

Supervision of Behaviour and Position Sensuous System for People having Mild Cognitive Impairments

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Abstract— The prevalence of disorders causing cognitive impairment is rising, primarily as a result of population aging and longer life expectancies. People having mild cognitive impairments or those in the advance stages of dementia may be able to long lasting life, better independently, and in a more secure environment at home with the use of sensory and monitoring devices. This work describes a wearable-based wireless sensor network (WSN) that gathers step and position data both indoors and outdoors and reports it over a long-range wide area network (LoRa WAN).

The measured data from each wireless wearable sensor (WWS) is transmitted over a long-range (LoRa) radio link with minimal power consumption. An accelerometer is used for a step detector algorithm, indoor room-level localization system based on infrared sensors, in addition to which an outdoor positioning module of the global navigation satellite system (GNSS) is employed. Caretakers and medical services can access these sensory data through an easy-to-use internet application that is stored in a database. In situations when a patient may be disoriented, this can be used to identify unusual alterations in the patient's regular routine and to determine the user's location. Caregivers' smartphones are also equipped with warnings that sound when a potentially dangerous circumstance arises, such the outpatient leaving a designated region or being in one spot for an extended period of time. Because it helps identify behavioral changes and maintains caregivers' peace of mind, the suggested sensuous system can do assist and extend the period of time that patients with MCI or those in the early stages of dementia can live independently.

Index Terms— Mild cognitive impairments (MCIs), Indoor positioning, Infrared sensors, Long-Range Wide area Network (LoRa WAN), Step detector, Wireless Sensor Network (WSN).

I. INTRODUCTION

Rising life expectancies and declining birth rates are the main causes of the world's population aging drastically. It is projected that over the next thirty years, the number of elderly people (those 65 and older) would more than double, to reach over 1.5 billion by 2050.

Dementia and other disorders are growing significantly more widespread in tandem with this growth. About 55 million people globally suffer from dementia, which is ranked as the fifth most prevalent cause of death. In most developed countries, it also plays a significant role in the development of dependency, affecting the physical, mental, social, and financial health of both patients and caregivers. Indeed, research shows that scaring people is linked to higher levels of stress, anxiety, and depression.

Dementia and other Srividya P ECE Osmania University UCEOU Hyderabad, India line 5: email address or ORCID cognitive diseases are also frequently associated with hospitalization and institutionalization, which suggests a further strain on the durability viability of public wellness technics and solutions. This situation, lowering the number of hospital admissions through the use of monitoring and technology in the homes of the patients may enhance both their and their caregivers' quality of life while lowering the cost of treatment.

Evaluating dementia patients' performance on fundamental, everyday tasks activities that the majority of healthy individuals can execute on their own is a crucial part of their medical follow-up. The incapacity to perform these tasks, commonly known as activities of daily living (ADL), is one feature of dementia that causes a progressive loss of independence and increases the strain on caretakers. As long as ambient-assisted living (AAL) solutions are applied carefully, compassionately, and ethically, information and communication technologies (ICT) have a great deal of promise to enhance the criterion and keep track of patients' ADLs. Human activity recognition, or HAR, is made possible by utilizing ICTs for indoor and outdoor real-time tracking, positioning, and physical activity surveillance. HAR can identify behavioural changes in patients or episodes of disorientation and notify medical services or caregivers in case of these situations. Caregivers can rest easy knowing that their patients in the early phases of cognitive decline are improving their independence, mood, and social functioning thanks to this supervised autonomy.

A persistent link between health care recipient, caretakers, and brilliant objects carried by the patients or placed throughout the environment should define ICT-based AAL solutions. This has the potential to create wireless sensor networks (WSNs) key that awareness for individuals with intellectual disability by utilizing the ability of IoT technologies. Patient data can be calculated and gathered for inspection, to notify caretakers. Whether they are carried by users, installed in robots, or deployed in the environment, IoT cameras can be used to supervise, track, and help dependent individuals. Cameras are invasive, though, so people tend to disregard them. Wireless wearable sensors (WWSs) are the foundation of one of the most popular and least invasive IoT sensory systems in this area. With the ability to measure, track, and evaluate a patient's precise location in any setting including their home and to support their autonomous daily life, these technologies hold great promise for treating multiuser HAR.

