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Development and implementation of a sensor-based monitoring system for the prevention of the elderly social isolation

Ghazi Bouaziz

LAAS-CNRS, University of Toulouse, CNRS, UPS, Toulouse, France

Abstract: Social isolation is likely to be one of the most impacted health outcomes for the elderly due to the COVID-19 pandemic, particularly for those living alone at home. Therefore, we try to identify this by detecting changing behaviors in the elderly through the meal intake and mobility. In this paper, we present a sensor-based monitoring system that allows automatic identification of (1) meal-taking activity (shopping, cooking, eating and washing dishes) and (2) mobility (within the home and when going out).

I. INTRODUCTION

All countries in the world are going through the demographic transition, the population ageing, due to the huge advancement in the medical field, and the improvement of economic and social fields. Indeed, people aged 65 and over will represent 16% of the world population in 2050 according to the UN (United Nations) [1]. Given this significant increase, providing security and support to this population is a growing concern, as the elderly face the problems of the appearance of risks of physical, cognitive and relational degradation. Indeed, the French association “Petits Frères des Pauvres” has made a report, in 2021 on “the barometer of loneliness and when over 60 in France” [2]. It points out that 530,000 adults aged 60 and over are socially isolated in 2021 (compared to 300,000 adults in 2017). The main factor that explains this increase is the Covid-19 pandemic, including its strong impact on the lives of older people, its duration and health restrictions to limit social interactions.

Social isolation is defined structurally as the absence of social interactions, contacts, and relationships with family, friends and neighbors at an individual level, and with society in general at a broader level [3]. Social isolation for an elderly is a risk factor for malnutrition [4] and reduced his/ her mobility [5]. Thus, we focused on two activities of daily living (ADLs) likely to predict social isolation through behavioral drift: (1) the meal taking activity (shopping, cooking, eating and washing dishes) and (2) mobility (inside home and the act of going out). The automatic classification of these ADLs can be challenging since every person maintains his own rhythm to do it, especially the meal-taking activity process. To address these

challenges, we are working on a monitoring system based on miniaturized sensors distributed in the person’s living environment to detect changes their behaviors (whether it happens suddenly or slowly over time), then to propose an intervention in adequacy with the behavior, the capacities of the person and his context of life.

Our work deals with the following issues: (1) Continuous and longitudinal monitoring through the deployment of low-cost, and non-intrusive sensors in the elderly’s home; (2) Automatic identification of the processes related to home mobility and meal-intake. A learning phase is conducted to model the behavioral pattern; (3) Establish the link between these two activities and the social isolation, that has been reinforced with the global COVID-19 crisis. This problem has been highlighted especially among seniors living alone.

II. BACKGROUND AND RELATED WORK

The desire to live independently at home is increasing dramatically among the elderly due to attachment to their homes and the cost of nursing care. With increasing advances in monitoring system technology, seniors can stay in their homes and their families feel safe. Different studies in Ambient Assisted Living (AAL) are based on different ADLs, such as bathing, grooming, eating... In this study, we focus on systems related to two main ADLs that we assume they could be related to social isolation: the process of having meals (from food shopping to dishwashing) and mobility (within the house and the act of going out).

Huynh et al. [6] proposed a system consisting of two types of non-intrusive sensors: a passive infrared (PIR) sensor in each room and a reed

switch to detect the opening and closing of the main door. After a real deployment of the system in 50 flats of elderly people living alone and the completion of a mental health and loneliness survey, this study showed that the system can detect the outing behavior of the people and identify the potential candidates with severe loneliness and depression based on the ratio of time spent inside and outside the flat. Cippitelli et al. [7] presented a solution to monitor the eating and drinking actions of elderly people. It is based on using a depth and RGB camera placed on the ceiling. The depth information is applied to track the person's movements and the RGB stream is used to recognize specific elements found on the table during eating-related activities, such as glasses. The fusion of these processed data leads to the identification of specific intake behaviors. Experimental tests reveal the system's ability to recognize intake actions.

While all these studies use several types of sensors and focus on monitoring ADLs, we consider them as an intermediate step to assess the social isolation status of the elderly. In addition, the user acceptance of the monitoring system is a compromise between the user needs and perception, especially with regard to privacy. A study conducted to get older people's perspectives on the use of sensors [8] indicated that surveyed seniors evaluated sensor monitoring positively as it provides them with a sense of safety which is an important premise for independent living. Therefore, this paper explores the possibility of an unobtrusive and passive sensor system to assess the social isolation status of the elderly based on the meal-taking process and mobility.

II. MOBILITY AND MEAL-TAKING ACTIVITY

A. Mobility

Mobility is defined as the ability to move freely or be moved easily. Mobility is important to an independent and self-sufficient lifestyle. Regular mobility and activity, even mild physical activity such as walking, improves mental and cardiovascular health, controls weight, keeps healthy bones and muscles, reduces the risk of falling and increases social interaction [9].

B. The meal-taking activity

Recognition of eating activity is important for monitoring the health of the elderly. Good nutrition has a significant impact on physical health, memory and mental function. As people age, good nutrition can boost immunity, fight disease-causing toxins, control weight, and reduce the risk of heart disease, stroke, bone loss, Alzheimer's disease ... [10].

