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# Development of Automatic Reminder System for Geriatric Medicine Intake

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*Abstract*—The consumption of medicine is typical in geriatrics, having many problems related to medications. Geriatrics often forget to take their medicine, and this problem can be overcome by using an automatic reminder system. In this study, an automated reminder system is developed as an improved community element, acting as a system that can help geriatric in taking their medicine on time, thus, boosting their health condition. This reminder system also includes an interaction between the geriatrics and their caretakers. This reminder system includes Arduino UNO as the microcontroller, with the notification system, Blynk Application, a buzzer, and a light-emitting diode (LED) system. To make this reminder system more versatile, the buzzer will alarm during the medicine intake time, giving information to the elderly on which medicine to take. When the time has reached to take medication, the buzzer will produce a sound. Suppose the medicine box opens after the buzzer's sound and is detected by the passive infrared sensor (PIR sensor). In that case, the caretaker will receive a notification through the Blynk application that the geriatric already took medicine. On the contrary, if the medicine box is not open after 3 minutes following the buzzer's sound, which indicates that the geriatric did not take their medicine, the system will not send a notification to their caretakers on the status. This prototype is tested on ten users for its accuracy and effectiveness. It is believed that this system can provide geriatrics more alert in taking their medicine on time, enhancing their health status.

*Keywords*— Geriatric's health; medication adherence; geriatric medicine intake; automatic reminder system; notification system

## I. INTRODUCTION

Geriatrics is referred to individuals aged from 50 years old and above that require particular regard to their healthcare problem. They are also defined as aged individuals receiving special care to improve their lives [1]. This group of individuals is often involved with medicine intake in their daily life. Their medication needs can be due to various diseases, such as hypertension, diabetes mellitus, Alzheimer's, stroke, and others [2]. Statistic from recent studies shows that approximately 80% of elderly in the United States of American have at least one chronic disease, while 77% of them have two chronic diseases per individual. These diseases can cause almost death factors to the geriatrics every year. Meanwhile, diabetes and hypertension are common diseases associated with geriatrics, where 23% of Americans are affected by diabetes, and 90% of elderly Americans are at risk for hypertension [3].

According to [4], getting older means that we are more exposed to healthcare problems, and only 41% of elderly aged 65 are free from any diseases. According to this research, arthritis may be one of the illnesses people aged 65 contend with. Almost 49% of geriatric patients were affected by this disease, leading to body pain and low quality of life. According to the Centre of Disease Control and Prevention (CDC), heart diseases are the leading killer among those aged 65 and above, where 489,722 deaths were recorded in 2014 caused by heart diseases. Based on Federal Interagency Forum on Aging-Related Statistics, heart diseases affect 37% men and 26% women aged 65 and above. Alzheimer's disease has represented 92,604 deaths of individuals aged over 65 years old in 2014. Alzheimer's Association also reports one of nine geriatrics aged above 65, which constitutes 11%, has Alzheimer's disease. Still, since the diagnosis is difficult, it is hard to determine the precise number of individuals affected by Alzheimer's disease. CDC appraises that 25% of individuals aged 65 and above are affected by diabetes. As indicated by CDC, diabetes caused 54,161 deaths among individuals at age 65 and above in 2014.

As the medication intake for these various diseases becomes an essential part of geriatrics, medication intake always becomes a problem. Previous studies have found that many geriatrics do not consume the medicine as instructed by doctors accordingly [5]. Statistical report from the studies has shown almost 55% of geriatrics in the United States did not consume their daily medication routine as instructed by their doctors [5]. As the geriatrics mostly forget to consume their medication, they need constant care and attention from doctors, nurses, and family members to look after their daily medication routine. Geriatrics need special care and attention

because they cannot do everything independently, especially with health problems. Geriatrics need a person to remind them to take their medicine. However, not many doctors, nurses, or even family members can give full attention and commitment to them due to their daily routines, such as work [6]. This results in establishing a proper reminder system for the geriatrics to take their medication on time. Thus, an adequate medicine reminder system is invented for geriatrics. Besides, this reminder system will also alert geriatric patients about consuming which medicine at certain times. This innovation is helpful for geriatrics to take medication on time as well as boosting their health status. The medicine reminder system can also provide assurance for geriatric family members about their elderly medicine consumption.