Global navigation satellite system (GNSS) sensors, which are widely available in commercial devices and enable the detection of potential disorientation, are one of the many sensuous technologies that wearables can unite. This allows for outside tracking. However, no equivalent well-established method exists for indoor tracking. RF methods based on received signal strength (RSS) are the most widely used approach with wearable devices. Some of the other technologies that could be used are cameras, acoustic signals, RFID, ultrawideband, visible light, IR, or other options with different levels of precision. In addition to patient tracking, one other crucial component is the physical actions observation that inertial sensors may provide.

However, additional technologies like cameras, acoustic signals, RFID, UWB, visible light, IR, or other possibilities by varying degrees of precision could also be engaged. Apart from patient tracking, another crucial element is a potential method of tracking physical activity by employing inertial sensors. Regular exercise enhances mental clarity and motor skills, reduces psychological symptoms, and enhances overall quality of life for individuals suffering from cognitive impairments.

II. LITERATURE SURVEY

- RF technologies grounded in RSS, like Bluetooth or WiFi, are widely used in wearable devices as one of the most popular indoor localization options. These systems are inexpensive and simple to implement, but their usage in wearables is limited by the high-power consumption of continuous RSS scanning. Moreover, a lot of these solutions are frequently imprecise and depend on machine learning (ML) techniques to determine the user's position, which adds another difficulty when managing power consumption and real-time operation.
- There are further RF-based options available for these kinds of systems. RFID technology is applied to a surveillance system by Lin et al, with the placement of tags in both indoor and outdoor areas as part of their proposed sensory system. When an elderly person goes too far or reaches a risky place, the technology can automatically alert caregivers. NOTECASE is an additional use case that combines RFID technology using a wearable GPS receiver to provide an instantaneous monitoring mechanism to watch old persons both within and outside. Caregivers can access data using both online and mobile applications, although the system's range is limited by WiFi-based connections.
- More accurate people tracking estimates are provided by UWB solutions. By calculating the arrival times connecting the beacons to the receiver for subsequent multiple latency, and by utilizing the dispersion of

certain encoded beacons, the NITICS system makes it possible to determine what the patient's location coordinates are in interior situations. The accuracy achieved by this idea is less than one meter. In fact, UWB allows for higher accuracies (10–30 cm). However, in order to enhance performance, several studies combine UWB with other technologies, like fusion filters are used in BLE or inertial navigation systems.

- One more way to track and monitor users is by using motion sensors, such as magnetometers, gyroscopes, and accelerometers. By combining how far walked throughout the exercise changing and the pose calculated from the magnetometer, they are employed in to identify ADLs. Here, machine learning methods are used to identify the user's present behaviour.

III. SYSTEM ARCHITECTURE

Every room or area in the monitored patient's house or care facility has a unique coded infrared beacon deployed. Every patient's WWS picks up the IR signal and uses it to locate the room that corresponds with the broadcasting beacon. As a result, it is possible to determine the patient's precise location inside the room. Additionally, the WWS has a GNSS receiver built in that allows users to get their position outside. All of these data are sent through LoRaWAN at a frequency to a gateway of 868.9 MHz, along with the user's steps, the battery's state, and the surrounding data. And, the data is uploaded to the cloud. This data is gathered by an application server, which also stores it in a database for web service playback and, in specific situations, sends alarms to caregivers. It should be noted that an infinite number of users can be watched at once, each with a separate wearable that can determine a person's location and activities. The hardware component specifications for this design are covered in full below.

