A STUDY ON HEALTH MONITORING SYSTEM: RECENT ADVANCEMENTS

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ABSTRACT: A proliferating interest has been observed over the past years in the development of an accurate system for monitoring continuous human activities in the health care sectors, especially for the elderly. This paper conducts a survey of the various techniques and methods that are proposed to monitor the movements and activities of the elderly people. These techniques promise a useful and dependable detection system to give support and lessen the medical expenses of health care for the elderly. The detection approaches are divided into five main categories: wearable device based, wireless based, ambience device based, vision based and floor sensor / electric field sensors based. These techniques have focused on the pros and cons of the existing methods for recognizing the prospective scope of research in the domain of health monitoring systems. Apart from highlighting and analyzing the features of the existing techniques, perspectives on probable future studies have been detailed.

ABSTRAK: Dewasa ini, pembangunan sistem yang tepat untuk memantau aktiviti berterusan terutamanya dalam sektor kesihatan warga tua mula mendapat tempat. Kaji selidik telah dijalankan dengan pelbagai teknik dan kaedah untuk meninjau pergerakan dan aktiviti golongan warga tua. Kaedah-kaedah ini memberikan sistem pengesanan yang berguna dan dipercayai untuk memberikan sokongan serta mengurangkan kos perubatan kesihatan bagi golongan tua. Pendekatan pengesanan dibahagikan kepada lima kategori utama; alatan yang dapat dipakai, alatan tanpa wayar, alatan berdasarkan persekitaran, alatan berasaskan penglihatan dan alatan berdasarkan pengesan pada lantai / medan elektrik. Teknik-teknik ini memfokuskan kepada pro dan kontra kaedah yang sedia ada untuk mengenalpasti skop prospektif penyelidikan dalam domain sistem pengawasan kesihatan. Selain daripada mengetengah dan menganalisa ciri-ciri teknik yang sedia ada, perspektif kajian akan datang juga diperincikan.

KEYWORDS: *health monitoring; elderly; wearable device; wireless device; ambience device, vision analysis; floor sensors*

1. INTRODUCTION

According to a survey on ageing population by United Nation in 2005 [1], the world population of the elderly is expected to double from the year 2010 to 2050 from 350 million to 1500 million. As such, with technological advancement, increasing research effort has expended in the field of elderly health care. The growing aging population will lead into several challenges for the health care system as well as for the society. An example is the increase in Alzheimer's or Parkinson's disease for which presently there is no cure. Increase in health care costs such as for hospitalization, travelling, and daily check-ups are also expected to increase. Due to lack of caregivers, high number of dependencies, and individuals who will be unable to live independently, will cause economic concerns to increase on society. Considering the fact that 89% of the elder people like to be in their homes, and looking into the expenses of nursing home care [2], it is essential to make some advancements in the technologies that assist elder people to age in their place.

This paper is organized as follows. In Section 2, different types of monitoring technologies are introduced. Five different categories of monitoring approaches are discussed. Finally, Section 3 concludes the paper with future directions of the research.

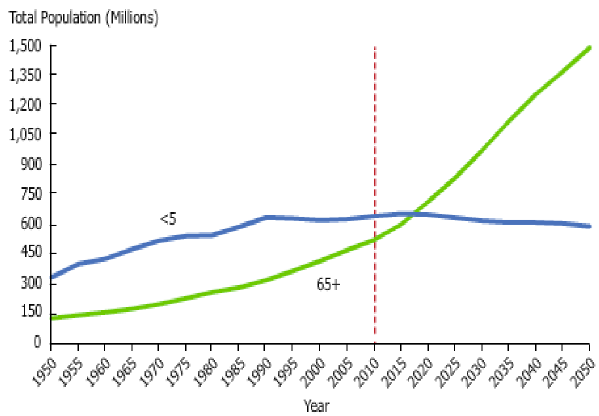

Fig. 1: World population forecasts over the years [1].

2. APPROACHES AND PRINCIPLES OF HEALTH MONITORING DETECTION SYSTEM

In recent years, researchers have developed a variety of health monitoring technologies to assist elderly citizens. In this work, different categories of detection systems are first identified and then a classification of detection methods is build according to their use and principles for better understanding of the existing approaches. This work further contributes toward a detailed discussion on the strength and limitations of the existing detection methods for health monitoring.

