A Prototype Device that Implements RFID and Remote Monitoring Technology to Track Medications for Elderly Healthcare Patients

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Abstract

Many elderly people require assisted living facilities because they are not able to independently manage their complex medication regimens. This restricts their ability to live independently and places a considerable burden on caregivers and the healthcare system in general. A system that implements RFID identification and remote monitoring technology to keep track of complex medication schedules can enable them to live independently while eliminating medication errors and reducing the burden on the healthcare system. The research presented concerns the development of a marketable device that will perform two essential functions: (1) to provide notifications to the user as to when medication is to be taken, and (2) to provide passive monitoring of the user's compliance to a remote caregiver. The device will be marketable because it features an intuitive user interface and can be easily integrated into the current healthcare infrastructure.

Objective

The prototype device developed in this project implements RFID identification and remote monitoring technology to manage complex medication schedules. This allows otherwise unable healthcare patients to live independently while eliminating medication errors and reducing the burden on the healthcare system.

Introduction

A large percentage of elderly healthcare patients fail to comply with their prescribed medication schedules. This can result in hospital and nursing home admissions, serious injury, or death. It is difficult for some patients to adhere to intense medication regimens because the prescribed schedule may be too complex, or the patient may be forgetful. We are attempting to solve this important issue by researching and developing an intelligent medication monitoring and notification system that will enable patients to follow prescribed medication schedules with minimal effort. This will enhance the lives of older adults and enable independent living.

The growing need for in-home healthcare devices is best described in [1] as the population growth of retirement-age Americans is projected and compared against that of working-age Americans. It is shown that in less than ten years, the current healthcare infrastructure will become overloaded and inevitably fail. Other authors support the implementation of more in-home healthcare technology at the present time because it greatly increases the efficiency of caregivers and lowers healthcare cost. This cost not only includes money, but also the burden to caregivers, many of which are volunteering friends or family members.

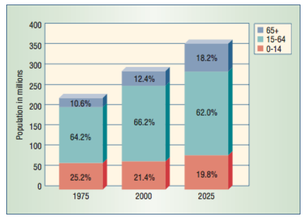

Figure 1: Projected Population Growth Emphasizing Age Group[1]

Unlike previous work, our device relies on prescription schedule information encoded into an RFID tag and attached at the patient's pharmacy. This information will be readily available considering it is a subset of the information concurrently printed on the label. This will allow the system to be easily configured by the patient simply by placing the new medicine container on the device. Our design also implements additional features such as the ability to dispense individual medicine containers and the ability for a caregiver to monitor patient compliance from a remote location using a network connection.

Overall, this project fills in many of the gaps of previous work and provides a practical means of in-home medication monitoring and notification using current technology. Once we finish prototype development, the design will be tested, optimized, and eventually redesigned for mass production. The final device will be easily deployable because the only change it requires from the medication industry is the implementation of a low cost RFID writer at the pharmacy.

Related Work

The system developed in this project is an extension of research discussed in [2] and [3]. The system presented in [2] requires the user to input medicine dosage information into a device using special electronic cards. The medicine container is then attached to a corresponding RFID tag and stored on top of the device. The system can then notify the patient when medicine is to be taken and show any necessary information on an external graphical display. It also uses a weight sensor to check that medicine has actually been taken. This system is further developed by different researchers in [3]. The revised system is separated into three wireless modules, the medicine platform, the user interface, and the patient notification device. This improvement allows easy expansion of the system and mobile notifications. The author does not mention how medicine dosage information is to be scanned into the system.

Figure 2: Similar Device Developed by Intel Research[2]

Figure 3: Similar Device Developed by Fujitsu Research Labs of America[3]

Methods

The goal of this research is to determine if a device can be developed that will eliminate personal medication errors and reduce the load on the healthcare system while enabling patients to live independently. We attempt to satisfy this by developing an appropriate prototype device. The following operation procedure demonstrates the device features.

1. When the system is powered on, it will attempt to load data from persistent memory. It will then scan in any medicine containers currently on the main surface and merge that data with the data from persistent memory. The system will then alert the caregiver of any missed dosages during the downtime.
2. When a new medicine container is placed onto the main platform of the device, the software recognizes the new container by scanning its embedded RFID tag. It will then interpret the medicine's dosage information from the RFID tag data and input it into the system.
3. When a medicine dosage is to be taken, the software activates an audible alert and rotates the correct container to the area above the scale for the user to take. It provides the user with instructions concerning the correct dosage amount and waits for the container to be placed back on the scale section to be reweighed.
4. If the medicine was taken correctly, the software checks if any other medicines need to be taken. If more medicine needs to be taken to complete the dosage, the system will prompt the user. If too much medicine has been taken, the system will alert the caregiver and continue normal operation.