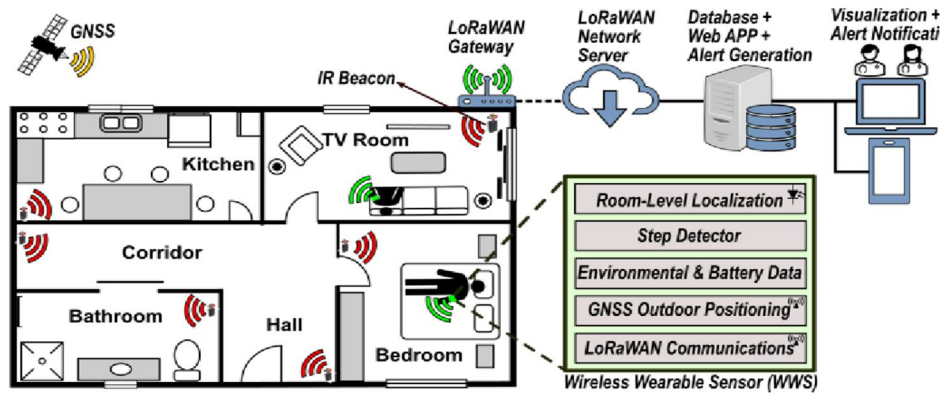


Fig. 1. System architecture

A. IR Beacons

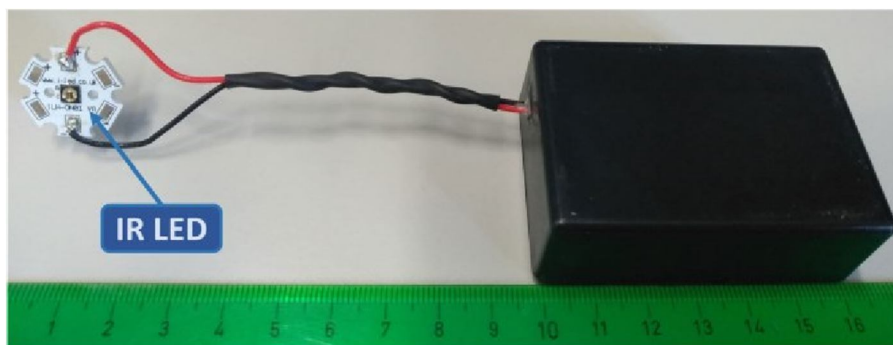


Fig. 2. IR emitting beacon packing

The ESP32-PICO-D4 system-on-chip (SoC) is the beacons' primary component and produces a 4-bit PWM signal more than a general-purpose input–output (GPIO) port. An IR led is driven by this PWM signal via a resistor. Given that it could be fascinating to own varying powers according to the area that has to be located, The beacons' individual emission powers can be modified Considering the resistor's value. To avoid interfering with one another, it might be wise to transmit at a low level in two nearby tiny rooms. However, in vast, isolated rooms, Well, it is preferable to produce a stronger emission.

B. Description of the WWS

The RAK5205 commercial board serves as the foundation for the WWS prototype, to which an IR receiver module and an external battery have been added. The transmissions are enabled by this receiver. Released by the beacons to be detected, and after processing them, it will be feasible to determine where the user is located. However, as the device possibly operate for up to 24 hours without requiring.