Existing health monitoring approaches can be explained and categorized into five different classes to distinguish different detection methods. The monitoring approaches can be divided roughly into five categories: wearable device based, wireless based, ambience device based, vision based and floor sensor / electric field sensors based. A classification of detection methods is built in Fig. 2.

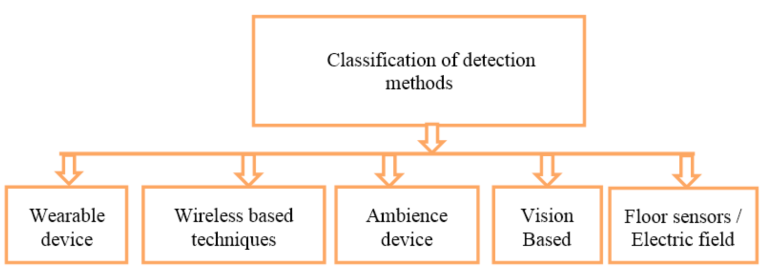

Fig. 2: Different approaches and techniques of detection methods for health monitoring systems.

2.1 Wearable Device Based Approaches

The key to wearable device based approach is connecting some device or wearing garments with embedded miniaturized electronic sensors, attached by a wireless or wired body area network to data processing and communication devices which will be embedded in the user's clothes as part of the clothing or an accessory. This health monitoring device is able to monitor the wearer's vital signs like blood pressure; cardiac activity, respiration, sleeping patterns and social interactions continually.

In most prototypes of wearable systems, microelectronics and electrical sensors are integrated in body-worn devices such as in patients' clothing, gloves, wrist-worn or an armband devices, finger rings, earlobe devices and patches [3]. A number of these wearable systems have demonstrated an increased efficiency in health monitoring.

HealthGear [4] is a product of Microsoft Research. It is basically a real-time wearable system for monitoring, visualizing and analyzing physiological signals. It uses a blood oximeter to monitor patients' blood oxygen level (SpO_2), heart rate and pulse while sleeping. This implementation is carried out using Bluetooth technology via cell phone. The physiological data obtained, is then further analyzed on a home PC at a later time.

Bodymedia [5] developed an armband that has multiple sensors (galvanic skin response, skin and near-body temperature, two-axis accelerometer and heat flux) to continuously collect physiological data for a few days at a time. Once the data is downloaded to a PC, a proprietary software derives what they call "lifestyle" information, such as energy expenditure, duration of physical activity, number of steps, etc.

However, in all cases the physiological data is analyzed on a home PC at a later time. Traditionally, personal medical monitoring systems, such as Holter monitors, have been used only to collect data for offline processing. One of the most popular remote health systems perhaps is the AMON (Advanced Medical Monitor) [6] system, a wearable (wrist-worn) medical monitoring device for high-risk cardiac/respiratory patients. The system includes continuous collection and evaluation of multiple vital signs, intelligent multi parameter medical emergency detection, and a cellular connection to a medical centre, hence minimizing the effect of the devices on the user's lifestyle.

The Vital Jacket [7] is a wearable vital signs monitoring system, which intelligently monitors electrocardiogram (ECG) waves and heart rate for different scenarios, such as in sports, security and medical applications. Here data is sent via Bluetooth to a PDA and stored in a memory card at the same time.

eWatch [8] is a wearable sensing and notification platform developed for context-aware-computing-research built into a wrist watch making it highly available and instantly viewable. The Bluetooth technology is used in order to connect to cellular phones or computers. eWatch provides visual, audio, and tactile notification while sensing and recording light, motion, sound and temperature.

Nguyen et al. [9] proposed a mobile waist mounted device which can notify caregivers during an emergency case. A tri-axial accelerometer and a CDMA standalone modem is used to detect falls and a 3 channel ECG circuit to determine heart rate. Nguyen also proposes a simple threshold algorithm to increase the accuracy of the system. If an emergency event happens, ECG and acceleration data will be sent to a remote server via CDMA module. The data is not processed locally, hence the response time is larger as compared to systems where data is processed locally.

