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Video Monitoring System for Identifying the Well Being of Elders at Home: A Survey

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Abstract - *This article examines the use of pervasive computing for the provision of care in the community for frail older people living alone in their own homes. The concept of well-being is explored using a conceptual framework that incorporates person, context, everyday activities, personal meanings, and well-being outcomes. The article reviews the implications of this model for developing a practical system within the home of an older person using nonintrusive pervasive sensors and computing devices to monitor indicators of his or her well-being. The data from sensors in the home can be used to detect trends in 6 key activities, which might be indicators of changes in the functional, psychological, and social status of the person. The aim of the well-being monitoring system is to provide care workers and carers with an intuitive early warning system to allow appropriate care interventions, leading to improved care services and an enhanced quality of life for the individual.*

Key Words: **Aging, care monitoring, care giving, computer vision; action recognition; assisted living; well-being.**

1. INTRODUCTION

Many elderly people require regular assistance for their daily living and healthcare. There is an increased awareness in developing and implementing efficient and cost-effective strategies and systems, to provide affordable healthcare and monitoring services particularly aimed at the aging population .Aging in place is the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level .

Allowing elderly people to maintain their quality of life as they get older and as long as possible in their homes is important both for the person as well as for the sustainability of public health care systems. According to the "World Population Prospects 2019: Highlights" of the United Nations in 2018, for the first time in human history, people aged 65 years or over outnumbered children under five years of age worldwide. The projections indicate that in 2050 there will be more than twice as many older people as children under five. If the aging trend is confirmed, there will be fewer people to take care of the elderly in the distant future. Assisted living technologies can be of great importance to take care of elderly people and help them to live independently. One way to achieve this is to monitor the activities of the elderly in a continuous fashion to detect emergency situations as soon as possible. For example, using ambient or wearable sensors it could be possible to analyze the daily activity of the person and detect if any activity s outside normal activity patterns. Also, it could be possible to prevent health issue by monitoring the person's behavior with respect to dehydration and lack of food intakes.

2. LITERATURE SURVEY

In the following section we present a review of literature approaches on the problem of action-based monitoring at home. The objective of this article is to focus on techniques and methodology used to recognize human activity and pattern. This paper provides a comprehensive survey of the recent developments in human activity analysis. It thus contains many new references not found in previous surveys. The organization of this paper covers all aspects of the general framework of the human activity recognition.

3. METHODOLOGY

3.1. Ambient Assisted Living Systems

Several surveys in the literature describe recent trends in smart homes aimed at assisted living systems. These monitoring systems can use exclusively ambient sensors (i.e., RGB and/or infrared cameras) to limit user discomfort as much as possible can use wearable sensors if health parameters need to be monitored or can exploit different modalities at the same time The following systems make a pervasive use of ambient and wearable sensors. Necessity is an ambient assisted living system, which monitors the states of the elderly (out, active, inactive, resting, sleeping and inactive anomalous), through different ambient sensors (pressure, door and activity) scattered into the environment. Both present an elderly healthcare system aimed at monitoring different activities using body sensors. A significant issue for systems based on body sensors is the need to apply them onto the subject, for better accuracy or to detect more actions or activities. This can be considered a critical aspect because wearable sensors can lead to physical discomfort for the user. A different kind of sensor, less invasive and more discreet, is used in the system presented by, which can both track and detect the fall of elderly people using smart tiles. Regarding video-based systems, ref.propose a method for human posture-based and movements-based monitoring, limited however to only 5 postures (standing, bending, sitting, lying and lying toward) and 4 movements (running, jump, inactive, active). Moreover, different from existing solutions in the literature, our system is carefully designed to support the recognition

and monitoring of a wider variety of actions, including status, different alerting situations as well as daily life activities. These actions have been specifically selected for monitoring elderly people at home.

