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A Real time Nursing Care Assistance in Intelligent Space using Task Activity Recognition

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Abstract - There is a lack of careers in Japan because of the rising ageing of the population. Thus, the itch has become a serious societal concern. “Information and communication technology (ICT) solutions have been developed in response to this to aid caretakers. Because of this, there are only so many tasks that can be supported. Caregivers must also devise a nursing strategy that takes into account the diverse health conditions of those they are caring for. This necessitates highly trained careers, which in turn raises the cognitive strain on them. Our goal in this project is to develop an assistance technology that will lessen carers' cognitive load and boost their productivity. For the most part, we use the iSpace (intelligent Space) idea to implement help that is based on observations made by caregivers and recipients of that help. The first step is to identify the current state of a task. Task activity recognition is the topic of this research. We believe that the tasks performed by nursing home staff are closely linked to their physical locations. To this end, we've devised an approach that uses a caregiver's current location and orientation in relation to predefined workspaces to estimate their current job activity. In addition, the prospective workspaces should be automatically extracted to broaden the applicability of this technique. In addition, we offer a technique to extract caregiver workspaces based on hierarchical clustering of caregiver movement trajectories. Experiments have shown that the caregiver's job activity may be reliably detected, as well as the possible workspace of the caregiver.

I. INTRODUCTION

In the developed world, an ageing population has emerged as a major social issue in recent years. This is due to the fact that as living standards and medical technology have improved, so has life expectancy and the ageing process. As one of the world's most developed nations, Japan has been dubbed a "super-aging society." This equates to a 65+ population of at least one in four people, or 27.7% of the total population. Elderly people over the age of 65 are expected to make up about 40% of the population by 2065 [1].

As the number of people over the age of 65 continues to rise, so does the need for elder health care. A chronic shortage of caregivers plagues the country's more than 45,000 facilities dedicated to caring for the elderly. With so many elderly people living in the facility, there's a lot of work to be done, including caring for each one's individual needs, cleaning, and completing daily reports. To put it another way, as a result, many caregivers experience stress as a result of working conditions and interpersonal relationships [2]. In addition, caregivers are under a lot of pressure because of the amount of work they have to do.

Research on information and communication technology (ICT) systems has been performed in an effort to ameliorate this situation. Several ICT systems utilise cameras and wearable sensors to monitor the behaviour of old people and identify accidents and odd circumstances, which helps reduce senior mishaps such as falls [3] [4]. The results of these earlier research, however, only apply to a small subset of activities and cannot be generalised to cover a broader variety of tasks. Therefore, it is not a basic answer to concerns such as a growth in the amount of duties that a caregiver is expected to do.

Nursing responsibilities must be arranged in accordance with the needs of patients in different stages of health. As a result, the cognitive strain on caretakers is increased. As a result, a system is required to assist caretakers with a variety of activities.

In this research, we want to develop a system that will ease the cognitive load on caregivers while also increasing the effectiveness of nursing care. Consequently, we concentrated on the intelligent space (iSpace) [5] (Fig. 1) notion. Human actions are supported by sensors and actuators dispersed throughout the iSpace. Information in the area may be measured using sensors like cameras, laser sensors, RFID tags, and actuators like displays and mobile robots [6] [7]. Robots are anticipated to offer knowledge and physical assistance to carers and care receivers in accordance with their current conditions. Caregiver productivity is projected to increase as a result of this.

Task recognition is necessary for the implementation of such a system.

Caregiver tasks may be described as a series of acts relating to the job at hand. As an example, a caregiver may aid in moving a patient from a bed to a wheelchair by doing such things as holding the patient in their arms, shifting them from the bed to the wheelchair, and then releasing them from the wheelchair again. A task activity and a task action are defined in this article as a complete task and a specific task action, respectively.

