Developing a Smart Belt for Monitoring Elderly Activities Based on Multi-Modal Sensors Integration and Internet of Things

Abdul Jalil*, Pujianti Wahyuningsih, Najirah Umar, Muhammad Risal, Suwatri Jura, A. Edeth Fuari Anatasya

Universitas Handayani Makassar,
Adhyaksa Baru Street, No. 1, Makassar, South Sulawesi, 90231, Indonesia.
Email: abdul.jalil@handayani.ac.id, ujiwahyuningsih@handayani.ac.id, najirah@handayani.ac.id, risal@handayani.ac.id, suwatrijura@handayani.ac.id, edetanatasya@handayani.ac.id.

Abstract

This study aims to develop a smart belt that can be used to monitor elderly activities at home by integrating Multi-Modal Sensors (MMS) and the Internet of Things (IoT). The MMS used in this study to collect elderly information is the IMU sensor, vibration sensor, push button, and ESP32 to process IoT data. Furthermore, the IoT platform used to transmit elderly information data from the smart belt to the family smartphone is Blynk. In this study, the smart belt can monitor the activities of the elderly when walking, sitting, lying down, and sleeping. After that, the smart belt can provide warning alerts when the elderly carry out abnormal activities at home. The results of this study show that the smart belt can monitor the activities of the elderly when walking, sitting, lying down, sleeping, and warning alerts on the family smartphone based on the integration of MMS and IoT.

Keywords: Smart Belt, Elderly, Multi-Modal Sensor, Internet of Things.

1. Introduction

The elderly is a person who has reached the age of 60 years or older [1]. During this phase, the elderly will have a reduced ability to perform activities, which means that their family will need to provide them with special assistance. In addition to monitoring the condition of the elderly at home, the busy activities of family members outside the home can pose an additional problem when caring for an elderly relative who is alone at home. Therefore, the urgency of this research is to build a smart belt device that can help family members monitor their elderly activities based on the integration of Multi-Modal Sensors (MMS) and the Internet of Things (IoT).

Some researchers have conducted studies on the development of devices to monitor elderly activities based on IoT technology. Hua et al. have developed a device that can be used to monitor elderly activities using ICE (IoT Cares for the Elderly) [2]. In that study, the researchers used a heartbeat sensor, a body temperature sensor, and an Intel Edison platform to monitor elderly activities based on the Internet of Things. Narasinghe et al. have conducted a study to monitor and detect activities of elderly care by integrating various technologies of wearable and non-wearable devices connected to the wireless network [3]. The researchers in that study used the heart rate sensor and the PIR sensor to detect elderly activities and the cloud system to store elderly information using an internet connection. Cheng et al. have presented an application to monitor elderly care with IoT [4]. In that study, the researchers used the ThingSpeak IoT platform and the ADXL345 accelerometer to monitor the elderly while doing activities at home. Rupasinghe et al. conducted the design and development of an IoT-based device to track the physical activities of the elderly using an accelerometer sensor [5]. Firebase IoT platform was used to transmit elderly information from the device to the smartphone of the elderly family. Furthermore, Naeim et al. have developed a device for monitoring elderly activities for safety based on mobile IoT [6]. In that study, the researchers used a low-cost prototype device to measure heart pulse, detect falls, and determine the location of the elderly, then used Blynk, Firebase, and Google Assistant for the IoT platform.

According to the results of the study shown previously, it can be seen that some researchers have developed devices to monitor elderly activities using IoT. Therefore, the contribution of this study is to develop a smart belt that can be used to monitor elderly activities based on the integration of MMS and IoT. In this study, we used the IMU sensor, vibration sensor, and push-button for MMS, and Blynk as an IoT platform to transmit elderly information from the smart belt to elderly activities when the elderly is walking, sitting, lying down, and sleeping.

This paper consists of a fourth chapter to elaborate on our study results. In the second chapter, we explain the method used in our study to develop a smart belt to monitor elderly activities. The third chapter presents the results of our study. Then in the last chapter, we show the conclusion and future work of our study.

2. Methodology

Figure 1 shows the architecture design developed in our study to build the smart belt based on the integration of MMS and IoT to monitor elderly activities.

