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# Smart house to detect meal-taking activity and mobility of elderly

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According to the UN (United Nations), people aged 65 and over will reach 1.5 billion in 2050[1]. Securing and supporting this population is therefore a growing concern, as advancing age encourages the appearance of risks of physical, cognitive and relational degradation. Indeed, an American report from the National Academies of Science, Engineering, and Medicine (NASEM), carried out before the COVID epidemic in 2020, points out that 24% of adults aged 65 and over living in the United States (i.e., approximately 7.7 million people) were socially isolated[2]. In fact, what each person experienced during this COVID-19 crisis period is what many elderly people experience throughout the year.

While social isolation and loneliness are closely related, they do not mean the same thing. According to the UK's National Institute for Health Research, isolation is a lack of social contact or support, whereas loneliness is the feeling of being alone and isolated (it is possible to feel lonely in a room full of people)[3]. Social isolation in the elderly is a risk factor for malnutrition[4], impaired mobility[5] and physical frailty[6].

Moreover, the desire to live independently at home is increasing among the elderly due to attachment to their home and the cost of nursing home care. The report of the French association "Little Brothers of the Poor" indicates that 84% of adults aged 60 and over express a strong desire to age in place[7].

However, it is often difficult for both older adults and their loved ones to detect changes in behavior that require intervention, whether in the area of safety or motivation. Therefore, by using the growing advances in technological monitoring system, the elderly can stay in their homes and their families feel safe.

In our work, we focused on the technological monitoring of two activities of daily living (ADLs) that seem relevant for a prediction of social isolation by detecting behavioral drifts: (1)meal-taking activity (shopping, cooking, eating and washing dishes) and (2)mobility (inside the home and the act of going out). Automatic classification of these ADLs can be challenged since each person has his/her own rhythm to do it especially for meal-taking.

To address these challenges, we are working on a monitoring system based on miniaturized sensors distributed throughout the person's living environment to detect changes in behavior (whether sudden or slow over time), and then propose an intervention based on the behavior, the person's abilities and their living context. For example, an elderly person may begin skipping the dinner (related to other days), the system notifies the caregivers/family of the situation and sends reminders to the elderly at the usual lunchtime to motivate them to eat.

Our work focuses on the following issues: (i) Continuous and longitudinal monitoring through the deployment of low-cost, unobtrusive, non-intrusive and miniaturized sensors in the individual's home; (ii) Automatic identification of processes related to home mobility and meal-taking. A learning phase will be carried out to model the behavioral pattern of individuals; (iii) Establishing the link between these 2 activities and social isolation, a phenomenon that has been reinforced with the global COVID-19 crisis. This problem has been highlighted especially among seniors living alone.

The choice of sensors used in the system meets the requirements of a home environment and the elderly expectations: miniaturized and wireless sensors, unobtrusive, non-intrusive, easy to install, not requiring the intervention of the elderly and a long-term battery capacity. Considering these constraints, we chose three types of sensors: Passive infrared sensors (PIR), the reed sensor and the power meter sensor.

Each room in the home is covered by one PIR sensor with the addition of three PIR sensors on top of the sink, oven and dining table. The reed switch sensors are installed on the front door, refrigerator and cupboard. The power meter is connected to the most used electrical appliances according to the person's habits such as TV, toaster, microwave... In addition, a Raspberry Pi pack with a Z-wave gateway collects the sensor data via the Z-wave protocol.

The analysis of data collected during 15 days of follow-up of a 26-year-old student living alone allowed the detection of meal-taking activity (shopping, cooking, eating and washing up), mobility (inside the home and the act of going out) and the difference in daily pattern between the weekend and weekday.

The system aims to automatically identify meal-taking activity and mobility in order to identify the social isolation of the elderly. It will respond to each case accordingly to the level of change in their behavior by motivating them to eat and move around and triggering an alert in case of a problems.

In a next step, we will use AI for automatic identification of ADLs, perform tests in the homes of elderly people living alone and detect those cases with abnormal patterns likely to be linked to social isolation problem.

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