Geriatrics are often associated with various health problems. The need for proper medicine intake is crucial for their daily life. However, some geriatrics are not aware of their medication intake time. Geriatrics are likely to forget to consume medication according to their schedule. For example, they forget what to take, when to take, and how the medication should be taken. Without proper care to the geriatric, they may get involved in something that can harm their health by not consuming their medicine correctly. Thus, this research's prototype development is helpful for them. Medicine reminders also help in consuming medicine to prevent wrong dosages. The market's existing product does not fulfill the need for a proper medicine reminder system for the geriatric. Most applications were not tested among geriatrics to take their medication on time [7]. Furthermore, the medication status cannot be detected by the application system. It is also difficult to ensure whether the geriatrics have taken the medication as instructed or not [8]. Thus, a medicine reminder system that can send a notification to the caretaker provides a complete need for geriatrics to take their medication on time.

Geriatrics need medication to improve their health and help them in their daily life [9]. Geriatrics require special care from their caregiver to monitor them in taking their medicine. Reminder to their daily medicine intake as instructed by doctors is essential for their health condition [10]. This study provides a system in improving the current medicine intake issue by the geriatric. This study introduces an alert system that can notify geriatrics to take their medicine on time and give the caretaker more efficiency in managing the medicine schedule. With a proper reminder system, geriatrics can boost their health and enhancing them.

## II. METHODOLOGY

The functionality of this project is to help geriatrics in taking their medicine at the exact time. This project also allows geriatrics to consume which medicine at a particular time. Overall, this automatic reminder system for geriatric medicine intake consists of two developments, which is hardware and software development, as shown below. In developing an accurate prototype functioning well, three stages were taken in this project, as shown in Figure 1. These stages include both hardware and software development as well as testing the prototype.

In stage 1, the circuit is designed, where the circuit of the prototype is developed. Few criteria are considered in designing the circuit to make it easier for geriatrics to use it. The hardware of the prototype has been created. Followed by stage 2, the study focuses on algorithm construction for the medicine reminder system software. In this stage, the algorithm is built carefully according to the circuit design to make it more accurate. In the last step, which is stage 3, the prototype was tested for its functionality according to the prototype's desired design and accuracy.
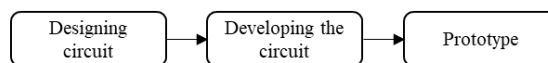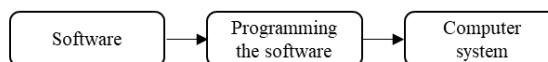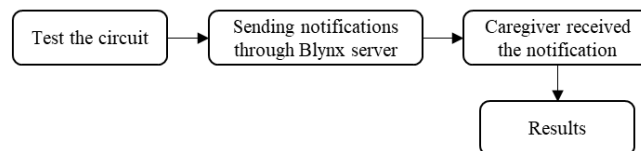


