Detecting Dull Features from Action Logs of Elderly

Naotaka Sato, Fumiko Harada, and Hiromitsu Shimakawa

***Abstract*—The stronger the trend towards nuclear families gets, the more elderly live without younger people who take care of them. It makes the elderly feel isolated and less active. The decrease of the activity weakens their muscle strength. There are many factors to prevent them from independently living. We need a method to confirm those elderly keep good health conditions enough to spend daily lives independently.**

This paper proposes a method to detect abnormal features from the elderly life logs. We use life logs indicating where he is and what he touches. Abnormal symptoms can be detected with the comparison of daily life logs with the derived features. Through an experiment, the proposed method has detected 4 features of dull arm and 2 features of dull leg. One feature means attributes common to objects which he does not touch when he feels his dominant arm dull. Another means attributes common to objects which he touches with his nondominant arm when he feels his dominant arm dull. In addition, the proposed method has detected that his steps increase and his length of stride is shorten in cleaning when he feels his leg dull.

***Index Terms*—The elderly abnormal features, RFID, life log.**

I. Introduction

The increase of the elderly population is discussed as one of the social problems in recent years. One of five Japanese are elderly now. In addition, the trend of nuclear families is increasing. As a result, the elderly living without younger ages are increasing.

In elderly living alone, it is easy for the elderly to suffer a body injury such as falls. It is a major cause of running into the state to be cared. Therefore, it is necessary to discover a body sense of dull movement that causes a body injury with some methods which takes place of watch by family members, to prevent the state to be cared before it happens.

This paper proposes a method which can find features of dull movement from daily life logs of elderly. In this study, we assume a tag space where RFID tags not only cover the floor but also are attached to all objects. If elderly wear RFID readers on his hands and feet, life logs such as where he is and what he touches are collected in the tag space. We identify the features of a body sense of dull movement by using the life logs. The features are common to multiple elderly. We aim to build a system which watches elderly, paying attention to the features.

We examined whether this method could detect the features of dull movement or not. Enforced dull condition is simulated to compared enforced dull condition with normal condition. As a result, the proposed method has detected 4 features of dull arms and 2 features of dull legs.

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II. Health Deterioration and Warning Sign

A. Problem of Elderly Living Alone

For elderly living alone, it is problem that no one can help the elderly if the elderly falls into the sickness and the injury. The elderly must find his own symptoms and go to a hospital. However it is difficult that the elderly manage their own health. The elderly cannot see a doctor at an early stages. As a result, their conditions become more serious and it makes his independent life difficult.

B. Existing Studies and Ex-Post Detection

In the process to the state to be cared, a dull movement such as moving neither the arm nor the foot easily appears to the initial symptom. If these symptoms get worse, their physical function comes down because of the decrease of activity. Elderly whose bodily function comes down easily go into emergent situations. The study to watch the elderly identify emergent situations of the elderly [1][2][3][4]. The method in [1] detects time periods when they do not move. The study in [2] proposes the framework finding emergency situation. Therefore frequent patterns of daily life are identified with acceleration sensors and wireless network. The methods of the study [3][4] find abnormal actions of the elderly with minimum sensors and low costs. These studies can find the situation such as a falling and getting worse suddenly. In the situation, the elderly require curing as quickly as possible. However, it is difficult for the elderly to get back the independent living once the elderly go into the emergency situation. It is necessary to detect the symptom that leads to serious situations to keep the independent living.

III. Detecting Dull Features in Movement

A. Watching Elderly in Tag Space

If the features in dull movement of the elderly are identified, the condition of their body parts where elderly feel dull can be detected with analysis of their life logs in daily life. In this paper, we assume a tag space, where RFID tags are installed on all over the floor and attached to every object. In the tag space, the elderly spend daily lives, wearing RFID readers on his feet and hands. We can get life logs indicating where he is and what he touches.

