. The coordinate and the detected location then will send as notification that save in history.

The GPS usage on application that build is same with the GPS usage in general. This is how GPS works in this application:

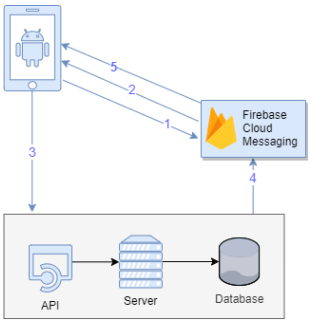
1. First, the user activated GPS before runs the application.
2. When the application detected fall incident and already confirmed, the application starts to utilize the GPS to get the location.
3. The application will send a notification and save the location as history.

3. API

On fulfil the need to exchange an information or the data on application, so it needs an API that connected with the build application. API used is Codeigniter 3.0 as the framework to build the API that apply to RESTful web service and used JSON as the data returned. Moreover, the security for API and resources access limited uses JWT (JASON WEB Tokens).

4. *Firebase Cloud Messaging*

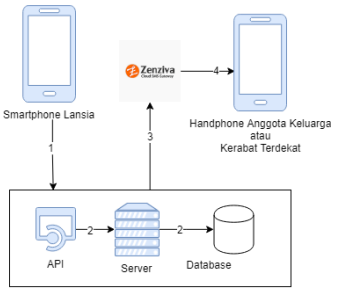
The workflow stages of firebase cloud messaging on the application that build in this research are:



Picture 9. The Firebase Cloud Messaging Workflow

5. *SMS Gateway*

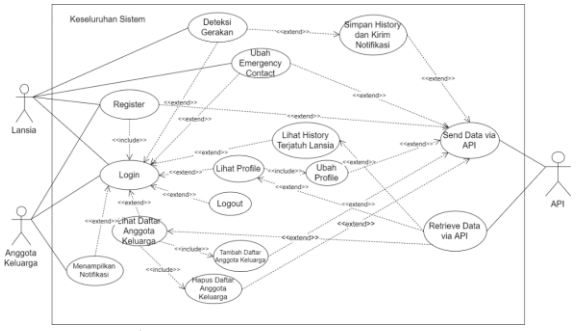
This research, researcher used SMS Gateway Zenziva. However, its use the sms gateway Zenziva usage is limited that only covered in Indonesia. The service utilization phase SMS gateway Zenziva in this application will build as below:



Picture 10. SMS Gateway Workflow

4.1.4 The Functionality Analysis

This is a use case from the system:



Picture 11. *Use Case Diagram*

4.2 The System Implementation and Testing

This is an explanation about the system implementation and testing:

4.2.1 The Implementation of Hardware Requirements

Running the application, its need a hardware that supported. This research, researcher divides into two parts that is, computer and smartphone with their specification as:

Table 1. The Implementation of Hardware Requirements

No	Software	Hardware Spesification
1	VGA On Board	1024 MB & 4 GB (*Hybrid*)
2	RAM	8 GB
3	CPU	7th Gen AMD® APU FX™-9830P, Clock Speed 3.0 GHz – 3,7 GHz
4	Hardisk	1 TB
5	Wireless	802.11 a/b/g/n/ac
6	Internet	1Mbps
7	Slot USB	Minimal 1 slot

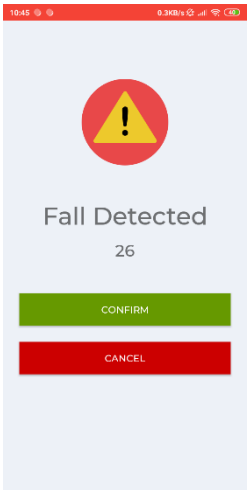
Moreover, this specification for smartphone:

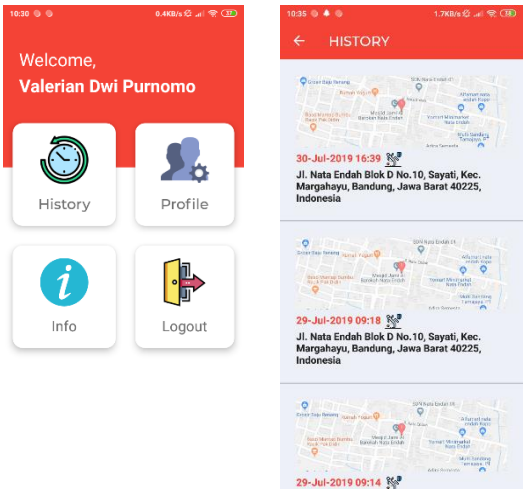
Table 2. The implementation of smartphone hardware