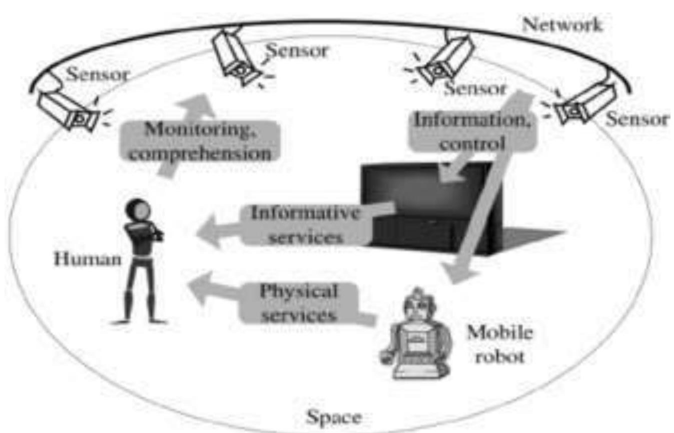

Figure 1. Intelligent Space Design [5]

A number of experiments have shown that deep learning can accurately identify human behaviours [10] [11]. There are a few issues with applying these strategies to support systems in this case. Individual variations in physique and task skill may affect the efficacy of these strategies. Furthermore, these systems are unable to execute real-time support operations because of their high processing costs. An appropriate task activity recognition approach for caregiver support systems is thus required..

In this case, we're going to suppose that the tasks performed by the caregiver are tied to a specific location in the care facility. Based on how the caregiver's position and orientation are defined in advance, we

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propose an algorithm to determine the caregiver's task activity based on their position and orientation. A spatial memory system is introduced in the iSpace platform to describe and identify task activity in an actual environment.

Adding automatic extraction of potential workspaces would broaden the applicability of this strategy. In order to deal with this, we also propose an approach based on the hierarchical clustering of the movement trajectories of caregivers to extract the potential workspaces of caregivers. We test the efficacy of all of the approaches we've come up with.

The following is the outline for this document. A caregiver's task activity is determined depending on his or her location and orientation in section II. Using hierarchical clustering of caregivers' movement trajectories, we describe an approach to extracting potential workspaces in section III. Our suggested methodologies were tested in parts IV and V. In Section VI, the findings of this research are summarized.

II. SPATIAL MEMORY

A Overview of Spatial Memory

Caregivers should be able to use the care support system's ability to understand their current task status and deliver support activities tailored to their requirements. For this reason, we used a spatial memory as the care support system.

Users may control a variety of digital information and networked devices via a single interface provided by a spatial memory. In order to handle digital information in real-world context, the system associates the information with a 3D location.

By moving their bodies, users may indicate their location in real time to access digital information. To put it another way, the spatial memory allows users to physically interact with digital information or transmit orders to different devices by moving their bodies. In this way, a spatial memory is likewise considered a cyber-physical system. The activity record of users in the environments is recognised as an access log for the spatial memory.

Spatial-Knowledge-Tag is the term given to digital information stored in the spatial memory (SKT). Space-related data may be stored in an SKT. The user's movement is recognised by the spatial memory, which then delivers information about the space when the user touches an SKT.

For the purpose of supporting human activities, numerous facilities (such as retail shops and parts assembly factories) have been used in research on the spatial memory system [13][14]. Sales and productivity have been improved as a result of using spatial memory systems. As a result, the use of the system is anticipated to lessen carers' cognitive load and enhance the effectiveness of their job.

As seen in Fig. 2, the spatial memory is used in this investigation. The positional link between the SKT and the caregiver is used to identify the caregiver's task activity. An SKT positioned near a bed, for instance, may detect when a caregiver is executing a task activity associated with that area since it is within range of the SKT. It is quite likely that the caregiver's task activity will be mistakenly identified if task activity detection relies only on the caregiver's location. As a result, we pay special attention to the carers' direction throughout the work.

We may infer that the caregiver's interest in the job was strongly tied to the actions performed on the job. Based on the location and orientation of carers in an SKT, we present a task activity recognition approach that may be used to identify the activities of caregivers.

B Task activity recognition

This section explains how the SKT may be used to identify task activity. The two requirements of the suggested technique are as follows: The caregiver's role plays a role in one of the illnesses. Another factor to consider is the direction in which the caregiver is looking. Using mathematics, we shall describe each task activity recognition condition.