Fig. 1 Three stages of the workflow

### A. Circuit Development of Buzzer and Light Emitting Diode (LED)

In this project, few materials have been used in developing this automatic reminder system. These materials are classified into two: material for the output system and material for the detector. Note that the buzzer and LED have been used for the output system. When a geriatric is needed to take medicine, the buzzer produces the sound to remind the geriatric. Simultaneously, the medicine box's LED will blink to indicate which part of the medication should be consumed.
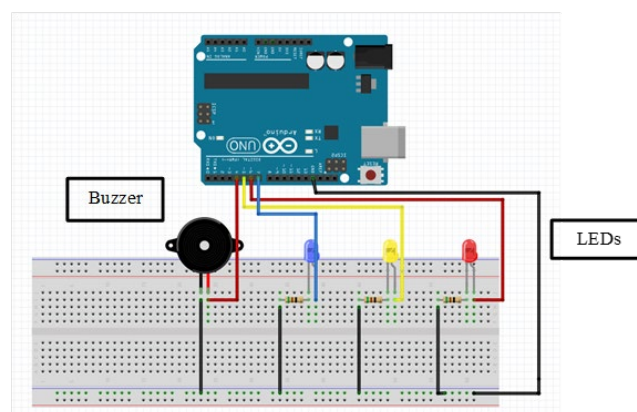


Fig. 2 Circuit connection for LEDs and buzzer

## B. Circuit Development of Passive Infrared (PIR) Sensor

PIR sensor (passive infrared sensor) is used as the main detector of this automatic reminder system. When the geriatric opens the medicine box, the sensor will detect the motion. As the motion is detected, the caretaker will receive the notification through the Blynk application that the geriatric already took medicine. If there is no motion detected at the medicine box, the notification will not be sent to the caretaker, indicating that the geriatrics did not take medicine.
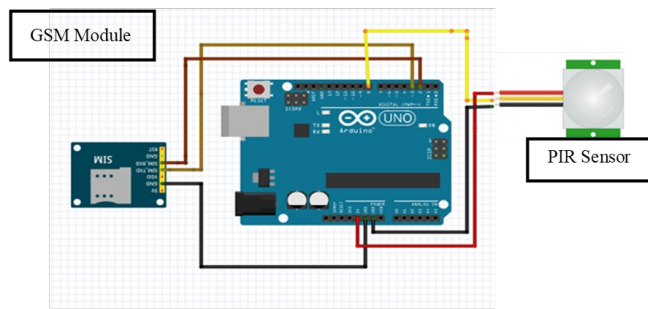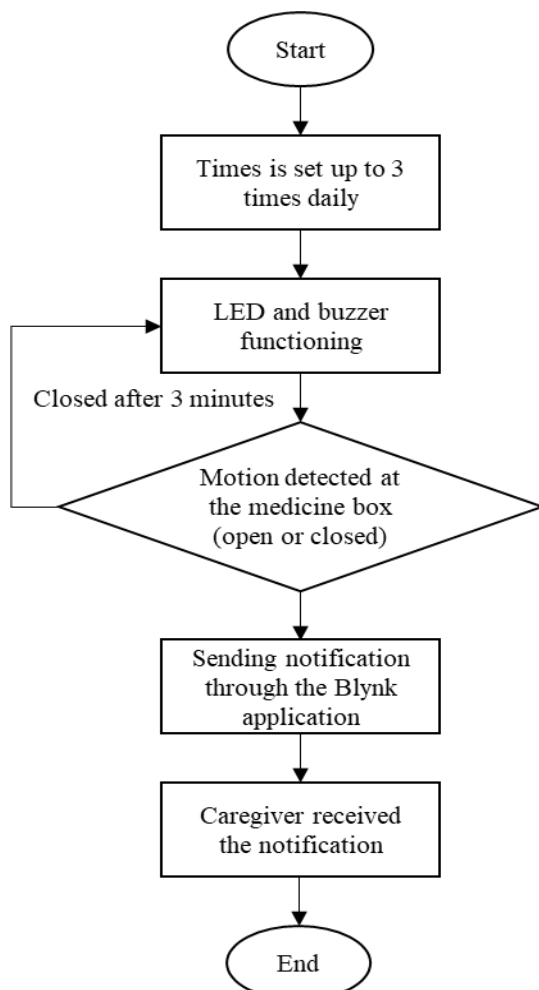


Fig. 3  Circuit connection of GSM module and PIR sensor

## C. Software Algorithm



The automatic reminder system is designed for users in the age group of 50 and above who always forget their medicine intake. The software that controls message flow is created using the Arduino IDE software and then transferred to the hardware board. The Arduino UNO's microcontroller is the main component in this project, controlling the whole system by associating it with all the hardware devices connected with it.