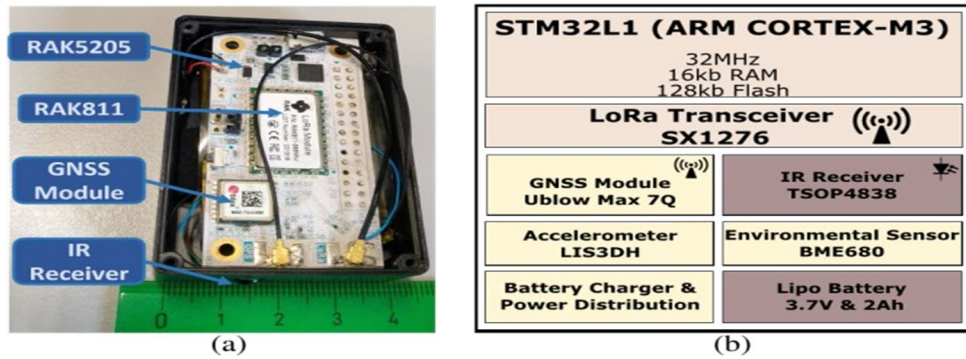


Fig. 3. Basic view of WWS

C. LoRa gateway Arrangement

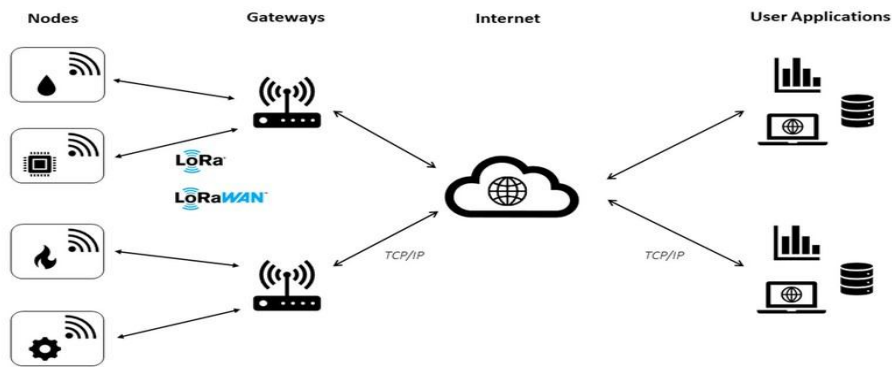


Fig. 3. LoRa Gateway

The built-in LoRa module, which controls the physical communication layer, transports the sense information gathered through the previously listed blocks to a gateway via the LoRaWAN. Through standard IP connections, that gateway acts like a clear span, sending communications to a network server from the wearables. It does this by translating IP packets into LoRa packets and vice versa. The gateway that is utilized. It is made to be deployed outside and has a range of 3 km in urban areas and 10 km in rural regions.

IV. METHODOLOGY

The accessory device software, the IR beacon applications for room-level localization, and the high-level utilization assistance for data management, alert generation, and visual appeal are the three software. The code connects to the Gateway, initializes all of the sensors, and puts the ARM in an idle state. It receives data from the sensors, produces the payload, and delivers it via LoRaWAN. It is programmed to awaken every ten seconds by a timer. A service interruption protocol that is triggered when the IR receiver module is activated processes the IR code from that the beacons, updating the details of the code and processing incoming IR signal. The GNSS module is used to determine the position if the WWS is not in any rooms and no code is retrieved. This could indicate a problem if some rooms are not beaconed, which would lead to a considerable mistake in the GNSS position because of indoor signal attenuation. The final location transmitted in this case is marked as unknown since the GNSS apparatus might in fact unable to acquire a point of area. Lastly, the number of steps that the step detector algorithm estimates is also sent, together with the battery level and ambient sensor data. For the purpose of clarity, this step detection method, application services, as well as the symbolic localization system are all detailed below in detail.

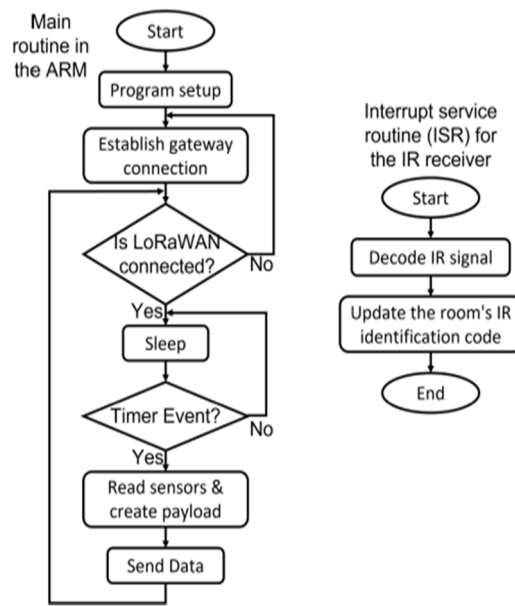


Fig. 4. Flow chart task implementation

This system transmits data from wireless wearable sensors (WWS) using low-power LoRa (Long Range) radio technology, which extends battery life and makes it suitable for long-term use. The system, which includes an accelerometer for step detection, infrared sensors for inside localization, and a Global Navigation Satellite System section for outside placing, allows full monitoring of the user's location and activity in varied contexts. The collected data is communicated in real time over a LoRa WAN to a central database, which caregivers and medical services can access via an easy-to-use online application. Caregivers also receive fast notifications on their cell phones in potentially harmful scenarios, such as when the patient leaves a defined location or spends too much time in one location, which improves the user's safety and provides peace of mind. Furthermore, the system can detect odd alterations to the patient's daily schedule, providing insight into behavioural patterns that may signal cognitive deterioration and enabling early intervention. This sensory system improves the quality of life Among individuals with MCI or preliminary delirium by enabling them to live freely and reducing the strain on healthcare systems.

