Futuristic Integrated Assistive System for Elderly Population of India

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Abstract—Elderly population in the world is rising fast and the rise is even faster for India due to the continuous rise in life expectancy. Delivery of health services to the elderly Indian population in rural areas, which is about 80% of the total elderly Indians, is a big challenge. An effective solution to the problem lies in developing assistive systems and devices based on modern technologies and designed to support or assist the elderly persons in having healthy, comfortable and dignified life in the society. This paper presents major challenges of elderly people. Some of the major research works already carried out on assistive systems and devices are summarily reviewed. Some further assistive systems/devices are proposed and desirable features for them are suggested. Novel concept of integrating the proposed assistive systems/devices into a single integrated system to serve the elderly users better is presented.

Keywords—Elderly, Assistive devices, Assistive systems, Assistive technologies, Embedded systems, Assistive robot, Wireless body area network

1 Introduction

The population of elderly people is getting considerable attention in the 21st century, especially in regard to the problems faced by them and to the possibility of using assistive technologies, systems and devices to mitigate the same. Between 2015 and 2030, the number of people aged 60 years or above in the world is projected to grow by 56 per cent, from 901 million to 1.4 billion [1]. From table1, it can be seen that the growth of elderly population during the period 2015 to 2030 is low (25.6%) for highly developed countries and high (70.6%) for less developed countries of the world. For Asia, the growth is not going to be as high as that for the less developed countries, but will much higher than that for the highly developed countries. The growth of elderly population in various continents, projected over the period of 1980 to 2050, is shown in fig.1 [1]. The number of elderly people and their growth rate are expected to be the highest for Asia. According to this report of United Nations, ageing of the population is a significant product of demographic transition.

Table 1. Elderly Population Above 60 Years[1]

Area	Population in 2015 (millions)	Population in 2030 (millions)	Percentage Change
Highly developed countries	298.8	375.2	25.6
Less developed countries	602.1	1027.2	70.6
Asia	508	844.5	66.3

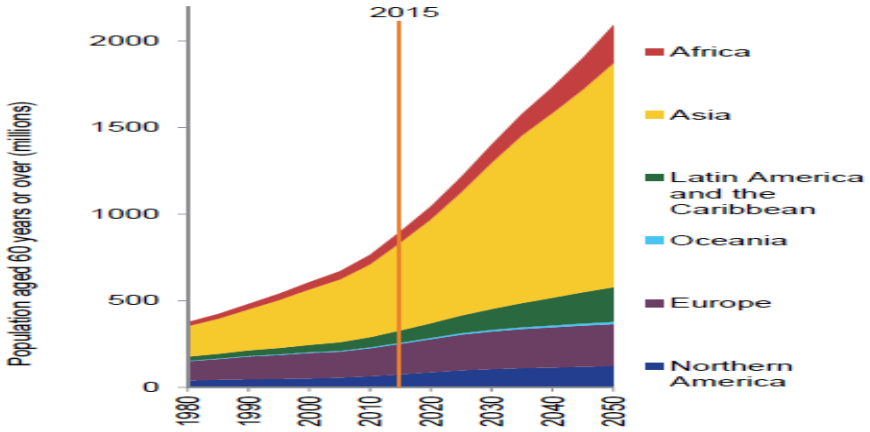

Fig. 1. Population of elderly people in different continents [1]

In India, the proportion of older persons has risen from 4.9% in 1901 to 5.5% in 1951, 6.5% in 1991, 7.7% in 2001 and it is expected to be 12% by 2025 [2]. The Indian population has approximately tripled during the last 50 years, but the number of elderly Indians has increased even faster [3]. The elderly population in India has increased from 77 million in 2001 to 104 million in 2011.By the year 2050, it is likely to increase by three times to reach around 300 million, which will be about 20% of the total population of India. Reference [4] links the growth of elderly people in India with demography and also gives some projections for the next 30 years. It says that a large percentage (30%) of the elderly is below the poverty line, and about 80% of them are in the rural areas, thus making delivery of any health related services to this population a big challenge. The solution lies in using modern technologies to support or assist them in having healthy, comfortable and dignified life in the society. Moreover, such assistive technologies, must be accessible, affordable and adaptable to the specific needs of the user [3]. The use of technology to support independent living and promote independence of elderly persons is mentioned in some Government of India policy documents (e.g. National Policy on Older Persons - NPOP). Technological interventions or assistive technologies can greatly help in achieving the objectives of the NPOP by providing vital inputs and capabilities.