In addition to the LCD display, the user interface panel also includes LED status indicators for power, busy, and notification. It also includes the following three buttons:

- **Refuse:** If a notification is to be ignored, the user can press the refuse button upon notification and the software will dismiss the notification and alert the caregiver.
- **Remove:** If a bottle is to be permanently removed from the system, the user can press the remove button upon notification and the software will discontinue alerts for the medicine that has been removed and alert the caregiver.
- **Reset:** If the user presses the reset button, all medicine information will be lost and the system will have to rescan each of the medicine containers back into the system.

Contributions

The following contributions will add to the small amount of previous work published in this category:

- A system will be developed that will allow healthcare patients to comply with complex medication regimens without the active assistance of a caregiver.
- The device that is built to implement the system will be designed in such a way that it will be marketable to anyone who takes medicine on a predefined schedule.
- All hardware and software design components associated with the device, including source code, will be published so that the device can be reproduced and further development can be done.

Results

Currently, we are completing prototype construction. The following figures represent the prototype design that is the result of our research thus far.

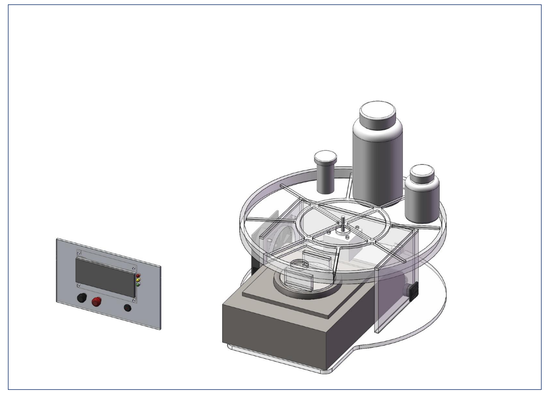

Figure 4: SolidWorks® Assembly Model of Prototype Device (Trimetric View)

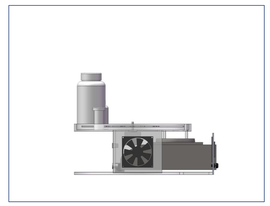

Figure 5: SolidWorks® Assembly Model of Prototype Device (Left Side View)

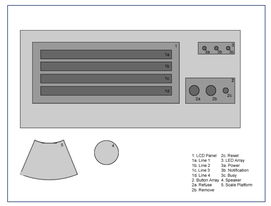

Figure 6: User Interface Concept Design

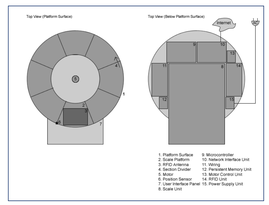

Figure 7: Hardware Concept Design

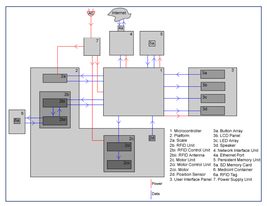

Figure 8: System Architecture Block Diagram

Conclusions

Our system expands on previous research in order to develop a device that is more useful by including the following four necessary features: (1) Both previous devices require the user to manually enter schedule information into the device, a task too critical to leave to an elderly patient. Our design will include schedule information on the embedded RFID tag that can be input into the system simply by placing the medicine container onto the device. (2) The device mentioned in [3] is unnecessarily split up into three dependent wirelessly communicating modules, one of which is linked using immature long-range RIFD technology. Although this increases expandability, the added complexity reduces reliability, which is unacceptable for such a critical device. Our design will be one piece. (3) Both devices incorporate a scale to check that medicine has been taken, but neither use it to check that the proper amount has been taken. Our design will check that the proper amount of medicine has been taken by measuring the medicine before and after consumption, and comparing the difference with the proper dosage. (4) Neither device includes a mechanism to alert a remote caregiver if the patient becomes noncompliant. Our design will incorporate a network connection in order to notify a remote caregiver when attention is necessary.

The successful implementation of the system described will accomplish our objective statement. Enabling independent living for patients who would otherwise be required to enroll in assisted living facilities gives them more freedom while increasing their safety and reducing their cost. This system will also benefit professional and volunteer caregivers by allowing them to passively monitor medication compliance, and more efficiently use their time.

Future Work

Future work should include a clinical trial in which critical feedback from users will determine the next stage of the project. The system should be redesigned until it is considered usable, reliable, and deployable. In addition to testing, the feasibility and value of a patent for the final device should be considered.

References

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2. Fishkin, K. and M. Wang, A Flexible, Low-Overhead Ubiquitous System for Medication Monitoring. Rep. no. IRS-TR-03-011. Seattle, WA: Intel Corporation, 2003.
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