IV. RESULTS

A. Steps taken over a day

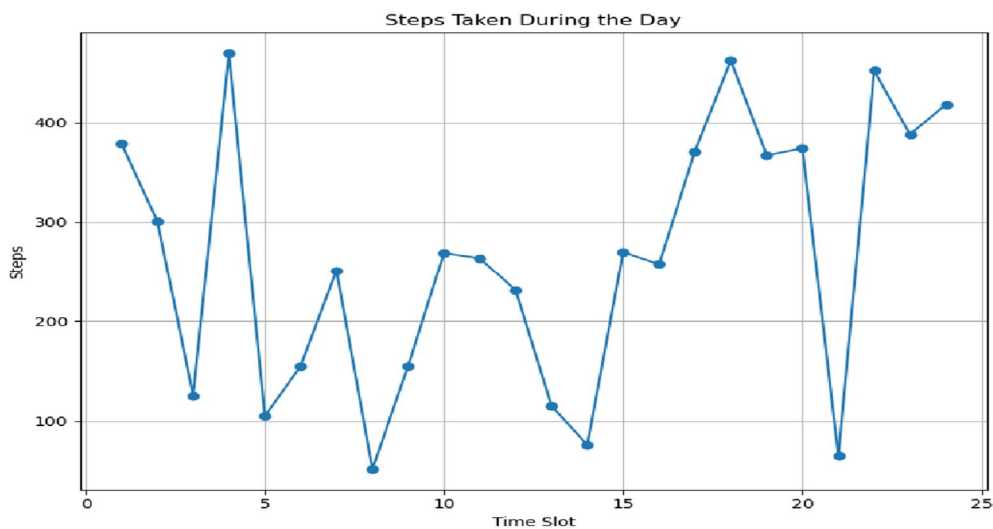


Fig. 5. Step count during a day

The first visualization is a line graph that tracks the number of steps taken during each hour of the day, represented by 24 time slots on the x-axis. The y-axis shows the number of steps taken in each time slot, with the data points connected by a line to depict trends in physical activity over time. This graph provides a clear and detailed view of how activity levels fluctuate throughout the day, potentially identifying peak periods of movement, such as morning or evening routines, and periods of lower activity. Such information is valuable for understanding daily behavior patterns, allowing for the optimization of personal schedules, fitness routines, or even workplace productivity strategies.

B. Routes taken over a day

Identified as "Test 1," "Test 2," and "Test 3," the second visualization is a bar chart that contrasts the quantity of routes traveled over three distinct days. The graph provides a clear comparison that illustrates the differences in activity between different days. Each bar in the chart reflects the total number of routes taken on a given day. This may be especially helpful in situations when the objective is to monitor adherence to movement protocols, check routine consistency, or study how various variables affect activity levels. This chart, for instance, could be used in a study setting to ascertain if variations in physical activity are caused by changes in the environment or by interventions.