The proposed method gets life logs such as the touched objects information and the walking information in the daily life of the elderly. The touched objects information consists

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of the touched objects, the time of contact to the objects. The touched objects information is acquired, combining RFID tags attached to objects and RFID readers on their both hands. The walking information consists of the steps, the stride length, the movement distance, and the time of movement. The walking information is acquired combining RFID tags installed on the floor and RFID readers on their feet. We identify the features of dull movement with the information. The features of dull arms are identified with a decision tree which specifies the common attributes in how to touch objects. The features of their dull legs are identified with the statistics of the walking information. The methods identify the dull movement. These features can keep tabs on the health condition of the elderly.

B. Change of Touched Objects

In this study, we will detect the features of dull dominant hand, because the elderly depend on dominant hands to touch many objects more than non-dominant hands in daily life. The features of dull dominant hands are derived by three phases. In the first phase, the touched objects information in the normal condition is compared with one in the condition of dull arms. At that time, the time of touching objects used as an index. In the next phase, the objects extracted by the first phase are classified on the basis of the change of the time of touching objects. We define the objects which change the way of touch in the dull condition as the touch change objects. The touch change objects belong to more than one pattern out of six patterns in the table1. The patterns can figure out the feature of dull arms in detail. In the last phase, the common attributes of the classified objects are extracted for each pattern. We define the concept which many objects have as the common attribute in this method.

Let as consider an example of "Twist", that is the common attributes of behavior over the objects. This attribute shows how to move the arm when the faucet is twisted and the door is opened. The common attribute is extracted from the touch change objects that belong to each pattern. The attribute becomes the feature when there is a sense of dull movement on the dominant hand. Characterizing in the attribute rises more than doing in the change touch objects generality, and can target a lot of the elderly.

C. Change of Walking

The features when there is a sense of dull legs are detected by comparing the walking information in normal condition with walking information in dull condition. It is necessary to decide compared periods. Daily life can consider all processes from getting up in the morning to the sleep at night to be the comparison period. However, if the comparison period is a day, the noise will grow and the detection of the feature becomes difficult, because the action in a day and their order are different from day by day. The noise should be suppressed, cutting out a habitual action such as cleanings and washing from daily life activities. We should make the action time as a comparison period. We have proposed a technique to cut out the action [5]. Two or more habitual actions exist. To detect the feature of dull legs, the action that frequently use their feet are compared. The action that frequently uses the feet is an action that often moves. In the action with a lot of number of steps, normal condition and condition of dull legs is compared, and the change in the walking information is discovered. The features corresponds to a sense of dull legs is identified from the change in the walking information.

TABLE I: CLASSES OF TOUCH CHANGE OBJECTS.

Pattern name	Pattern context
Pattern 1	Time of touched objects with both hands gets longer.
Pattern 2	Time of touched objects with both hands gets shorter.
Pattern 3	Time of touched objects with dominant hand gets shorter.
Pattern 4	Time of touched objects with non-dominant hand gets shorter.
Pattern 5	Hand which touches objects turns dominant from non-dominant.
Pattern 6	Hand which touches objects turns non-dominant from dominant.

IV. DETECTING DULL FEATURES IN DOMINANT HAND

A. Common Change of Touched Objects

The common features are detected for not the individual but multiple people. Individual patterns of the touch change object are integrated as follows. The touch change objects of each pattern are extracted for each individual. A threshold is determined for a certain touch change object. The object of each pattern that fills the threshold is extracted, and it is made the common contact change object. The common touch change object to multiple people is extracted through this process.

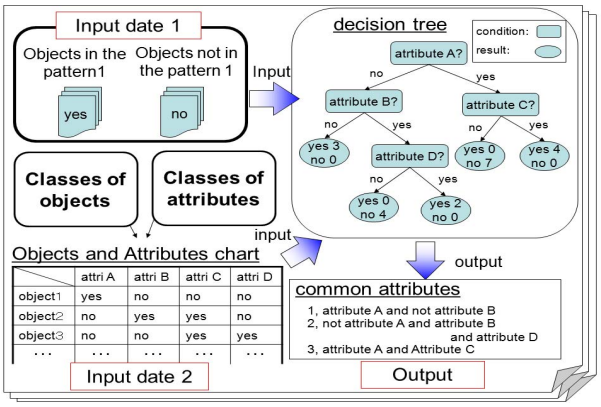

Fig. 1. Process to detect common attributes with a decision tree.