No	Software	Harware Spesification
1	LCD	Resolusi 1440x720
2	Battery	3000mAh
3	Chipset	Qualcomm Snapdragon 625
4	Internal	64 GB
5	RAM	4 GB
6	*Sensor Gyroscope*	*On*
7	*Sensor Accelerometer*	*On*
8	GPS	*On*

4.2.2 Interface Implementation

This is the interfaces implementation from the application:





Gambar 12. The Interface Implementation

4.2.3 Testing

Testing the features on the applivation that build, researcher uses the functional testing that following with equivalent partitioning testing and boundary value analysis and fall incident detector testing.

Table 3. The result of functional testing

No	Testing Class	Testing Results
1	Login	Accepted
2	Sign Up	Accepted
3	Fall Detection Service	Accepted
4	SOS Service	Accepted
5	Family List	Accepted
6	Add Family	Accepted
7	Delete Family	Accepted
8	History List	Accepted
9	Map History	Accepted
10	Profile	Accepted
11	Change Profile	Accepted
12	Change Password	Accepted
13	Edit Emergency Contact	Accepted
14	Logout	Accepted
15	Show Notification	Accepted

Moreover, the resulsrs from the equaivalance partitioning testing and boundary value analysis as below:

Tabel 4. The results of equivalence partitioning and boundary value analysis

No	Column	Testing Results
1	*Nama*	Accepted
2	*Usia*	Accepted
3	*Email*	Accepted
4	*Telepon*	Accepted
5	Password	Accepted

Testing the motion detection tester used confusion matrix method and divide into 4 value condition that is:

1. TP = true positive (the user is fall and system detected fall.)
2. TN = true negative (the user does not fall and system detected fall)
3. FP = False Positive (the user does not fall and system detected Fall)
4. FN = False Negative (the user is fall and censor detected not fall.)

That fourth condition is used to knows the recall value (true positive rate), specificity (true negative rate), precision (the accuracy of fall detection), accuracy (the fidelity of fall detection). So it should found that values, tester does 5x testing in various category and movement condition. The results from testing that gets is:

Tabel 5. The Results of Fall Detection Condition Testing

Categorize	Condition	Actual	Results Number
Fall backward	Ending in sitting position	Fall (TP)	5 TP
	Ending in lay down position	Fall (TP)	4 TP, 1 FN
	Ending in sideway position	Fall (TP)	5 TP
	Rise up	Not Fall (TN)	5 TN
Fall forward	With knee	Fall (TP)	2 TP, 3 FN
	With the protection of the arm forward	Fall (TP)	4 TP, 1 FN
	Ending in lay down position	Fall (TP)	4 TP, 1 FN
	Ending in sideway position	Fall (TP)	4 TP, 1 FN
Fall to the right side	Ending in lay down position	Fall (TP)	4 TP, 1 FN

	Rise up	Not Fall (TN)	5 TN
Fall to the left side	Ending in lay down position	Fall (TP)	4 TP, 1 FN
	Rise up	Not Fall (TN)	5 TN
Fall straight	Lean against the wall then slide vertically and end in a sitting position	Fall (TP)	5 TP
ADL (Activity Daily Living)	Sit in a chair then stand up	Not Fall (TN)	5 TN
	Lay on the mattress then rise	Not Fall (TN)	5 TN
	Walk a few meters	Not Fall (TN)	5 TN
	Bend down then back in an upright position	Not Fall (TN)	5 TN
	Running	Not Fall (TN)	5 TN
	Climbing up the stairs	Not Fall (TN)	5 TN

Based on the result of testing, so it can be concluded that the true positive (TP) that its get around 41, True negative (TN) is around 45, False (FP) is around) and False Negative (FN) is around 9. Moreover, it also get that recall on the application that build is 82%, specificity is 100%, precision is 100% and accuracy is 90,53%.

5. CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the implementation and analysis, it can be concluded that through this research "the application develop of fall detection over elder based on android". Is:

1. The fall detection application over elder makes an easier to detect movement especially fall movement on elder daily activity.
2. The fall detection application over elder makes simplify the family member to get the information when the elder falls.

5.2 Suggestion

This application builds to make an easier detected the fall incident and simplify the family member to get the information but this application needs to develop more. Therefore, there are a few suggestions that can used as the reference for software development. It is for supporting content and adding better accuracy on software. As for the suggestions towards on the fall detector application over elder that is:

1. Developing the application display to more interests.
2. Developing the application on others platform. Considering this application only supporting on Android platform.

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