Even though the microcontroller acts as the main component of this project, an algorithm needs to be developed because the microcontroller will not function without proper software development. It will allow the microcontroller to send the input and respond precisely. In designing the medicine box software algorithms, few criteria are considered, including time taken to take medicine, medicine intake schedule, and medicine intake records. This medicine box is designed to help geriatrics in consuming their daily medicine intake. The software that conducts the message flow is designed on Arduino software using the C++ language and Arduino library, instructing the Arduino module to work as required. The flow process of the algorithm is shown in Figure 4.

## D. Working Principle of Automatic Reminder System

Many features were considered to develop the reminder system to authorize helping geriatrics take their medicine correctly. Geriatrics are likely to forget to consume the medication as scheduled by their doctors. To improve the medicine intake in the elderly, the automatic reminder system was beneficial to them.

Basically, the automatic reminder system consists of two outputs, a buzzer, and an LED, controlled by the microcontroller. The reminder system is set up to 3 times per day, 7 am, 3 pm, and 11 pm, ideal for taking medicine. The medicine box will produce a sound signal through the buzzer to remind the geriatrics to take medication at the prescribed time. Simultaneously, the LED at the medicine box will light up, showing which parts of medicine the geriatrics should consume at a specific time.

As the geriatrics open the medicine box to take medicine, the PIR sensor will detect the motion at the box's opening. When motion is detected, a notification will be sent to the caretaker through the Blynk application showing that 'medicine has been taken.' If the sensor detects no motion at the medicine box's opening within three minutes, the buzzer will also produce sound again. No notification sent to the caretaker indicates that the medicine is still not taken. By doing this, the caretaker can make a direct phone call to their geriatrics. The process will iterate continuously until the box is opened and the medication is taken.

## III. RESULTS

Several tests had been conducted to test the accuracy of the automatic reminder system. It should be tested to make sure that it can function well as expected. This section will show the results of the prototype that has been developed. The output from the reminder system is discussed with the results of both hardware and software development.

### A. Prototype Development

Hardware development of the automatic reminder system is tested to determine the accuracy of this prototype. This prototype's hardware development consists of the output system, which is a buzzer and light-emitting diode, LEDs.
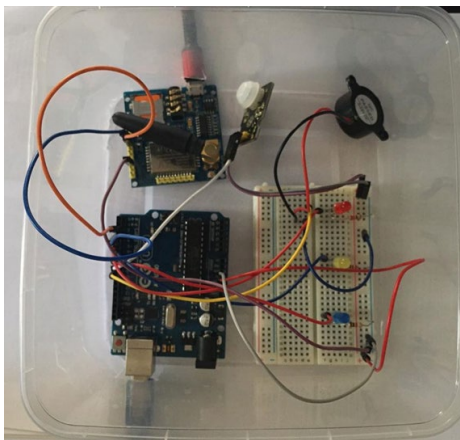


Fig. 5 Prototype development

### B. Buzzer

In this prototype, a buzzer is located at the medicine box. Generally, the time taken for geriatric to take medicine in this prototype is three times per day. When the geriatric's medicine time has reached, the medicine box's buzzer will produce a sound signal and alert the geriatric to take medicine. When the geriatric opened the medicine box, the buzzer will stop. If the geriatric did not open the medicine box in three minutes, the buzzer would sound again as a second reminder for the geriatric to take medicine.