Assistive technology is defined as any equipment or system that assists people who have difficulties, due to age or disability, in carrying out everyday activities. Older persons can also get some psychological benefit in the face of stressful life events with help of assistive systems. These systems have been categorized as Architectural/

Home Elements, Aids to Daily Living, Kitchen Gadgets & Appliances, Furniture, Foot Wears, Clothing, Communication, Sensory Functions, Mobility and Recreation/ Entertainment Devices [5]. The emphasis in this paper is on the assistive systems/devices related to the health and daily living.

Challenges faced by the elderly are highlighted in section II. Some of the major existing research works on assistive systems/devices for elderly are summarily reviewed in section III. Some assistive systems/devices with novel and highly useful features are proposed in section IV. In section V, the concept of integrating the proposed assistive systems into a single integrated system, so as to serve the future needs of both urban and rural elderly persons of India better, is presented. The last section concludes the work and lists out some of the challenges for future research work and suggests some directions for further research work on assistive systems and devices for the elderly.

2 Challenges for Elderly Persons

Weakness and disability frequently coexist in aged persons and both of these problems increase with advancing age. Deterioration broadly depends on genetics, nature of lifestyle and the food quality. A gradually weaker physical capacity and psychological strength are observed during this time of the life. The diseases among older people depend upon their surroundings and own habits. The number of asthma cases is rapidly increasing in many parts of the world. In India, it occurs mostly among the aged and the rural populace as well as the people with poor level of health. Advanced age in fact is a risk factor by itself in the causation of several diseases, particularly the vascular diseases. When an age-related disease inflicts an increasing number of citizens in a country, it becomes a challenge for the society and the country too. The worst thing is possibly that modern society leaves the elderly parents to live on their own, which leads to even more serious challenges for them. Some of the major challenges for elderly persons are discussed below:

2.1 Lack of companion

Loneliness is now considered as the biggest problem of the elderly persons who are away from their children or have lost their life partner. Such a drastic change in the life may even take them to mortality. An assistive enabling system can help them live longer in such circumstances.

2.2 Lack of physical fitness

The lack of physical fitness leads to isolation of the elderly persons from social relationship. It also increases their psychological as well physiological problems. Restoring and maintaining physical fitness is very important to the survival of elderly persons. In addition, some devices are available to assist them in performing certain physical activities.

2.3 Dementia

Dementia is the disease of forgetting belongings and keeping track of items like wallet, supporting stick, spectacles, medication etc. Several assistive systems and devices, including micro-size intelligent tags to be attached to their belongings, have been developed to assist such dementia-affected people.

2.4 Lack of communication

At the time of a fall or a sudden medical problem or an attack by a stranger, the elderly person generally fails to communicate. An assistive system is needed to trigger communication in such situations.

3 Reported Research in Assistive Systems

Some of the major research works on assistive systems and devices reported in the literature are reviewed below:

3.1 Fall detection and location monitoring using smart phone sensors

Elderly people fall more often than the young persons do because of the general health deterioration. Moreover, the consequences of fall become more and more serious as the age advances. Hence detection of an elderly person's fall and finding his/her location at the time of fall are extremely important. Since mobile phone is commonly carried by all people, the inbuilt sensors (such as the three-axis accelerometer) of a smart phone can be used to detect a fall [6]. But detection of a real fall is made difficult by many factors. For example, the user may abruptly lie down on bed to take rest. In such a situation there should not be any false triggering of alarm of fall. Training of the system is important, so is the selection of sensor. GPS of a smart phone can be used to find the location of the elderly person when user is out of his/her home [7]. When he/she is in a public building, the GPS would not work. If the public building is having free Wi-Fi, then his/her smart phone or a customized monitoring system can transfer his/her current location to data-cloud. In all these cases, the information is delivered to a hospital and his/her relatives and/or friends.

3.2 Automatic cough detection

When elderly persons suffer from cough, they may be careless or turn too weak to visit a doctor. The condition can be detected by a customized sensor system using microphone array reported in [8].

3.3 Daily activity recognition

Recognition of daily human activities is possible using wearable sensors in a Motion Node reported in [9]. The Motion Node is a combination of a three-axis accelerometer, three-axis gyroscope and a three-axis magnetometer. However, the data of the node needs to be trained on a good training model (eg. sparse representation-based framework) before using it on a subject.