Those who wear devices at their wrist are reported to have comparatively less sensitivity than those who wear it on the waist [10]. Lindemann et al. [11], claimed that those who wear an accelerometer behind the ear had better sensitivity in simulated falls. They also argued that the fall detector's position on the head would permit the device to be worn at night when a bigger risk of falls remains when the patient is not in the bed [12-13].

VivoMetrics [14-15] developed a 'LifeShirt System', a lightweight, machine washable, non-invasive shirt with embedded sensors for continuous ambulatory monitoring, a system that can ascertain pulmonary, cardiac, respiration, posture, movement and other physiologic data during a person's daily routine. Respiratory function sensors are woven into the shirt around the patient's chest and abdomen. A three-lead, single channel ECG measures heart rate, and a three-axis accelerometer records subject posture and activity level. An external PDA stores the data and extracts the vital parameters, allowing researchers to correlate the physiologic parameters measured. However, the LifeShirt System is no longer available for sale. Because of the cumbersome recorder and peripheral attachment to be carried around it is not recommended for prolonged and incessant monitoring.

After identifying the disadvantages of the first prototype in the area of sensorized garments, researchers focussed on smart textiles. Smart textiles have been proved to be successful in the applications of materials and nanotechnology research (in the case of health monitoring). The smart textile method of Sensatex, i.e., the *Smartshirt*, has been developed and patented primarily by researchers at Georgia Institute of Technology. This receives analog signals via conductive fiber sensors and transmits them via a conductive fiber grid, which is knitted in the T-shirt [16].

Health-Shirt (h-Shirt) [17-18] is a wearable device that is made of electrodes from e-textile materials. The h-Shirt is intended to monitor blood pressure cufflessly and continuously by simultaneously recording ECG and PPG signs. The ECG is taken from the two wrists, with a reference electrode placed on the forearm to evade respiration induced noise.

Another such system which uses textile (micro-sensing device) for monitoring human body falls was suggested by Lin et al. [19]. Micro-mercury switch and optical sensors were embedded into a coat and a processor was used to processes data from the sensors in order to identify the status of the wearer.

Lee and Chung [20] likewise proposed a smart shirt, which measures ECG (Electro Cardio Gram), and acceleration signals for continuous and real-time monitoring of health. The shirt was made up of conductive fabrics to acquire the body signal. The observed and measured data are transmitted in an ad-hoc network for remote monitoring.

Wearable device approaches are advantageous as well as disadvantageous in some aspects. The prime benefit is the cost effectiveness of wearable devices. Also the installation and setup of the design is quite easy. The devices are comparatively easier to function and detect the primary signs of health worsening. The drawbacks consist of intrusion and fixed relative relations with the subject, which makes the device disengaged. Such drawback makes wearable devices a critical option for the elder people. The drawback of the wearable device is that it is invasive. The practicing doctors commented that most of the patients do not wish to wear device for the detection of fall because they feel well before any fall. In accordance with the research and studies, the elderly user wearing sensor can be challenging especially when the user has a cognitive injury or dementia, in that they have to wear the device and use it as well.

Another unavoidable fact is that it can be uncomfortable to the patients, since it maybe huge for some patients. In addition, batteries are required to be replaced very often. To resolve such battery troubles, patients can wear RFID tags [21].

The stated review demonstrates that these kinds of systems can be used for normal living atmospheres. Most of the techniques are advantageous over the Computer Vision and Acoustic & Ambience sensors based techniques. The primary advantage is that a person can leave his/her house and yet the monitoring continues. Noise interference is not there too. These systems are cost effective since no infrastructure is required. Nevertheless these approaches have some limitations as well. These approaches offer an obtrusive method of monitoring. Moreover, for designing such kind of stand-alone systems, the battery life is also a key concern. The weight is also a vital part to consider.