The variable accessp, which can be derived from the equation, is required for the determination of task activity recognition criteria based on location (1). The caregiver's location coordinates (xc, yc, zc) are checked to see whether they fall within the parameters of SKT I (xi,min, xi,max, yi,min, yi,max, zi,min, zi,max). Caregiver proximity to SKT I is taken into account when $access_p$ is substituted for SKT id I when a caregiver is within the SKT i's range.

$$access_p = \begin{cases} i, \text{ if } x_{i,min} \le x_c \le x_{i,max} \text{ and } y_{i,min} \le y_c \le y_{i,max} \\ \quad \text{and } z_{i,min} \le z_c \le z_{i,max}, \\ 0, \text{ otherwise.} \end{cases} \quad (1)$$

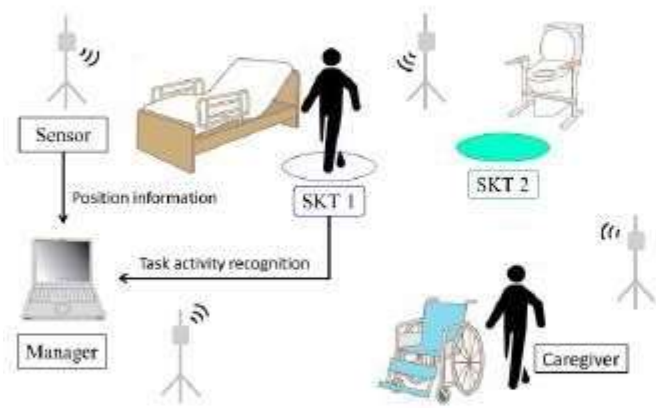

Figure 2. Proposed system overview

In contrast, the variable accessd, which can be derived from the equation, is required to identify the task activity recognition depending on the caregiver's orientation (2). Caregiver angle ac is measured in this situation to assess if it falls within a range (ai,min – max) for entering or exiting the SKT I. The term "angular area" refers to this range of angles. If the caregiver's orientation is inside the angular region, the system decides that the task activity has been begun or finished in that space and assigns the SKT id I to $access_d$.

$$access_d = \begin{cases} i, \text{ if } a_{i,min} \le a_c \le a_{i,max}, \\ 0, \text{ otherwise.} \end{cases} \quad (2)$$

Each of these situations has a specific time and place. In order to determine a caregiver's task status, the system employs the task activity recognition based on the following conditions: When the caregiver enters and departs the SKT, the system employs task activity recognition based on condition (2) to determine the state of the caregiver's task activity.

Accessp and accessd are used to identify the caregiver's task activity in the suggested technique. First, the system compares the variables a and b. The system looks for an SKT whose ID number matches the value of these variables if they are the same. A task may be connected with an SKT if they are found to match. As an alternative, if all of these conditions are not satisfied, the system determines that the caregiver was conducting an unrelated activity. Even in the same working environments, the suggested technique allows for the identification of various task activities.

III. EXTRACTION OF WORKSPACE

Task activity recognition may be applied to a broader variety of scenarios using our technology. In order to identify the caregiver's task activities, it is important to designate the workspace as SKT in preparation. Because of this, we have developed a technique for automatically extracting caregiver workspaces based on the clustering of caregiver movement trajectories.

Using hierarchical clustering, this research was able to identify a large number of prospective workplaces (clusters). Hierarchical clustering may be approached from the bottom up or the top down. We employ a bottom-up approach in our work, which allows us to quickly discover the whole structure. Furthermore, the Euclidean distance, which is often employed to express the dissimilarity across individual datasets, is utilized. When two points I (xI, yI, and zi) are separated by the Euclidean distance diJ from one other, the distance is represented as (3).

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2} \quad (3)$$

The shortest distance technique is used to compute the distance between groups of different data using a cheap computing cost. W is the new cluster formed by merging the two clusters u and v into one. As a result, we may represent the difference Dwt between the cluster w and any other cluster t in terms of their differences, which are stated as follows:

$$D_{wt} = \min(D_{ut}, D_{vt}) \quad (4)$$

If an integrated cluster has more than three points, it isn't worth considering as a possible workplace. Using this method, the caregiver's possible workplaces are removed from the rest of the prospective workspace clusters. In statistics, a filter variable is a numerical value used to limit the amount of data points that are included in a certain statistical cluster. The number of points in a cluster has little bearing on the usefulness of a cluster as a workspace, but this filter variable does.