3.4 Intelligent wheel chair

A robotic assistive wheelchair reported in [10] can be used as an assistive device by elderly persons, either manually or through simple voice commands. Interaction facility can be added to the robotic chair to make its use more interesting. The chair is also used to monitor a few health parameters after the subject sits in it.

3.5 Companion robots

Lack of a companion makes the life of many elderly people miserable. Companion robots, in the forms of humanoid and animal robots prove to be very helpful to such elderly persons [11]. In addition to the shape or form of the companion robot, if the voice of interaction matches with the voice of a beloved relative like his/her grandson, son or daughter, the solution becomes much more attractive and effective. The companion robot need not have many degrees of motion and can have minimum actions, so that the complexity of control system and cost of the robot are low.

3.6 Assistive robotic arm

Lack of physical fitness is another major and common challenge for a large percentage of very old persons. The robotics technology can play a very good role by providing physical assistance to such persons in lifting objects like kitchen vessels and home appliances. Research works have been reported on the development of robotic arms and wheel-chairs mounted with robotic arm as solutions to this problem [12].

3.7 Assistive embedded system devices for dementia

Reference [13] presents a good overview of the dementia-care frameworks and assistive technologies for dementia affected persons. Micro-size intelligent tags (wireless communication devices), which can be attached to their daily-use articles, like wallet, supporting stick and spectacles, keep a track of these items. The tags communicate with a master device and inform about their locations. The main objective of the dementia-assistive systems, which can be mobile phone based, wearable or home based, is to link the user and his/her caregiver in all types of situations.

3.8 Wireless body area network

Basically, wireless body area network (WBAN) is used to monitor the health of an elderly or differently-abled person. The data collected from the WBAN is sent to his/her care giver. Both invasive and non-invasive devices are available for WBAN applications. The most commonly used technologies are Bluetooth, Bluetooth Low Energy, IEEE 802.11, IEEE 802.15.6 and other radio technologies [14]. Vehicular ad-hoc networks (VANETs) are now used for intelligent transportation of elderly and differently-abled persons. In that case, the data collected through WBAN can be sent to the care-giver using VANET [15].

3.9 Home automation

Applications of wireless sensor network (WSN) in home automation for the elderly are very wide. It can be used to convert a classical control of home appliances into smart home automation. ZigBee has been used to develop smart home automation without use of internet technologies [16]. Home appliances can be controlled by collecting data from different sensors or imaging system and analyzing the same to find gesture of the user [17]. By using WSN and imaging system together, appliances can be controlled based on psychological problems and perceptions [18].

4 Proposed Assistive Systems for Elderly Persons

Some novel assistive systems are proposed below for making the life of elderly persons more comfortable or at least less stressful. Some desirable features are also suggested for each of the proposed assistive systems/devices.

4.1 Smart assistive robot cart

A robot cart can serve elderly persons both as a companion and an assistant. It can be used by them to carry their belongings within and outside the premises of residence. Development of a robot cart should aim at the following provisions/features:

- It should be a remote controlled system.
- The system should require zero or minimal effort to control.
- If there is any problem or failure in the cart, the same should be automatically sensed and informed to the caregiver of the elderly person using GSM or GPRS technology.
- The robot cart should follow the owner and maintain a touchable distance with him/her while moving or standing, so that he/she can access or use the cart comfortably.
- While the cart is following the user, there should not be any collision.
- There should be some user identification system so that the cart follows the authorized user (owner) only.

- The robot cart can be controlled by care taker from remote in case the user fails to control it.
- User should be able to use the robot cart as a walker when he feels the need of a support. .

4.2 Intelligent medicine dispenser

Functional block diagram of the proposed Intelligent Medicine Dispenser (IMD) is shown in fig. 2. Primarily it is designed to remind the user (elderly person) to take medicine as per a recommended schedule to maintain wellness. It will be portable and can be carried by user when he/she goes out of station. All operations of IMD are controlled by a micro-controller. Medicine containers in a larger box are driven by the micro-controller through a stepper motor to the designated location one by one as per the schedule. A keyboard allows setting the schedule and making necessary adjustments. A display unit and audio alarm are used by the micro-controller to display messages/warnings and issue reminder alarms to the user, respectively. There is one more attached unit with IMD, called Portrayed User Interface (PUI). It is used to communicate any critical problem of the user to his caregiver. The user shall touch a particular point on the PUI to indicate his critical problem, like chest pain or back pain etc. Then a message related to the touched point is automatically communicated to the caregiver. A Blutooth (BT) interface is provided to sync data as per need. The user can also get first-aid medicine from IMD.