### C. Light Emitting Diode (LED)

In this prototype, LEDs are also used as an alert for the geriatrics to take medicine. Three LEDs are used in this prototype, indicating three times per day for taking medication. The LED is located in different parts of the medicine box. When the time taken for the geriatric to take medicine has reached, the buzzer will produce a sound signal. At that time, one of the LEDs will also light up as a reminder for geriatric, showing which part of the medicine the geriatric should consume at a particular time.
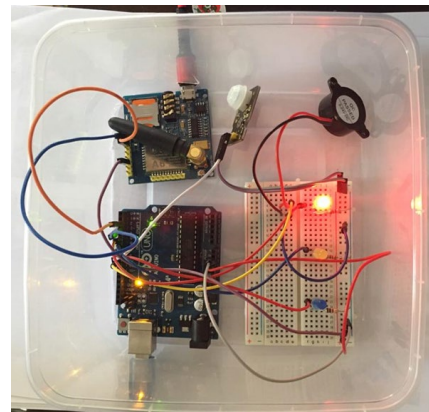


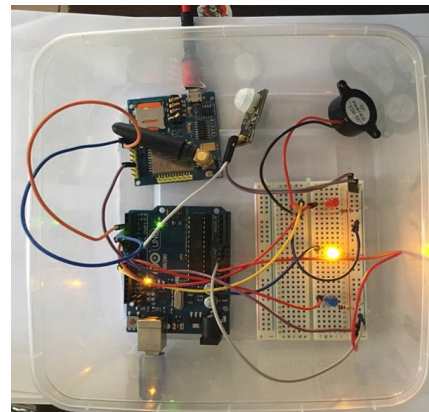Fig. 6 Red LED blink when the first time taken reached



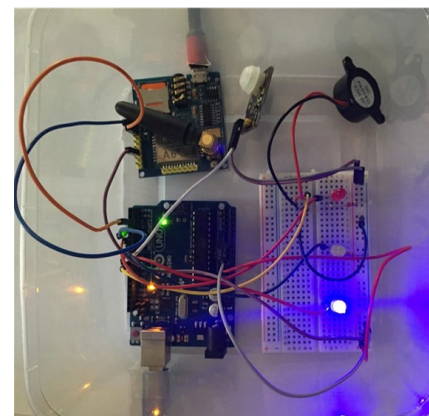Fig. 7 Yellow LED blink when the second time taken reached



Fig. 8 Blue LED blink when the third time taken reached

When the time taken to take medicine is not reached yet, the buzzer and LEDs will be in standby mode. However, when the time taken reached, the buzzer will start ringing, and the LEDs will light up. Table 1 below shows the function of the buzzer and LEDs in this automatic reminder system.

| Condition | Buzzer | LEDs |
|---|---|---|
| Time taken not reached | In standby mode | In standby mode |
| Time taken reached | Ringing | Light up |

### D. Passive Infrared (PIR) Sensor

PIR sensor is used as the motion detector and located at the medicine box. When a motion is detected at the medicine box opening, a notification will automatically send to the caretaker showing that the geriatric already takes medicine in the medicine box. On the contrary, if no motion detected by the sensor at the medicine box, no notification will be sent to the caretaker.

After the LEDs and buzzer functioning, the user, which is geriatric, will open the medicine box to take medicine. When the PIR sensor detects a motion at the medicine box, a notification message will be sent to the caretaker showing that the geriatric already takes medication. Table 2 shows the function of the PIR sensor and GSM module at certain conditions.
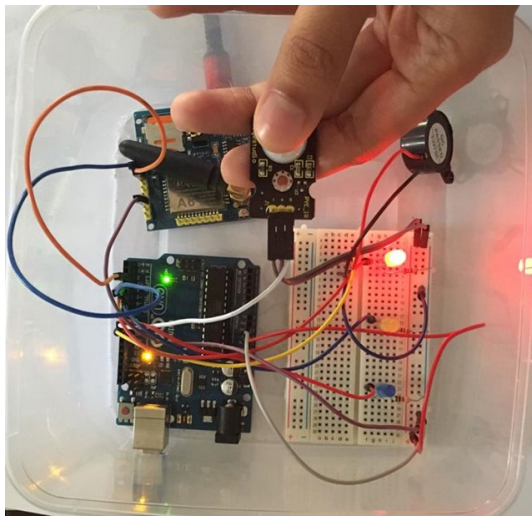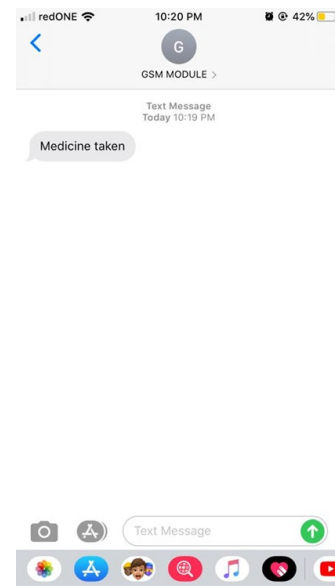