Fig. 6. Routes taken by the patient

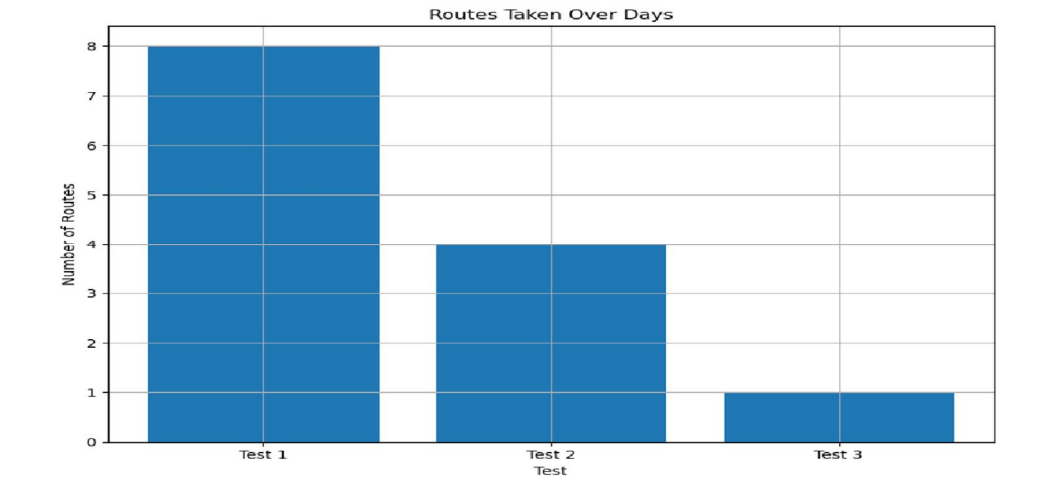


Fig. 6. Routes taken by the patient

C. Occupancy Percentage in Different areas

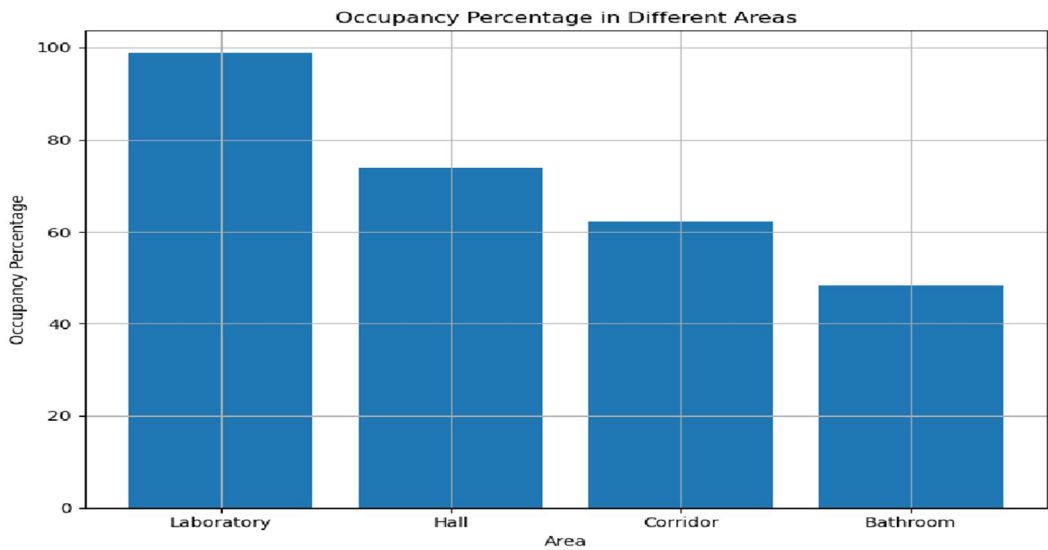


Fig. 7. Occupancy percentage

The Laboratory, Hall, Corridor, and Bathroom are the four separate locations within a facility where the occupancy % is displayed in the third visualization, which is another bar chart. The areas are listed on the x-axis, and the percentage of time that each area was occupied is displayed on the y-axis. This diagram shows which regions are most frequently used and which are underutilized, giving insights into how various locations are used. Facility managers need to know this information since it can help with decisions about resource allocation, space planning, and even energy management. Less utilized spaces might be repurposed or scheduled for maintenance without creating considerable disturbance, while heavily occupied areas might require more frequent cleaning or could be candidates for space optimization.

When combined, these visualizations create an extensive dataset that may be applied to several analytical tasks. The route comparison chart shows differences in travel across days, the step count graph sheds light on patterns of daily physical activity, and the occupancy chart gives a clear picture of how much space is being used within a facility. Making data-driven decisions that optimize resource utilization, increase productivity, and improve general well-being can be greatly aided by these visual tools. The information gained from these visualizations can be applied to facility management, workplace optimization, personal fitness tracking, and other areas where significant changes could be made.

VI. CONCLUSION

The system Concludes WSN for wearing a WWS to monitor the location and activities of patients with MCI, such as those with early-stage dementia. A WWS prototype has been created for this reason, utilizing a commercial board. The wearable is equipped with an accelerometer to calculate the patient's movements with a suggested method that is additionally described, a GNSS module for outdoor positioning, and an Infrared reception module for inside room level positioning. Information is transmitted both indoors and outdoors using LoRaWAN connections. By placing IR coding beacons in every area of the home, room-level sensor localization is accomplished. The wearable's IR receiver module detects the periodic sequences from the beacons and decodes them to estimate the location. With minimal power consumption, a 24-hour battery life, and LoRa coverage, using LoRaWAN enables allowing the patient to roam around freely within and outside of within the house without needing extra connectivity. An easily navigable web application makes it possible to assess how the patient's routines have changed over time. by displaying the sensory data over time. Additionally, alarms about the patient's potential risk can be sent to the caregivers' cellphones. Thus, the suggested WSN promotes additional monitoring conducted by the health services, gives caregivers peace of mind, and improves self-sufficient living for several individuals with cognitive illnesses in their early stages.

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