2.2 Wireless Technology Based Approaches

The Wireless Body Area Network (WBAN), was first introduced by Van Dam et. al. [22] and Latre et. al. [23], to fully exploit the benefits of wireless technologies in telemedicine and mobile health. This is a wireless sensor network. Internet, intranet, or satellite communication is used for distant monitoring of patients' vital signs. WBAN technology provides the automatic real-time acquisition of vital signs to ensure flexibility and keep up patient mobility. In general, for helping patients who necessitate urgent aid in surgical and intensive care units of modern hospitals, such technology is used. WBAN makes use of wearable sensor devices and actuators, mobile devices and wireless network devices to deal with physical health conditions of patients. The health conditions are usually predicted through signals like body temperature, body weight, waistline, blood pressure (BP), pulse rate (PR), oxygen saturation (SpO_2), blood sugar electrocardiogram (ECG), electroencephalograph (EEG), and electromyography (EMG) without any emphasis on geographical locations of patients. The sensors and actuator devices distantly gather signs for diagnosing patients' health conditions in real-time. ZigBee and the Bluetooth standards are usually used for radio interface in WBAN systems.

Interestingly WBAN is not suitable due to lack of an appropriate wireless technology (such as Bluetooth, Zigbee, GPRS and Wi-Fi) that will satisfy all the requirements of the WBANs. Chavez-Santiago et al. [24] illustrated that the suitability of ZigBee and Bluetooth for healthcare applications is to be examined, since ZigBee has high exposure to interference, Bluetooth has scalability problem and both ZigBee and Bluetooth support low data rate communication, therefore they are not suitable for wireless medical applications. Moreover, Chavez-Santiago et al. [24] suggested the use of UWB since they are of low power consumption, less complex. The UWB signals do not cause significant interference to other systems operating in the vicinity. Hence they do not create a threat to patient's security because they protect the transmission of patient's data by reducing the probability of detection. This therefore, rescinds the need for health data encryption that results in lower complexity of the electronics and smaller size of the devices.

In the area of wireless sensor networks, the MobiHealth [25] project supported by the European Commission is one of the projects that integrates the wearable sensor devices namely PDA's mobile phones and verifies that a person keep it with them. It allows patients to be monitored continuously by measuring and transmitting the video recordings along with the physiological data to health service providers who provide very consistent distant aid in the time of accidents, hence enabling prediction and detection state of the patients. MobiHealth [25] proposes the convergence of various network systems namely BAN, PAN and WAN to facilitate personalized and mobile healthcare.

CodeBlue [26] is a hardware and software platform developed-based research project at Harvard University, intended for deployment in emergency medical applications. The hardware design part consists of the design and development of a mote-base pulse oximeter, two-lead ECG, along with a motion analysis sensor board. The software architecture is based on publish/subscribe model for data delivery.It is design to work across various network densities and for a wide range of wireless medical devices in an ad hoc routing protocol, allowing sensing nodes to publish streams of data (vital sign, location and identities) to PDAs or PCs which can be accessed by physicians and nurses who are subscribed. The system specifies and collects patient's data for each step in case of any accident, starting from the place of accident to the hospital environment.

A research by Advanced Health and Disaster Aid Network (AID-N) [27] came up with a radical design of wearable biomedical system (to be used in wrist devices) to facilitate the patient's monitoring by collecting the data for imperative signs and location, storing this acquired data in record. It offers triage status tracking that enables the runtime monitoring. This system was designed as part of the CodeBlue [26] project in collaboration with AID-N [27]. The implemented design consists of a GPS receiver, blood pressure sensor, a pulse oximeter and an electronic triage tag to signal the danger level of a subject, an LED and a buzzer to indicate about alert conditions. The device has a capability of running for five to six days continuously.

The OnkoNet [28], a mobile agents-based architecture is used to tackle the difficulty of accessing to medical care services by consumers via mobile devices. The OnkoNet architecture can maintain a knowledge intensive cooperation between people and software agents to produce, convey, maintain and consume medical care services in virtual communities maintaining the assistance of actors indulged in diagnosing cancer as well as therapy. The OnkoNet can also allow local and mobile access as well as attain better incorporation of patients and medical care practitioners. The architecture ensures the support of community oriented medical care arrangement which reduces the cost and does not incorporate into grids to maintain accessibility as well as service provisioning quality.

The Ubiquitous Healthcare System (UHS) [29] includes critical signs devices as well as environment sensor devices to gain context information for continuously observing and maintaining health condition of patients. The framework is aimed at the advancement of four healthcare applications containing self-diagnosis, distant monitoring, exercise management and crucial services. Nonetheless, the framework is actually not solely based upon virtual community. It also does not integrate into grids to ensure quality and ubiquitous services at minimum cost.