3.2. Action Recognition Methods

Activity recognition is a well-known process and is one of the most promising research topics for context-aware computing and ambient assisted living. It aims to detect or recognize human activity and behaviour patterns in real-life settings (Kim et al., 2010a). Thus, it becomes an essential element for many health applications, such as automating human behaviour monitoring for the elderly people. As mentioned previously, human's behaviour in daily activity is complex and highly diverse. So too is the challenge of monitoring such activity. These challenges are outlined in (Kim et al., 2010a) and are: (a) recognizing concurrent activities: performing several activities at the same time, (b) recognizing interleaved activities: activities that are overlapped with others in real life, (c) ambiguity of interpretation: similar actions may be interpreted differently based on the context, and (d) support of multiple residents: recognize the activities performed in parallel by the occupants in a group. Many advances have occurred in human behaviour recognition. In the literature, different approaches, methods, and algorithms have been proposed and improved upon. Generally, the activity recognition field comprises many different topics such as activity modelling, behaviour, and environmental monitoring, data processing and pattern recognition. Hence, in practice, the recognition of activities (Chen and Khalil, 2011) can be roughly characterized by the following four basic tasks.

1) The use of appropriate sensors in the subject's environment to capture environmental changes and to monitor and capture the behavior.

2) The collection and processing of perceived information through aggregation and fusion of data to extract high-level contextual abstractions.

3) The design of computational activity models in a way that allows software systems and agents to conduct reasoning and manipulation.

4) The design of methods and algorithms to efficiently infer activity from sensor data..

3.3. Detection of behavior patterns

Detecting anomalies in human behavior, when performing daily activities and monitoring well being is another challenging task.

This process is heavily influenced by methods that get applied for performing detection, choosing sensors and extracting features. We now summarize the main challenges regarding human behaviour and health monitoring systems.

1) Defining normal behaviour is difficult. The boundary between normal and abnormal behaviour is often blurred. Some borderline abnormalities can actually be considered normal and vice versa.

2) By its very nature, human behaviour is irregular and constantly changing. Thus, normal behaviour today may not appear normal in the future

3) Anomalies varying depending on the subject's nature and situation. For instance, some behaviour and vital signs could be abnormal for one subject and not so for another.

4) The use of appropriate methods for detecting anomalies requires training, which can because major issues.

5) Data coming from sensors is often incomplete or contains noise, which in some case is similar to real anomalies. This makes the process more difficult. Consequently, increased processing is required to clean the data.

3.4. Action Grouping

As reported, not all the actions have the same duration, alert level or movement type. Considering these characteristics, we have implemented a conceptual grouping that resulted in three different action groups. The identified action characteristics are the following: “Long” property means that actions actually can be performed in a long range of time, vice versa “Short” suggests that the actions can be executed quickly in a small amount of time. “Warning” property denotes actions that might represent a potential warning the subject, the opposite “Common” represents common actions that do not show potential danger situations. Starting from datasets that provide the requested actions, we created three different groups of actions: Status, Alerting and Daily-life.

Applying predictive and analytical methods to such data helps to provide more specific knowledge about the subject's health. This can help in understanding when to notify caregivers if there is a high probability that the subject's health is likely to decline. Predictions are useful in automating the process of understanding the subject's normal behaviour. This, in turn, can be used to detect irregularity or any deviation in the behaviour of the subject.

3.5. Design of the Monitoring System

In this section, we design and present a system for monitoring elderly subjects, based on the proposed monitoring approach, set of actions, collected datasets, and trained action recognition model, described in the previous Sections. We will start by defining the high-level goals of such system, in order to gradually refine them in terms of features of a client-server application

The typical end-user, called a “guardian” in the following, is a person in charge of monitoring subject who can take care for him/her-self, but who is at high risk of domestic accident

when living alone. The main goal of our application is to give the guardian an effective exploration of the events regarding the monitored subject. Specifically, the application should satisfy the following set ofrequirements:1.A quick and intuitive way to reach the desired information. If the guardian has a precise idea of what he/she wants (a specific timestamp for example).2.A synthetic yet exhaustive abstraction of the detected events. If the guardian is broadly exploring a given time range.3.Timely notifications for situations of interest. The application should actively reach the guardian when specific conditions are met.

ACTIVITY PATTERN DISCOVERY

Complementing the idea of activity recognition is automatically recognizing activity patterns in an unsupervised fashion. Tracking only preselected activities ignores important insights that other discovered patterns can provide on the residents' habits and the nature of the environment. In addition, recognizing and tracking automatically discovered activities eliminates the need to prelabel data and use it to train recognition algorithms.