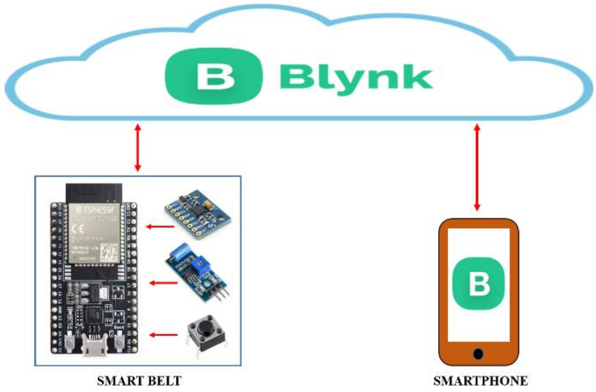


Fig.1. Architecture design

According to the information in Fig. 1, it can be seen that the sensor devices used to develop MMS in our study consist of the IMU sensor, vibration sensor, and push button. The function of the IMU sensor in this study is to detect the activities of the elderly when they walk, sit, lie down, and sleep. We detected it when the degree of motion of the IMU sensor was observed following the activities of the elderly. IMU sensor is a sensor device that can be used to detect the degree of motion of an object according to acceleration and gyroscope [7]. The vibration sensor function in the smart belt is to confirm that the elderly is moving when the IMU sensor detects that the elderly walk, sit, and lie down. Then after that, when the IMU sensor detected the elderly in a sleep position and the vibration sensor did not detect the elderly moving, the system confirmed that the elderly was in a sleep state. The vibration sensor is a sensor device that can detect the vibration of an object based on the mechanical quantity received by the sensor and then convert it into electrical current [8]. Furthermore, the push button function is a security button that sends elderly information when the elderly need helps or are in an abnormal condition.

In this study, the microcontroller used to read and process MMS and IoT data is ESP32. ESP32 is a microcontroller that can be used to process sensor data for the controller, is low-cost and low-power, and is integrated with the Wi-Fi and Bluetooth module on a board [9]. The IoT platform used to transmit IoT data between the smart belt and the smartphone in this study is Blynk. Blynk is an IoT platform that can be used to communicate IoT data between devices to an iOS or Android smartphone over an Internet connection [10]. Furthermore, Fig. 2 shows the flowchart system developed in our study to operate the smart belt based on IoT.

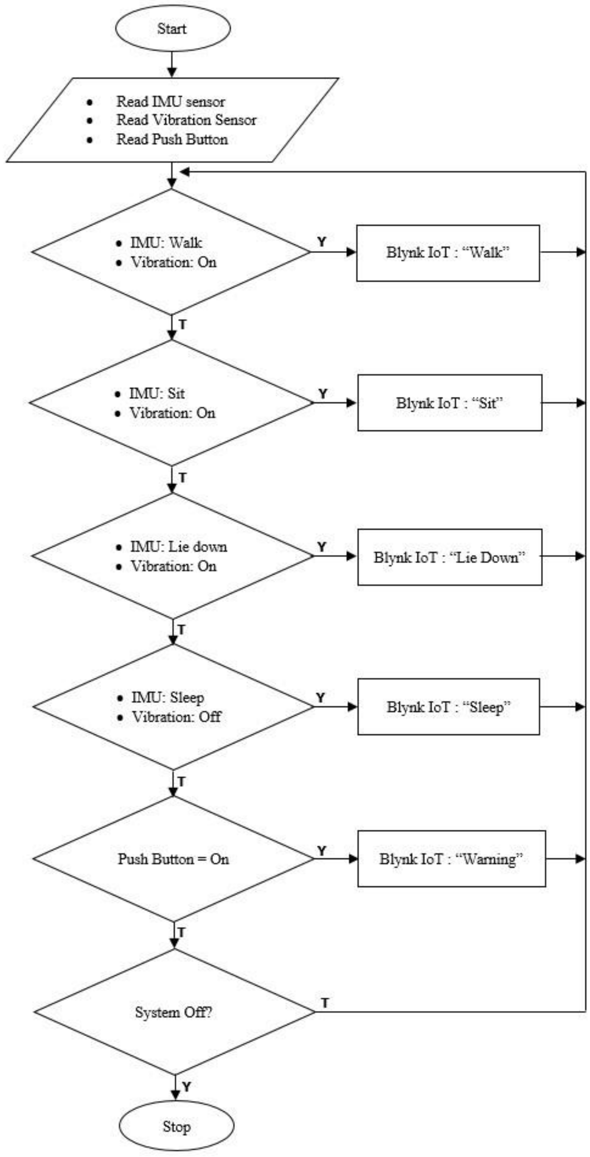


Fig.2. Flowchart systems

Based on the information in Fig. 2, it can be seen that, in the first step, the smart belt reads the data input received from the IMU sensor, vibration sensor, and push button, then processes the IMU and vibration sensor data to detect elderly activities. When the system detects that the elderly is walking, the system then sends the information from the smart belt to the family's smartphone to inform the elderly that they are walking using Blynk IoT, connected over the Internet connection.