Researchers at the MIT Media Lab have developed and prototype MIThril [30], a technique for human-computer interaction for body-worn applications. It is basically a cloth integrated design which allows sensing and networking. Presently research on a wearable application of MIThril for human behavior recognition and to create context-aware computing interfaces, is being conducted. Another health monitoring application was demonstrated in [31], a health-wear system with sensors that can continuously monitor the user's vital signs, daily activity, social interactions, sleep patterns, and other health indicators. Based on the data obtained by the system a personalized profile of the patients physiological performance record can be generated which will help the patient in future.

The Smart Medical Home [32] makes use of infrared sensors, computers, bio-sensors, and video cameras, which provides medical services to patients and health care experts. Moreover it also provides motion and activity monitoring, pathogen detection and skin care, and personal health care recording for consumer-provider decision support.

The Ubimon Ubiquitous Monitoring [33] is from the Department of Computing, Imperial College, London. The project aims at the development of wearable and implantable sensors for distributed mobile monitoring. It is also aimed at investigating mobile monitoring, using sensors and real-time biomedical data collection for long time trend analyses.

Juyng and Lee [34], proposed a reliable data transmission health monitoring device based on ZigBee control mechanism to monitor physiological signals. The work develokped wrist, chest belt, shoulder, and necklace devices. In their work it was seen that the devices required only a small battery for power supply and it also showed that the devices was lightweight and small hence easy to carry around, moreover the device could function properly for at least six hours without being recharged or replaced. However the batteries life spam should be improved for longer hour's operation.

Recently, Bluetooth has gained more attention than ZigBee because of its widespread availability. Qureshi and Tounsi [35] implemented their first work on Mobile Intelligent Remote-access Healthcare Management System (MIRHMS) based on mobile healthcare system using Bluetooth to generate patients' data for obtaining case-specific advice on a mobile device hence able to monitor patients. The same authors proposed an extension of their work [36] based on a remote healthcare system using Bluetooth enabled smart phones with WAP technology. The system proposed would be able to identify and diagnose remotely located patients thus reducing the frequent visits to healthcare service provider. The proposed system uses Bluetooth channel for acquiring data into the patients' mobile devices, from Bluetooth enabled medical measurement devices. The received data is directly transferred to a Solver subsystem which integrates an intelligent medical expert system through Wireless Access Protocol (WAP) over the existing cellular link (GSM) or (GPRS).

Gaddi Blumrosen et al. [37] proposed a UWB technology to monitor/assist tremor symptoms which includes neurological disorders such as Parkinson's disease (PD), midbrain tremor, etc. The author stated that the common approach used in the assessment of tremors were by using motion capture devices and video tracking systems. However Gaddi demonstrated a novel approach based on UWB sensor node for the transmission of a wideband electromagnetic signal. In his approach multiple sensor nodes were placed in different locations in a home, the sensor node is used as a small radar system to capture tremor in one axis. The raw data obtained from the sensors are then sent to a UWB hub for further analysis. Then the data can be further relayed by an internet gateway to a health care center for monitoring and for continuously assess and report tremor conditions during daily life activities.

Akyildiz [38] illustrated a health care delivery of multimedia content in wireless multimedia sensor networks (WMSNs). Two types of architecture have been proposed, namely cross-layer communication architecture based on the time-hopping impulse and ultra wide band (UWB) technology. The UWB technology showed to be a better choice, in that it enables low power consumption and high data rate communications.

Wireless technology monitoring has had a major impact on the average human lifestyle. It ensures ease and flexibility in using internet services and different communication applications. This is one of the main advantages about the wireless system. In this system patients who stay in distant places from the hospital can receive instant and emergency treatment. A key concern on wireless means of sending data however is security and privacy. The government has formulated strict regulations to assure the security and privacy of patients' Personal Health Information (PHI); for instance, HIPAA [39]. Nevertheless, when an observer knows that a patient sends his/her PHI to a particular doctor, the observer has a high probability to guess the patient's disease. Three kinds of threats are stated in [40]. These are: un-authorized access, misuse of patient identities, and alteration of PHI in the health monitoring system. A protection scheme of patient privacy in wireless health monitoring system is needed. The main advantage of wireless health monitoring system is in the countryside areas, since it offers cost effective and quality healthcare services to individuals via mobile devices. In contrast, there are custom developed wireless sensors which can be unobtrusive and can also have natural activity patterns. Nevertheless, lack of proper standard and development enhances the time of designing and system cost [41]. According to [42], the advantages of wireless technology include convenience, portability, installation ease, and cost effectiveness.