Model-Based Daily Routine Discovery

One intuitive way to find a daily pattern is to build a hierarchical activity model. The lower-level activities, such as sitting, standing, eating, and driving, are recognized using a supervised learning algorithm. The higher level of the model discovers combinations of the lower-level activities that represent more complex activity patterns.

In the topic model approach to activity pattern discovery, 3 activity patterns are recognized similar to the way topics can be pulled from a document using a bag-of-words approach. A mixture of topics can be modeled as a multinomial probability distribution p(z|d) over topics z. The importance of each word for topic z is also modeled as a probability distribution p(w|z) over words in a vocabulary. Where d is document, w is word, and z is topic, this equation shows the word distribution that's expected for a set of topics:

$$p\,w\,d\,p\,w\,z\,p\,z\,d\,z\,T\,(\,)\,|\,=\,(\,)\,|\,(\,)\,|\,=\sum 1\,.$$

Activity patterns can be similarly discovered and topicword distributions, where words correspond to recognized activities and daily routines, correspond to topic activation

Activity Data Pattern Discovery

An alternative approach to activity pattern discovery is to visually observe activities and extract individual poses from video data. Activities can then be represented by constructing probabilistic context-free grammars using the poses as the grammar alphabet.

Next, specific classes of rules are extracted from the data that represent repeating sequences of poses and complex combinations, as shown in Figure 6. For example, the kick activity is composed of three pairs of poses, denoted as q1 through q3 in Figure 6 (left). If the kick activity is combined with a recognized object such as football, the combination corresponds to a more specific activity that can be recognized such as play football.

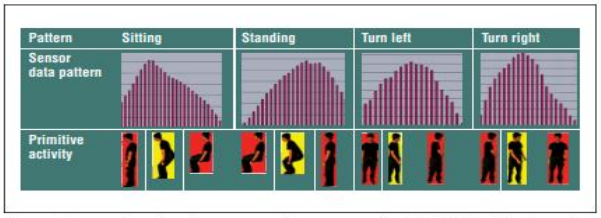

Figure 5. Extraction of motion patterns from sensor data.[6] Each video key frame is composed of three primitive poses.

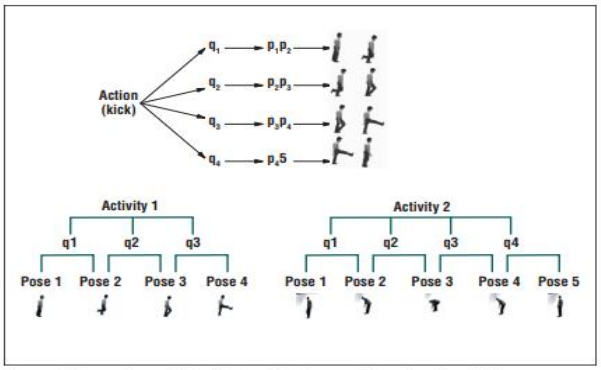

Figure 6. Composite activities.[6] An activity is a combination of multiple poses according to a sequence rule.

Once activities are discovered, they can provide the basis for a model to recognize the activity, track its occurrence, and even use the information to assess an individual's wellbeing or provide activity-aware services. These activity discovery and recognition technologies are thus valuable for providing pervasive assistance in an individual's everyday environments.

Activity and pattern recognition research can benefit significantly from a community effort in which collected activity data is shared and made easily accessible. One effort in this direction is a project hosting longitudinal home activity datasets as a shared resource. The project aims to create a new community database of the various data sets structured as dense, multimodal sensor records of people living in homes that have been instrumented with a sensing infrastructure.

4. CONCLUSION

The well-being monitoring system outlined in this article represents an example of emerging "third generation" telecare systems that exploit the potential of pervasive computing. These kinds of systems represent potentially important avenues for the development of new technology-based services in the context of ageing populations across the world. The need to serve larger numbers of frail and care dependent older people, while at the same time enhancing quality and extending consumer choice, is a major driver

within this market. The specific aim of this article has been to outline a conceptual framework to guide the development of a prototype wellbeing monitoring system that will provide targeted information that can be used by professional carers, family carers, and older people themselves to help them remain independent and enjoy a good quality of life.

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