Tracking of Physical Activity Using Sensor System At Home

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Abstract- Human activity tracking and recognition within home is one of the bases of modest wellness monitor of a rapidly aging population in developed countries. Rather than the aging population, most of the people, today, spent their time in sitting at workplace, in automobiles, watching television, in front of computers which eventually become a cause for the innumerable diseases. Thus it is require tracking the physical activities of sedentary and aging population in order to estimate the amount of their daily physical movements. By this research we can determine that by using only three – four doorway sensors, it is possible to imprison the sufficient movements in order to determine the activities of the elderly population which can eventually help them to track the level of their physical activity, which can subsequently helps the doctors to develop the further procedure of treatments for the elderly patients if they are suffering from any disease.

Keywords: Aging population, sensors, activity tracking, health

I. INTRODUCTION

The aging population have particular physical condition issues that have to be considered. A considerable ratio of elderly population may undergo with elevated chance from age-related situation such as diabetes, cardiovascular disease, different chronic diseases, blood pressure and restrictions in functions of the body. Several times, aging population requires unambiguous monitoring of daily activities in order to calculate if a health condition is being accurately controlled or not. Another necessity is to identify before time when a disease or sickness is budding or to take remedial measures when an impulsive alteration in medical parameters occurs [1].

Along with aging population number of people live a sedentary life which leads to millions of deaths per year [3]. The level of physical inactivity among the people has increased due to the transformation of the physical, social and economic atmosphere and it leads to innumerable fatal diseases [4]. Thus, sedentary population, too, requires monitoring of their daily activities in order to check their physical conditions [14].

In order to monitor and encourage the physical activities, a low cost sensor system can be introduced. This research found that the small number of sensors can be used within the homes, in order to track the movements and then conclude the level of physical activity among the elders [2].

II. BACKGROUND AND RELATED WORK

Physical activities monitoring can be performed by using two types of sensors-active sensors and passive sensors. Active sensor system gathers data from the wearable or body-worn sensors and it needs the actions of the users [10]. Whereas in the passive sensor system, sensors are attached to the different objects in the surrounding and also the passive sensor system does not require user’s actions [5], [9].

Chatterjee et al. [11] built an in-home activity monitoring system to detect the daily routines of elderly people with diabetes by using biological sensors and body wearable sensors. Pulkkinen et al. [12] introduce a platform for tracking daily physical activities of elders suffering from diabetes by using different types of sensors at home which helps in detecting if the patients are following the suggested exercise and diet plans, which consequently helps the doctors to design further treatment procedure and automatic notifications can be provided to the patients. Chiang et al. [13] introduces a set of wireless sensor network devices to sustain physical therapy to be carried out by aged stroke patients. Stroke patients typically have to replicate particular activities or postures during their treatment, as indicated by their physiotherapists.

Predominantly for the elders, active sensor system can raise the errors in data collection and quality of information. Since the sensors are attached to the body of the user, due to the advanced age of the elders there may be some situations in which the movements in the body may be performed accidentally, which can lead to the incorrect measurements inferring to the wrong results. Some system uses accelerometers for tracking the activities [6], [8]. Also, some researches has recommended that sensors worn on the wrist may prove improper for recognising slow speed ambulation actions.

Fig. 2.1: Doorway Sensors [7]

Instead of using active sensors, passive sensor system may provide better result. One of the examples of a residential community is TigerPlace which broadly implemented sensors to hold secure aging-in-place [3]. Another work using passive sensor system is connecting sensors on the doors between the rooms in order to detect the people moving between the two rooms [7]. In such system, the sensors can make a distinction among the persons depending upon their height. It is indoor tracking system which provides room-level tracking without user participation, high-cost sensors or wearable devices.

III. SYSTEM REVIEW

This research applies simulation, optimization and regression techniques in order to display the possibility of gathering the data to track the physical movements of elders at their home by placing some passive sensors and accordingly infer the level of physical activities of the elders [2]. For this system,
Data were obtained from the American Time Use Survey (ATUS) micro-data files, made accessible by the US Bureau of Labour Statistics. These surveys confine free time and physical activities providing activity level information including activity code, location, duration, and activity start and stop times, on a per individual basis for meticulous day. Table I provides a snapshot of a data subset contained in the ATUS one activity i.e. for each activity case ID, a combination of the three tier codes (TUTIER) indicates the activity performed. For instance, a combination of 01 (TIER1), 02 (TIER2) and 01 (TIER3) corresponds to the action of ‘washing, dressing and grooming oneself’. The snapshot in Table1 indicates five different activities performed by a particular individual and provides information regarding the ID of the individual (TUCASEID), serial number of the activity performed (ACT), the duration of the activity performed (DUR) and what the actual activity was (combination of TIER1, TIER2 and TIER3).