The networks may help residents and their caregivers by offering continuous monitoring service, controlling home appliances, enhancing memory, accessing to medical data, and making urgent communication. Continuous monitoring will enhance diagnosis of urgent conditions in the early hours and also offer an extensive range of healthcare services for people with different degrees of physical and cognitive disabilities [43].

2.3 Ambient Devices / Environmental Sensors Based Approaches

Ambience sensor based approach consists of a device using multiple sensors installed in a closed room / area and a dedicated PC to collect the relevant data of a person such as walking or falling based on their vibration patterns when the person is in close vicinity to the sensors installed. The PC is based on certain conditions and thresholds, which decides on the detection of an event.

Sixsmith et al. [44] developed a system known as Smart Inactivity Monitor using Array-Based Detectors (SIMBAD). This system is based on pyroelectric IR sensor array installed on the wall for detecting the activity of a person. The system's infrared sensor array can locate and track a thermal target within sensor's field of view, that is only the warm moving objects are seen and not the static background. This array collects the location, size of velocity of the moving warm objects. A processor then detects the activity through analyzing the collected data. This system is proposed to be low-cost; however this system has limited application due to limited range of infrared sensors. Outdoor monitoring is also not possible at all.

Zhuang et al. [45] proposed a detection approach using the audio signal from a single far-field microphone. A Gaussian mixture model (GMM) was proposed in his work, when a movement (fall) occurrs a super-vector was created to model each fall as noise segments. The difference between the audio segments determines the occurrence of the falls.

Alwan et al. [46] proposed a detection scheme based on floor vibration, which is completely passive and unobtrusive to the resident. The system uses a special piezoelectric sensor coupled to the floor surface by means of a mass and spring arrangement. These sensors detect the occupancy at any moment. A processor identifies a fall by analyzing the location data thus a successful differentiation between the vibration patterns of a human fall from others can be obtained.

Most ambient device based techniques make use of pressure sensors to detect a subject to track. The working principle of a pressure sensor depends on the idea of sensing high pressure of the subject due to the subject's weight for detection and tracking purposes. It is a less expensive but useful and less invasive for implementing surveillance systems. Nevertheless, it has a drawback of sensing pressure of everything in and around the subject and creating fake alarms for fall detection, which results in less accuracy for detection purposes.

The trouble of such techniques is that monitoring is done only at places where the sensors are installed. Additionally, these techniques assume that the subject of interest is the only one doing these events.This kind of technique also has less accuracy and high rate of fake alarms. Another drawback of this method is that they cannot be confirmed by the caregiver [47].

One benefit of this method is the comparatively plain and inexpensive hardware compared to the computer vision based techniques. Furthermore, systems based on these sensors have a passive and unobtrusive nature. This technique also reduces the risk attributed to privacy issues that some people may have with the computer vision based techniques. More than one person can be monitored with such techniques although more studies are required for this development.

2.4 Vision Based Approaches

Camera based systems [48] use image processing which are considered to be one of the best way for human tracking. Image processing usually necessitates extorting required information from data offered by an imaging sensor which gets its information from TV, camera or an infrared camera. Camera based systems gives a precise and promising identification on positioning due to the use of stereo vision, however there are several deficiencies, they are expensive to install since multiple cameras are need to be installed in a single room, hence takes lots of space also the systems are susceptible to shadows, and reflections, also require more computing power. Furthermore they also face the line-of-sight issue. One major disadvantage is the issue on privacy generally people do not prefer to install camera in private places like their homes.