B. Common Attributes Using Decision Tree

A decision tree is made to detect the features when there is a sense of dull arm. Fig.1 shows the process. Two input data are used for making the decision tree. Input data 1 are sets of the touch change objects that belong to each pattern in the Table I and do not belong to each pattern in the table1. Input data 2 are Objects and Attributes chart where the attribute was given to the object. The chart is composed of the combination of sets of each object and sets of attributes. Two kinds of "Belong" and "Do not belong" attributes are given to the objects. For example, we think about the case where the attribute of cleaning supply is given to the cleaner and the refrigerator. The attribute "Belong to the cleaning supply" is given to the cleaner, and the attribute "Do not belong to the cleaning supply" is given to the refrigerator. Thus, the attribute is given to each object by the standard "Belong" and

"Do not belong". To classify the object that belongs to the pattern and the object that does not belong using these two input data, the decision tree is made. The given attribute is a branch condition of the decision tree. The made decision tree is traced from the leaves of sets of objects to the root. The attributes of the traced branch condition are output data. The output data are common attributes to the touch change objects. They are also output in each pattern. The relation between each pattern and the extracted attribute is the features when there is a sense of dull arm.

V. Experiment and Discussion

A. Purpose and Content

We experimented to verify whether the feature of dull movement by this method is able to be extracted. We have collected the life logs. In the experiment, the examinees spend predefined actions both in a normal condition and an assumed dull condition. The examinees are six men whose ages are twenties, and their dominant hands are right hands. The experimental environment is a house with a living room, a kitchen, a lavatory, a washing place, and a rest room. In the tag space, the examinees take actions wearing an RFID reader attached to slippers in their right foot and RFID readers in both hands.

There are 11 kinds of actions of life. The actions are getting up, taking a newspaper, having a wash, turning on a washing machine, preparation for breakfast, meal, putting away of breakfast, laundry drying, cleaning, and taking of laundry. One set is composed of the 11 kinds of actions. The examinees take the actions in a normal condition by three sets and in a dull mode by three sets.

B. Enforced Dull Condition

The elderly often have the problem in the joint. For example, it becomes difficult to move their joints or the elderly do not move their joints because of pains. In the experiment, we have paid attention to the joints, and we have simulated the state of enforced dull arm and leg. There is a joint of the shoulder and the elbow on the arm. Two kinds of states of dull arm are simulated. The examinees A and B put up the weight of 2 kg made with the sandbag to their wrist. As a result, the joint of their shoulder is hard to move. The examinees C and D fixed their elbow with the stick. As a result, the joints of their arms are not made easy to move. There is a joint on the knee in the foot. The examinees E and F fixed their knee with the stick. As a result, the joint of their knee is hard to move.

C. Dull Arm

The touch change objects of each pattern shown in the table1 are extracted from the life log of examinees A, B, C and D. As a result, 24 in 33 objects belonged to pattern 3, while 25 in 33 objects belonged to pattern 5. A lot of objects belong to these two patterns. On the other hand, three objects belong to pattern 4, while four objects belong to pattern 6. The objects that belong to these two patterns are few. The decision tree is shown. Pattern 3 and pattern 5 are able to extract common attributes, but pattern 4 and pattern 6 are not able to extract common attributes because the belonging object is few. In pattern 3 and pattern 5, two kinds of common attributes are extracted respectively. The Table II shows the common attributes. The extracted attributes are the features when there is a sense of dull arm. If the elder does not touch the object with the attribute of pattern 3 so much in daily life. The elderly has the sense of dull arm.

TABLE II: Detected Common Attributes.

Pattern	Common attributes
Pattern 3	In kitchen, No furniture
Pattern 3	Not in kitchen, Used laundry, No home electronics, No dish
Pattern 5	No home electronics, Used laundry
Pattern 5	No supplies, No towel, In washroom, No home electronics, Not used laundry

D. Dull Leg

The most actions of the number of steps are extracted from the life log of the examinees E and F. As a result, the action is a cleaning in 11 sets of 12 sets.