<table>
<thead>
<tr>
<th>TUCASEID</th>
<th>AC T</th>
<th>D U R</th>
<th>TIER 1</th>
<th>TIER 2</th>
<th>TIER 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>20060101020210</td>
<td>1</td>
<td>210</td>
<td>01</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>20060101020210</td>
<td>2</td>
<td>40</td>
<td>13</td>
<td>01</td>
<td>31</td>
</tr>
<tr>
<td>20060101020210</td>
<td>3</td>
<td>40</td>
<td>01</td>
<td>05</td>
<td>01</td>
</tr>
<tr>
<td>20060101020210</td>
<td>4</td>
<td>10</td>
<td>11</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>20060101020210</td>
<td>5</td>
<td>30</td>
<td>18</td>
<td>05</td>
<td>01</td>
</tr>
</tbody>
</table>

Table 1: A Sample Data Subset [2]

Then the activities codes which are obtained from the ATUS were mapped to a supposed activity position by physically creating a mapping from the activity type to the activity location. The following table provides the information concerning the time used up by the elder in each room depending upon the ATUS data and mapping.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Room</th>
<th>Room</th>
<th>Room</th>
<th>inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1091.7</td>
<td>116.5</td>
<td>121.8</td>
<td>40.4</td>
<td>10.9</td>
<td>202.2</td>
</tr>
<tr>
<td>Standard</td>
<td>269.7</td>
<td>80.9</td>
<td>141.5</td>
<td>38.6</td>
<td>35.1</td>
<td>197.8</td>
</tr>
</tbody>
</table>

Table 2: Time (In Minutes) Spent In Rooms [2]

By using only two sensors, 59% of all activities can be detected and if the third sensor is added to the system, then it can be increased up to 85%. Thus the optimization study recognize that in order to detect maximum amount of elder’s physical activities, sensors can be placed at the doorways [1], [7]. Then, in the regression, the target is to conclude that how one can predict the distance travelled by the elders within their home, which is based on the number of passes between the doorways where the sensors are placed.

IV. SMART HOME SYSTEM FOR ELDERLY ADULTS

The idea of pervasive sensing arises in the smart home, in which a wide variety of devices or sensors incorporated in daily objects and infrastructure at home is connected by network technologies in order to collect related information about human activities. There are generally two categories of activity monitoring approaches in terms of sensor operation i.e. Audio/visual-based approach and sensor-based approach. The audio/visual-based approach involves audio and visual sensing devices, such as cameras, microphones, headphones to monitor the individual’s movements. On other side, the sensor-based approach is based on the use of sensors implanted in the smart home location or worn by the users.

Environmental sensors are used to track human activities related to particular objects or performed in particular area, while wearable sensors are used for tracking ambulatory activities.

Fig. 3.1: Architecture of activity monitoring system in Smart home system [1].

Using microphones can provide accurate information but however it may suffer from functioning complications and elevated computational costs related to the audio processing algorithms obligatory to discriminate dissimilar sounds, mainly when there are multiple inhabitants indoor. Microphones can also be perceived as privacy threats, since they can potentially record private conversations. Video cameras can perform multiple-users’ activity monitoring but however, it may face complications including privacy issues, high computational expenditure and environment dependency.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Smart home system</th>
<th>Low-cost Sensor system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Sensor Type</td>
<td>Passive as well as Active</td>
<td>Only passive</td>
</tr>
<tr>
<td>No. of Sensors</td>
<td>More number of sensors</td>
<td>3 to 4</td>
</tr>
<tr>
<td>Sensors used</td>
<td>Accelerometers, Video Microphone, Cameras, Wearable sensors</td>
<td>Doorway sensors</td>
</tr>
<tr>
<td>Privacy concern</td>
<td>Privacy is not maintained due to the use of video cameras and microphones</td>
<td>Privacy is maintained</td>
</tr>
<tr>
<td>Sensor location</td>
<td>At different objects in the surrounding</td>
<td>Doors between the two rooms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Face challenges in accuracy</td>
<td>Accurate to great extent</td>
</tr>
</tbody>
</table>

Table 3: Comparison of Smart Home System & Low-Cost Sensor System.
elders. Only few passive sensors are utilized which does not create any privacy issues. This research is committed to development of system for tracking the physical activity particularly to the requirement of the elders.

V. ADVANTAGES

This system is the unobtrusive physical activity tracking system which has the number of advantages over the other sensor systems for activity tracking.

1) This study involves the use of the passive sensors instead of the wearable sensors which in case of the aging population provides better result of tracking activities, because wearable sensors used by elders may have more probability of generating errors as accidental and unwanted body movements may occur leading to incorrect measurements, also wearable sensors may be badly chosen for the slow speed ambulation activities.

2) This study uses a very small number of passive sensors which is very cost-effective.

3) It is unobtrusive than the other tracking systems.

4) System does not affect the privacy of the residents.

VI. CONCLUSION

It can be concluded from this study that this low-cost sensor system is a trustworthy solution for tracking the physical activities of the aging adults in home by using a small number of low-cost and to a greater extent obtrusive sensors. This system does not affect the privacy concerns of the inhabitants and there is no need to pay high amount for placing the sensors. We can conclude from this research study that it is possible to place small number of sensors and to detect a large percentage of physical activities. It is also concluded that in this system, it is possible to characterize the activities patterns and the different types of individuals and the errors by varying the number of sensors and their locations.

VII. FUTURE SCOPE

Beside the aging population, the sedentary population can use the low-cost sensor system in order to track the level of their physical activities to make them aware about their physical conditions and to take the corrective measures to overcome the physical health issues. Beyond the aging population, this system can also be used to monitor the activities of the person at home after any surgery in order to determine the improvement in health of that person. This system can also be used to track the movements of the patient at home post-accident to track the recovery and progress in the physical functions.

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