Fig. 9 Motion detected by PIR sensor



Fig. 10 Message received by the caretaker after geriatrics took the medicine

TABLE III
PIR SENSOR AND GSM MODULE AT CERTAIN CONDITIONS

| Condition | PIR Sensor | GSM Module |
|---|---|---|
| Box opened | Motion detected | Message sent to the caretaker 'medicine taken' |
| Box closed | No motion is detected | No message will be sent to the caretaker |

### E. Accuracy Test

To test the accuracy of this developed prototyped, this prototype is tested on ten subjects and the results show promising applicability to geriatric. Table 3 presents the results of the accuracy test of the ten subjects.

## IV. DISCUSSIONS

The prototype is used as an alarm system to remind the geriatric in medicine intake. The buzzer will ring, and the LEDs will light up when taking medicine is due. When the geriatrics open the medicine box, the PIR sensor detects the motion, and a message will be sent to the caretaker through the GSM Module. This indicates that this reminder system provides an interaction between the geriatric and the caretaker. The prototype is travel-friendly for the geriatric since it only weighs around 80g.

The automatic reminder system's accuracy is 90% because some tested subjects did not open the medicine box when the LED and buzzer are functioning. This might be caused by the geriatrics who did not open the medicine box because they forgot to consume the medicine even though the

reminder system exists. However, a few limitations also occur in this prototype, causing the geriatric to forget taking medication.

The first limitation is that the PIR Sensor becomes less sensitive after tested on a few subjects. When the geriatric opened the medicine box, the PIR sensor did not detect the medicine box's motion. Thus, no message was sent to the caretaker even though the geriatrics already consume the medicine.

The second limitation involves convenience, where the buzzer's sound is not too loud to some deaf geriatrics. The Arduino IDE software can control the sound of the buzzer. To overcome this limitation, the reminder system's buzzer should be set at a high pitch so that the geriatric can hear the buzzer. Other than that, two buzzers can be placed near the geriatric.

TABLE IIIII .

THE ACCURACY TEST ON 10 SUBJECTS

| Subject | 7am | 3pm | 11pm |
|---------|-----|-----|------|
| 1 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 2 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 3 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 4 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 5 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box closed<br>Message unsent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 6 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 7 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 8 | Buzzer ringing<br>LED light up<br>Box closed<br>Message unsent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 9 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent |
| 10 | Buzzer ringing<br>LED light up<br>Box opened<br>Message sent | Buzzer ringing<br>LED light up<br>Bix opened<br>Message sent | Buzzer ringing<br>LED not light up<br>Box closed<br>Message unsent |

The accuracy of the automatic reminder system is

$$\left(\frac{27}{30}\right) \times 100 = 90\%$$

## V. CONCLUSIONS

Many technologies had been developed using the Internet of Things (IoT), positively impacting life. This can be seen by developing an automatic reminder system that alerts geriatrics and helps them take their medicine. This automatic reminder system is one of the best initiatives to help caretakers monitor geriatric medicine intake. At the same time, geriatrics will become more comfortable staying at home with an alert system rather than moving to the healthcare facility and giving the caretaker more assurance about their elderly behaving from time to time. This system helps geriatric to take their medicine at the correct time that can increase health.