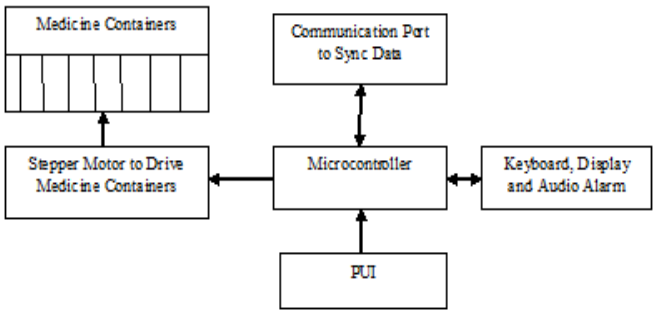

Fig. 2. Intelligent Medicine Dispenser

4.3 Automatic status and health detector

In the event of a fall or sudden medical problem or stranger attack, the elderly person may go to unconscious state or may otherwise fail to raise an alarm. So, there should be an automatic status detection and trigger system to detect conditions like those stated above and trigger an alarm. This automatic detection can be done using suitable sensors mounted on (or attached to) the body of the elderly person along with a wireless body area network (WBAN). Vital health parameters of the person can also

be monitored using appropriate sensors and the WBAN. The WBAN can communicate with a remote caretaker or medical care centre, as per the requirement.

4.4 Intelligent pendent controller

Pendent buttons are used by elderly persons at the time of emergency. The proposed pendent controller will have some additional but intelligent provisions. For example, pre-recorded sounds rather than simple text messages will be transmitted for alerting the caregiver. It will be having an automatic fall detector too and the message will be initiated automatically by the fall detector.

4.5 Intelligent support stick

The intelligent support stick will be having following features:

- LED torch
- Atmosphere temperature alert system
- Robot cart controller
- 'No stick' indication, and
- WiFi control of home appliances.

4.6 PLC based home automation

Communication technologies used for home automation are wired and wireless. Wired communication using power line carrier communication (PLCC/PLC) should be preferred in a home of elderly people because it gives no radiations. A care giver can also control the home appliances from remote using internet technology along with PLC.

5 Proposed Integrated Assistive System

The main goal of research in assistive technologies is to develop assistive systems and devices that must be highly helpful to the elderly persons in leading a near normal life. Operating or handling several assistive systems/devices may itself be a challenge for an elderly user, who may already be suffering from a diminishing mental alertness. Therefore, integration of different types of assistive systems/devices into a single system can be a highly valuable research work. Collecting data from the large number of sensors provided in various assistive devices, controlling the end devices and messaging critical details to care-giver and medical care unit are some of the important tasks to be assigned to the integrated system.

A framework for the integration of the five assistive systems/devices (WBAN, intelligent medicine dispenser, intelligent support stick, robot cart and pendent controller) and the PLC-based home-automation system, proposed in the previous section, is presented in fig. 3. An intelligent master controller unit (IMCU) provides central

control on the operations of the integrated system. With several serial communication interfaces, IMCU is an embedded system. However, a computer can be used as IMCU in the starting stage. The IMCU is a controller cum data logger and used to control the end devices, obtain signals from sensors and get inputs from the elderly user and his/her caregiver. The elderly user or his/her caregiver (or someone else acting on his/her behalf) needs to do feed necessary information in the beginning through key-board and display interface. This may comprise the names and contact numbers of the user, caregiver, healthcare unit or hospital and values of some parameters like waiting times, reaction times and delays etc.