Furthermore, when the elderly is sitting, lying down, and sleeping, the system sends the information data to the family's smartphone based on the information from the IMU and vibration sensor, respectively. When the system detects that the push button is pressed, the Blynk IoT then sends the warning information to the family that the elderly need helps or are in an abnormal condition. The systems then run repeatedly until the power on the smart belt is turned off.

3. Results and Discussion

We have developed a smart belt that can be used to monitor the activities of the elderly based on the integration of MMS and IoT. Figure 3 shows the smart belt developed in our study.

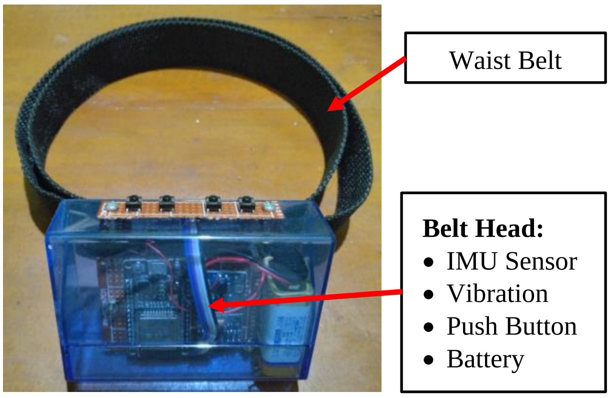


Fig.3 The smart belt developed in this study.

Based on the information in Fig. 3, to implement the experiment, we used an IMU sensor (KKHMF, MPU-6050) to detect elderly activities when walking, sitting, lying down, and sleeping according to the degree of movement of the IMU sensor (acceleration and gyroscope), a vibration sensor (DKARDU, Piezoelectric) to confirm elderly activities when walking, sitting, lying down, and sleeping according to the vibration of elderly moving, then push button as trigger for the smart belt to send a warning to the family when the elderly is an abnormal condition. The microcontroller used in our study to process MMS data and IoT is ESP32 (ESP32 DEVKIT V1) and then used the Blynk platform to transmit IoT data between the smart belt and the family smartphone. Furthermore, Table 1 shows the DATASTREAM ID and data type used to transmit the elderly information from the smart belt to the family smartphone using Blynk.

Table 1. The DATASTREAM ID and data type are used to transmit elderly information.

Elderly Information	DATASTREAM	Data Type
Walking	V1	INT, 0/1
Sitting	V2	INT, 0/1
Lying Down	V3	INT, 0/1
Sleeping	V4	INT, 0/1
Warning	V5	INT, 0/1

According to the information in Table 1, we use INT data type 1 or 0 to confirm the activities of the elderly when they walk, sit, lie down, sleep, and have abnormal conditions. When the system detected that the elderly was doing activities (walking, sitting, lying down, sleeping, and abnormal conditions), the system then sent the INT data of 1 to confirm that the elderly was doing the activities. If not, the system sends 0 data information to the family smartphone. Furthermore, Fig. 4 shows the activities of the elderly when walking, standing up, sitting, and lying down, respectively. Fig. 5 shows the elderly information on the family smartphone using the Blynk application based on the Android OS when the elderly walk.

Fig.4. Activities of the elderly when (a) walking, (b) standing, (c) sitting, and (d) lying down.

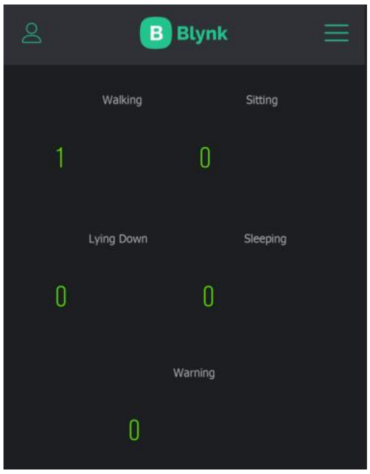


Fig.5. Information of elderly when walking.

4. Conclusion

In this study, the development of a smart belt based on the integration of MMS and IoT that can be used to monitor elderly activities when walking, sitting, lying down, sleeping, and under abnormal conditions was carried out. We used an IMU sensor, vibration sensor, and push button for MMS and ESP32 as a microcontroller to process MMS and IoT data, then Blynk for the IoT platform. In our study result, the smart belt can detect the elderly walking, sitting, lying down, and sleeping on the family smartphone.