2.5 Floor Sensor Based Approaches

The integration of detectors into a user's floor has been taken as an alternative. Aud et al. [49] present the development of a ''smart carpet'', whereby a fall detector device is installed in a floor covering. The sensor within the floor coverage area may detect issues like whether someone is walking on the carpet, or whether someone is lying flat on the floor. The smart carpet has advantages in that it does not require the user to remember to maintain the batteries, as it uses ''energy scavenging sensors'', which is able to harvest energy (namely light, thermoelectric and vibrational energy) from the neighbouring environment. Moreover, Aud et al. [49] revealed that participants found no significant dissimilarities between walking on a standard carpet and walking on the smart carpet and, proposing that this feature would increase the suitability of the fall detector. The upcoming research area is field trials on the smart carpet [49]. However, Noury et al. [50] identify the problem faced by floor sensors not being able to detect falls when it does not occur on the ground, for instance the fall may occur on furniture.

A recent study explored the use of electric Near-Field Imaging (NFI) in floor sensors [51]. The human body conductivity can be sensed by this system through emitting a low-frequency electrical field. By a matrix of planar electrodes under the floor surface the field is produced and sensed. These electrodes are etched on aluminum foil which is laminated between thin PET plastic films [51]. The NFI system is being used in a nursing home in Finland where it detects residents falling, getting out of bed, leaving rooms, and entering the toilet [51]. The disadvantage of this system can be said as its' incapability to recognize the person or object which has been positioned. During the time when falls occur or patients suffering from dementia leave their rooms, this system proved advantageous. Furthermore, nurses can benefit from the identification characteristics as they could receive context-related information, such as patient records, or acknowledge NFI alarms by entering a room. It was also found that the system was not accurate when people fell to their knees, only detecting 20 per cent of such falls [51].

3. CONCLUSION AND FUTURE WORK

In this review, a study on the existing products of the health monitoring detection methods are presented in literature, focusing on identifying the approaches and principles of the existing methods. A class categorization of the detection methods has also been presented. Methodologies of five different types of technologies for health monitoring and detection system has been surveyed and discussed. The techniques focuses on wearable devices, wireless based, computer vision and video analysis based, ambient based sensors and floor based sensing techniques.

In summary, wearable-based devices are considered to be obtrusive and troublesome during continuous use. From the view point of an elderly patient, these techniques are not practical or user-friendly because one must pay attention to the device and remember to carry it at all times, otherwise monitoring does not take place. Furthermore if the devices are battery powered, regular charging is required or batteries need to be replaced from time to time.

Wireless based technology has shown to improve the lifestyle of people by providing early detection, convenience and flexibility. Hence people who live far from hospitals, immediate and quick treatment during an emergency can be obtained. However the major drawback in this technique is the security and privacy of transferring data.

Camera / vision-based techniques are considered to be one of the best ways for human monitoring. Camera based systems give a precise and promising identification on positioning due to the use of stereo vision, however there are several deficiencies, they are expensive to install since multiple cameras are needed to cover a single room. Considerable space is required. Furthermore such systems are susceptible to shadows, and reflections, also require more computing power. Furthermore, they also face the line-of-sight issue. A major disadvantage is the issue of privacy. Generally patients do not prefer to have installed cameras in private places like their homes, whereas they are best suited for monitoring large groups of people in an unobtrusive manner.

The ambience sensor based techniques, which use vibrations or sounds for monitoring are also restricted to indoor use and the signals obtained from the sensors are easily influenced by the excessive noise from the environments which degrades the signal received from the sensors. They are, however, very suitable for a group of people and are also unobtrusive, like the camera / vision based approach.

The floor-based approach has the most potential for future advancements for indoor monitoring. It involves detection and monitoring of people more conveniently, the person being monitored does not have to carry or attach any device to their body or clothing. The floor sensors are mostly embedded under the ground / above the celling allowing patients to feel free to move around comfortably and not worry that they are being watched, unlike when using cameras. Hence the floor sensor based approach is considered to be better among the rest for the application in elderly care centres because of its cost effectiveness, portability, robustness, and reliability.

The study reported in this work will allow researchers to set a platform for them to design a monitoring system according to the requirements of the current health services in care centres or at home, hence motivating the elderly population to live in their own environment. Moreover, this platform will allow patients, clinicians, managers and even researchers to make better-informed decisions, leading to better patient outcomes and fewer mistakes.

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