III. Our proposition

The choice of sensors used in our system meets the requirements of a home environment and the elderly expectations: miniaturized and wireless sensors, unobtrusive, low intrusive, easy to install, without any intervention of the elderly themselves, and long-term battery capacity. Given these constraints and based on previous works, we proposed to use three types of sensors: passive infrared (PIR) sensors, reed sensors and power meter sensors. Each room in the house is covered by a PIR sensor, with the addition of three PIR sensors above the sink, oven and dining table. Reed switches are installed on the front door, fridge and one cupboard. The power meter is implemented on the most used electrical appliances according to the person's use such as TV, toaster, microwave... A Raspberry Pi with a Z-wave gateway collects data from the sensors via the Z-wave protocol. The Raspberry Pi uses DomoticZ: a home automation software to collect and store the data sent by the sensors through the mesh network using the Z-wave wireless module of each sensor. Our algorithm analyzes the data and detects the targeted ADLs. Figure 1 shows activities detected by the algorithm, based on the features of each activity during a weekday and the activity pattern reported in the survey. The survey contains information about the activities performed by the person during a standard day. It shows the targeted ADLs such as preparing food, eating, washing dishes, going (out of the home) and other activities. Other activities are those that differ from the targeted activities, such as playing the piano, cleaning the table after eating, etc.).

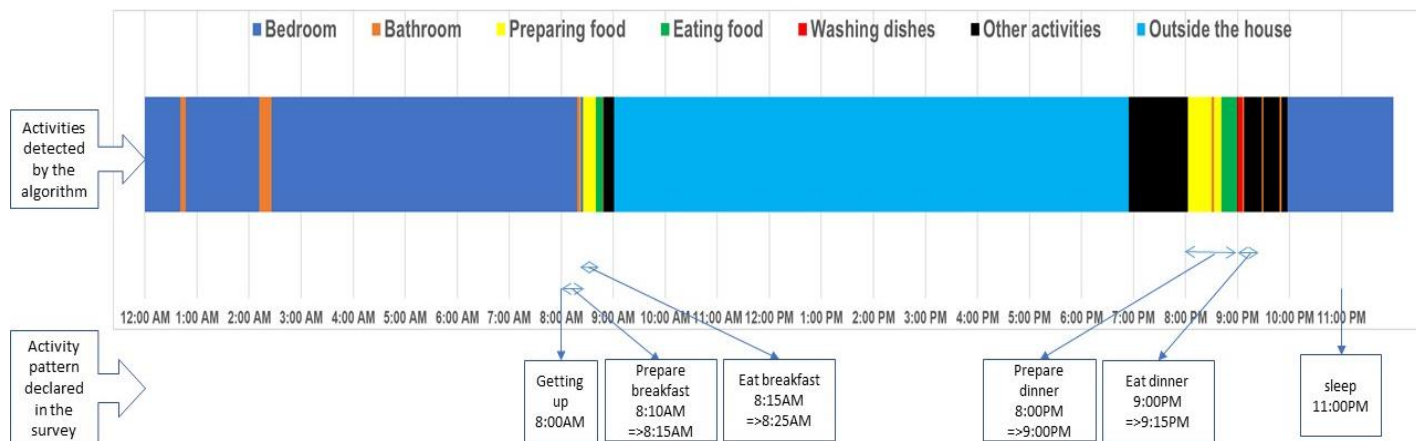


FIG. 1. Example of activities detected during a week day and activity pattern declared in the survey

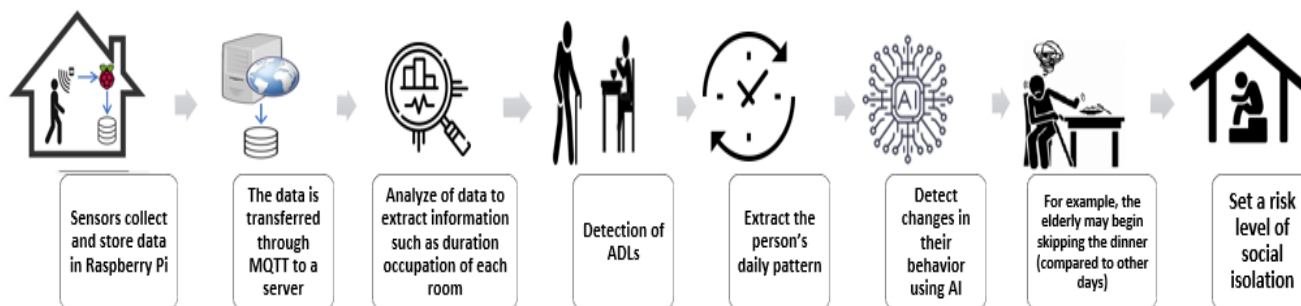


FIG. 2. Different steps of the process monitoring

Getting this information provides a good overview of the person's daily pattern. Each activity has duration, a start and end time, a location and even a sequence of actions. These parameters define the behavioral pattern which is recalculated daily by a sliding window over the last 7 days. Deviations in the realization of activities from the model trigger an alert with a risk level on the social isolation. Here, only the mobility, i.e. the movements, and the process of taking meals are aggregated to determine the level of risk. Figure 2 describes the different steps of the process analysis.

V. CONCLUSION

In our study, we presented a sensor monitoring system composed of PIRs and reed switches sensors to monitor the activity patterns of people at home. The system aims to automatically identify meal-taking activity and mobility to detect social isolation of the elderly at an early stage. Currently, we are developing artificial intelligence for automatic ADL identification. The system is being deployed in the homes of elderly people living alone. A decision-making support will detect cases with abnormal patterns that may be related to a social isolation problem.

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