References

1. J. P. Putri and J. Natalia, The Dynamics of Aging Process Adaption From the Late Adulthood to the Elderly in Panti Werdha X. Psikostudia: Jurnal Psikologi, Vol. 11, No. 3, 2022, pp. 467-478.
2. B.D.C. Hua, H. Fahmi, L. Yuhao, C.C. Kiong and A.Harun, Internet of Things (IoT) Monitoring System for Elderly, International Conference on Intelligent and Advance System (ICIAS), 2018.
3. N. Narasinghe, RPS. Kathiarachchi and M.W.P. Maduranga, IoT based Health Monitoring and Activity Detection for Elderly Care, 13th International Research Conference General Sir John Kotelawala Defense University, 2020, pp. 396–401.
4. B.J. Cheng, M.M.A. Jamil and R. Ambar, Elderly Care Monitoring System with IoT Application, ICITAM SCI 863, 2020, pp. 525–537.
5. I.D.M.S. Rupasinghe and M.W.P. Maduranga, Towards Ambient Assisted Living (AAL): Design of an IoT-based Elderly Activity Monitoring System, I.J. Engineering and Manufacturing, 12(2), 2022, pp. 1–10.
6. M.K.M. Naeim, G.C. Chung, I.E. Lee, J.J. Tiang and S.F. Tan, A Mobile IoT-based Elderly Monitoring System for Senior Safety, International Journal of Technology, Vol. 14(6), 2023, pp. 1185–1195.
7. W. Suryanto, Supriyanto, E. Hartantyo, T. Juhana, Budiarjo, A.S. Handaru and J. Satriani, IMU (Inertial Measurement Unit) Device for Internet of Things Based Disaster Early Warning System: Application and Innovation, IOP Conf. Series: Earth and Enviromental Science, 2020.
8. D.N. Ilham, R.A. Candra, A. Budiansyah, E. Sipahutar, M.K. Harahap and F. Anugreni, Implementation of Vibration Sensor and Pin Lock using Keypad for Charity Box Security, International Journal of Multidisciplinary Sciences and Arts, 1(2), 2022, pp. 125-133.
9. D. Hercog, T. Lerher, M. Truntič and O. Težak, Design and Implementation of ESP32-Based IoT Devices, Sensors, 23(15), 2023, pp. 1-20.
10. D D. Babić, I. Jovović, T. Popović, N. Kovač and S. Čakić, An Internet of Things System for Environmental Monitoring Based on ESP32 and Blynk, 26th International Conference on Information Technology (IT), Zabljak, Montenegro, 2022, pp. 1-5.

Authors Introduction

Abdul Jalil

He received his Bachelor's and Master's degrees in Computer Systems, 2012 and 2015, respectively, from STMIK Handayani Makassar, Indonesia. He then received his Doctor of Engineering in 2023 in the Department of Computer Science and Systems Engineering, Kyushu Institute of Technology, Japan. His research interest includes robotics, embedded systems, network, and Internet of Things.

Ms. Pujianti Wahyuningsih

She received her Bachelor's degree in Information Systems in 2015 from STMIK AKBA Makassar, Indonesia. Then received her Master's degree in Computer Systems in 2017, from STMIK Handayani Makassar, Indonesia. Her research interests include information systems engineering and management information systems.

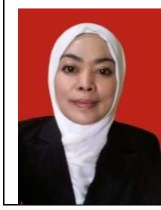
Ms. Najirah Umar

She received her Bachelor's degree in Informatics Engineering in 2000 from STMIK Handayani Makassar, Indonesia. She then received her Master's degree in Electrical Engineering in 2007, from Hasanuddin University, Indonesia. His research interests include software engineering and database management systems.

Mr. Muhammad Risal

He received his Bachelor's degree in Computer Systems in 2006 from STMIK Handayani Makassar, Indonesia. Then received her Master's degree in Electrical Engineering in 2011, from Hasanuddin University, Indonesia. His research interests include embedded systems, microcontroller, networking, and Internet of Things.

Ms. Suwatri Jura



She received her Bachelor's and Master's degrees in Computer Systems, 2010 and 2015, respectively, from STMIK Handayani Makassar, Indonesia. His research interests include information systems and software engineering.

Ms. A. Edeth Fuari Anatasya

She received her Bachelor's degree in Information Systems in 2012 from STMIK AKBA Makassar, Indonesia. She then received her Master's degree in Computer Systems in 2015, from STMIK Handayani Makassar, Indonesia. Her research interests include informatics engineering and management information systems.