This project aims to develop versatile hardware and software that can help geriatrics in taking their medication. The development of a medicine reminder system can have a significant impact on geriatrics life. This proposed project can help geriatrics taking their medicines according to the schedule set by the caretaker. Hence, this study can provide new technology for the geriatrics group regarding their medicine intake, thus improving their life quality in the future.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

## REFERENCES

[1] Netuveli, G., & Blane, D. (2008). Quality of life in older ages. British Medical Bulletin, 85(1), 113–126.

[2] Vijayan, M., & Reddy, P. H. (2016). Stroke, Vascular Dementia, and Alzheimer's Disease: Molecular Links. Journal of Alzheimer's Disease : JAD, 54(2), 427–443.

[3] Khalil, A., Nizar, M. H. A., Anis, S., & Lai, K. W. (2018, December). Clinical Trial of a Digital Scoliometer Device for Scoliosis Diagnosis. In 2018 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES) (pp. 102-107). IEEE.

[4] Madeline R Vann, M., & Pat F. Bass, MD, M. (2014). The 14 Most Common Health Concerns for Seniors - Everyday Health.

[5] Marek, K. D., & Antle, L. (2008). Medication Management of the Community-Dwelling Older Adult.

[6] Yap, A. F., Hons, P., Thirumoorthy, T., London, F., Kwan, Y. H., & Hons, P. (2016). Journal of Clinical Gerontology & Geriatrics Medication adherence in the elderly. Journal of Clinical Gerontology & Geriatrics, 7(2), 64–67.

[7] Yared, R., & Abdulrazak, B. (2016). Ambient Technology to Assist Elderly People in Indoor Risks. Computers, 5(4), 22.

[8] Vinjumur, J. K., Becker, E., Ferdous, S., Galatas, G., & Makedon, F. (2010). Web-based medicine intake tracking application. In Proceedings of the 3rd International Conference on PErvasive Technologies Related to Assistive Environments - PETRA '10 (p. 1). New York, New York, USA: ACM Press.

[9] Chutka, D. S., Takahashi, P. Y., & Hoel, R. W. (2004). Inappropriate Medications for Elderly Patients. Mayo Clinic Proceedings, 79(1), 122–139.

[10] Gray, S. L., Mahoney, J. E., & Blough, D. K. (2015). Medication Adherence in Elderly Patients Receiving Home Health Services Following Hospital Discharge, 35, 539–545.

[11] Haghighi, P., Gaber, M., Krishnaswamy, S., & Zaslavsky, A. (2007). An architecture for context-aware adaptive data stream mining. Proceedings of the International Workshop on Knowledge Discovery from Ubiquitous Data Streams (IWKDUDS07). IWKDUDS.

[12] Hayes, T. L., Hunt, J. M., Adami, A., & Kaye, J. A. (2006). An Electronic Pillbox for Continuous Monitoring of Medication Adherence. In 2006 International Conference of the IEEE Engineering in Medicine and Biology Society (Vol. 1, pp. 6400–6403). IEEE.

[13] Oster, S. P. (1996). Elderly patients' problems with medication, 255–256.

[14] Pollack, M. E., Brown, L., Colbry, D., McCarthy, C. E., Orosz, C., Peintner, B., … Tsamardinos, I. (2003). Autominder: an intelligent cognitive orthotic system for people with memory impairment. Robotics and Autonomous Systems, 44(3–4), 273–282.

[15] Tang, L., Zhou, X., Yu, Z., Liang, Y., Zhang, D., & Ni, H. (2011). MHS: A Multimedia System for Improving Medication Adherence in Elderly Care. IEEE Systems Journal, 5(4), 506–517.

[16] Wan, D. (1999). Magic medicine cabinet: A situated portal for consumer healthcare. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 1707, 352–355.

[17] Wan, J., Zou, C., Ullah, S., Lai, C.-F., Zhou, M., & Wang, X. (2013). Cloud-enabled wireless body area networks for pervasive healthcare. IEEE Network, 27(5), 56–61.