The walking information in cleaning is compared in their normal condition and the condition of dull leg. The change is detected in the number of steps per a minute. Fig. 2 shows the number of steps of examinees E and F in cleaning. In both examinees, the number of steps is increased in the state of dull foot. For examinee E, the number of steps in normal condition varies from 24 to 31 steps, while that in the dull condition varies from 37 to 47 steps. The number of steps increases by 15 steps on the average in the dull condition. For examinee F, the number of steps in normal condition varies from 40 to 48 steps. The number of steps in the dull condition varies from 51 to 61 steps. The number of steps increases by 12 steps on the average in the dull condition. The feature that the number of steps per a minute increases by ten steps or more is found in both examinees.

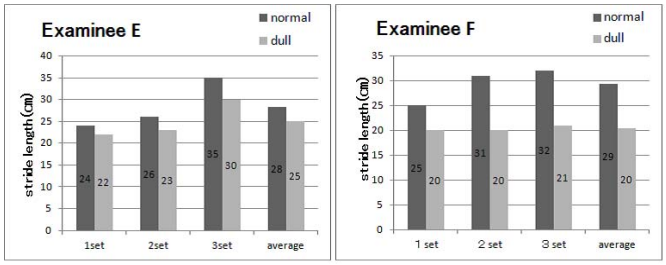

Fig. 2. Examinees E's and F's steps.

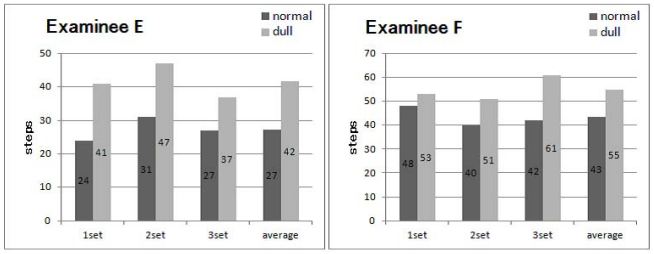

Fig. 3. Examinees E's and F's stride length.

In addition, the change of the stride length in cleaning is detected. Fig. 3 shows the stride length of examinee E and F in cleaning. In both examinees, the number of stride length gets short in the state of dull foot. The stride length of examinee E gets short by 4 cm on the average in dull

condition. The stride length of examinee F gets short by 9 cm on the average in dull condition. In the experiment, the features of an increase in the number of steps and a decrease in the stride length in cleaning are detected in the condition of dull leg.

E. Discussion

We discuss the result of the condition of dull arm. The attribute of pattern 3 and pattern 5 is able to be extracted among six patterns of the table1. Pattern 3 is a set of objects that the time of touching objects get short by the dominant hand. Pattern 5 is a set objects changed from the dominant hand to nondominant hand. It seems that the examinees do not use their dominant hand so much when there is a sense of dull arm, and they often use their nondominant hand instead. There are two problems on the result. First, the common attributes are not extracted with pattern 1 and pattern 2 though the number of extracted objects reaches 1/3 of all objects. Second, there are a lot of "Do not belong" of the extracted attributes. It seems that the given attributes are not selected appropriately. If a specialist like a doctor decides the attribute, this problem will be solved.

We discuss the result of the condition of dull leg. We compare walking information other than the number of steps and the stride length in cleaning. For examinee E, the time of movement get short by 37 seconds on the average in the dull condition. For examinee F, the time of movement gets long by 29 seconds on the average in the dull condition. The result is different in both examinees. A common feature is not detected though there is an influence in the time of movement. In addition, there is no change in the movement of distance as both examinees. It seems that the features of dull condition are an increase in the number of steps and a decrease in the stride length.

VI. Conclusion

This paper proposed the method for detecting the features of elder dull condition in the tag space. Through an experiment, the proposed method has found 4 features of dull arm and 2 features of dull leg with the walking information and the touched objects information. For the future work, we will verify whether the dull condition can be automatically detected by using the extracted features.

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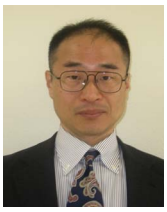

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