IV. Results and discussion

For this experiment, we are testing the accuracy of the suggested approach for recognising task activity in the real world. Fig. 3 depicts a test setup resembling a nursing facility room where we performed the experiment.

A Dataset

Fig. 3 illustrates the location of the caregiver during the transfer task, and this dataset includes the caregiver's position and orientation. In the experiment, the cared-for individual was transferred from their bed to a wheelchair and then back to their bed. motion analysis corporation MAC3D System was used to collect this data. "Osprey" and "Raptor" cameras from Motion Analysis Corp. are employed in this system. A sample period of 0.01 s and a measurement inaccuracy of 1.0 mm are the specifications of this system. In

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addition, the experimenter labels each observed caregiver's position coordinate and orientation according to Table I. Ten datasets collected under these conditions are used in this experiment.

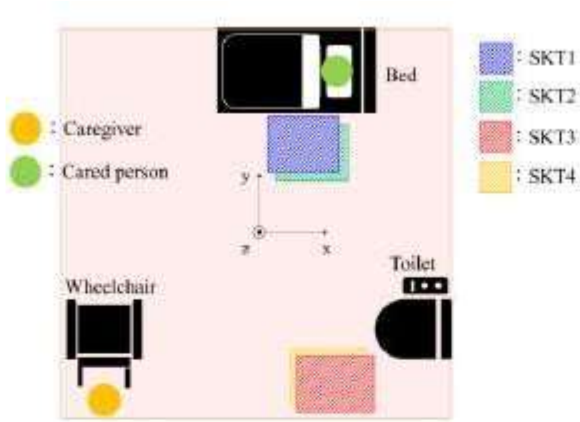

Figure 4. Experimental environment

TABLE I. TASK LABELS

Task Labels	Assisting the transfer of elderly people	SKT ID
Task 1	from a bed to a wheelchair	SKT 1
Task 2	from a wheelchair to a bed	SKT2
Task 3	from a wheelchair to a toilet	SKT3
Task 4	from a toilet to a wheelchair	SKT4
Task 5	Other operations	

B Conditions of the experiment

This system's utility is tested by comparing it to four different task activity recognition situations (A through D). SKTs and angular areas are determined in this experiment by referring to the location and direction of each measurement. The SKTs are set up in the manner seen in Fig. 3. Also indicated in Table I, each SKT is paired with a task label that identifies the task activity. Evaluation items in this experiment include task activity recognitions, labelled task activity times, and system-determined task activity times.

The caregiver's position coordinates and orientation were the two kinds of datasets utilised in this experiment, comparable to the dataset used in Section IV. Section IV's dataset is utilised in one of the datasets in Section V. This dataset is referred to as group I, whereas group II is referred to as group II. Group II was seen to begin the task activity at a different place.

C Conditions of the experiment

Two kinds of data sets are employed in this experiment to test the applicability of the suggested strategy. Experimentation is used to determine the values of the threshold and the filter. Variables for threshold and filter are 5.0 mm and 400, respectively.

A caregiver's prospective workstations at the institution were discovered as a consequence of the study. Additionally, prospective workstations and non-task-related locations were separated.

V. CONCLUSION

As part of the caregiver support system, this article developed a task activity identification technique and a workspace extraction technique. Tests were performed to see whether these two approaches were effective. The findings of the task activity recognition experiment reveal that the caregiver's position and orientation may be used to identify the task activity. It was found that the suggested strategy of locating prospective carers' workspaces was successful in the workspace extraction experiment, however.

Each suggested solution will be improved in the future in order to produce a support system that reduces the cognitive load of carers and improves job efficiency. For example, the workspace extraction technique will be enhanced such that prospective workspaces may be inserted as SKT and the angular area can be determined automatically from the angle of each SKT. In contrast, the approach for identifying work activities will be upgraded in order to better identify work activities and to recognise more specific work actions. These two technologies will eventually be integrated into a care support system that uses spatial memory.

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