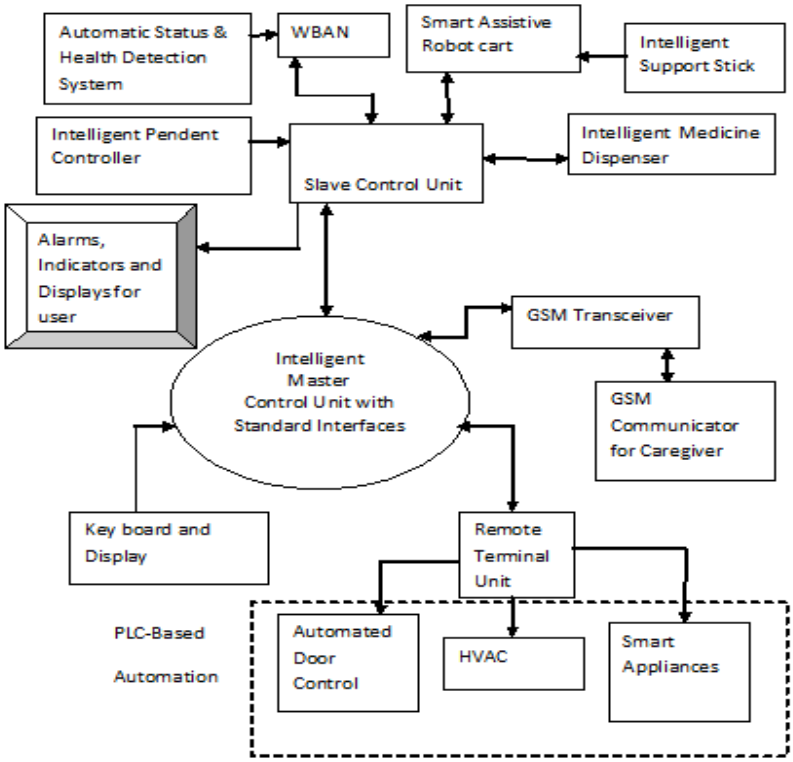

Fig. 3. Proposed Integration Framework

Communication between IMCU and the five assistive devices, which will supposedly move with the elderly user, is proposed to take place through a slave control unit (SCU), which will also move with the user. When the user goes outdoor or out of station with these devices along with SCU, and the devices are close to SCU coming within the range of the Bluetooth (less than 10 m), they will form a sub-network using Bluetooth (BT) technology. SCU, in turn, will communicate with IMCU using GSM or the Internet. When the user comes back to his/her home network, then the SCU can sync data of all devices either automatically using Wi-Fi or manually using USB.

Communication between IMCU and the PLC-based home-automation system (which in fig. 3 comprises smart home appliances, HVAC equipment and automatic door control) is proposed to take place through a remote terminal unit (RTU). The RTU communicates with the automated appliances etc. using the wired communication technology of PLC and with IMCU using either WiFi or USB. The foregoing recommendations and options for communication are given in table 2.

Table 2. Communication options for the Proposed integrated System

Possibility	From Device/Part	To Device/Part	Communication – Direction
1	IMCU	Caregiver	GSM or Internet
2	WBAN	SCU	BT or RF 433 KHz
3	Pendent controller	SCU	BT or RF 433 KHz
4	Intelligent Medicine Dispenser	SCU	BT or RF 433 kHz
5	GSM Transceiver	SCU	USB or Wi-Fi
6	SCU	IMCU	USB or Wi-Fi
7	RTU	IMCU	USB or WiFi
8	RTU	HVAC	PLC
9	RTU	Door Automation	PLC
10	RTU	Smart Appliances	PLC

The communication link between the care-giver and IMCU can be either GSM or the Internet as indicated in the table. The table recommends some alternative communication techniques too. Instead of BT, 433 kHz RF links can be used to connect assistive devices to SCU. Design of IMCU involves two major challenges: The main challenge in interface design is to accommodate several communication protocols and a big challenge in data processing is handling of data in diverse formats, both the data received and the data to be transmitted.

6 Conclusion

Trends in the growth of population of elderly persons in the world in various continent, with special mention of the Asian continent, have been presented in the paper. The population-growth figures taken from various authentic reports have brought out the fact that the elderly population in India is growing at a very fast rate. In addition, the problems and challenges for the elderly people, especially those in India, have been highlighted. The paper has also explained how the use of assistive technologies, systems and devices can help the elderly people in meeting these challenges and in making their lives less difficult. Major research works related to it has been summarily presented. Some novel assistive systems and devices have been proposed along with several suggestions regarding useful and desirable features of each proposed assistive system/device. The paper has presented a novel framework of integrating the proposed assistive systems/devices and PLC based home automation system. The motivation is to ensure a coordinated operation of all the assistive systems/devices and automated home appliances without requiring any effort on the part of elderly user or intervention from the caregiver. The proposed integration involves a careful

selection of communication technologies. The paper has put forward various communication technology options.

The future research work is expected to focus on the development of assistive systems and devices that would require zero effort from the elderly user and cost effective products. Extensive use of smart sensors, micro-actuators and artificial intelligence may be the other aspects of future research work on assistive systems and devices for the elderly.

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