A Solution to Prevent Wandering by Geriatric Patients - A Validation Test to Ensure Safety in Nursing Care Facilities

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Abstract

This paper discusses a solution that aims to prevent wandering by geriatric patients and also associated accidents. This solution is achieved by combining a motion detection camera and a face recognition camera. The motion detection camera does not detect the entry of people but only those exiting, while the face recognition camera automatically identifies a person who is exiting. When these two cameras are used in conjunction, it is possible to build a system that sends alerts to the staff by detecting the exiting of only those facility residents/users who are in need of nursing care and assistance. Face recognition does not put a burden on the facility residents/users as does the carrying of an RFID tag and it is free from management problems such as loss or equipment failure. Besides, RFID use is more costly because malfunctioning caused by electrical signal leakage must be prevented. The use of a camera is therefore a more rational solution. In addition to describing the system, this paper also discusses the validation testing results.

Keywords

image analysis, motion detection, face recognition, wandering by geriatric patients prevention

1. Introduction

In Japan, the population has aged significantly thus far, and it was expected that this trend would be further accelerated from 2012, the year when the postwar baby boomers turned 65. In 2012, the aged population of 65 and over exceeded 30 million for the first time and accounted for 24% of the entire population. It is estimated that there are now more than 4 million people who require nursing care. An aging society is not a phenomenon peculiar only to Japan but rather a common problem that is shared by European countries and other advanced nations.

In Japanese nursing care facilities, a perceived shortage of nursing staff remains unsolved, which is proving to be a problem. Moreover, nursing care levels adopted at the nursing care facilities run by national insurance are showing a tendency to increase annually, which is presumably also increasing the burden on the nursing staff.

Under these circumstances, various accidents are actually occurring and they are increasingly becoming social issues in the nursing care facilities. Personal efforts by staff to prevent accidents in the actual workplace are under pressure due to staff shortages and increased workloads.

In the light of these circumstances, we investigated the plausibility of operational support in nursing workplaces using IT. In terms not only of the magnitude of inflicted damage but also of the efforts required to deal with, unauthorized outings due to wandering behavior, in particular, are considered to put tremendous stress on the staff because they have then to find the missing resident/user. For this reason we became convinced that there was a demand for an appropriate solution to prevent prohibited outings by facility residents/users and also for notification to the staff of any attempted outing. In section 2, we examine the required functions of such a solution.

2. Development of a Wandering Prevention Solution

2.1 Required Functions

The functions required for such a solution are considered to be as follows. Firstly, the solution should be able to detect the outings of the facility residents/users without omission, and secondly, the system should be capable of decreasing the number of alert transmissions (or false alarms) of those other than the residents/users. Technologies that are important in achieving these two functions can be considered as the capabilities

of; 1) distinguishing the residents/users from others and 2) distinguishing characteristic outing movements from those of other movements. In other words, a false alarm may sometimes be sent when a person other than the facility resident/user is going out or when someone enters the facility or passes in front of the entrance. For this reason, we conducted evaluation testing based on the two factors: recognition of facility residents/users and detection of characteristic outing movements. Additionally, it is important that the burden be lightened not only on those receiving care but also on those that provide the care.

From the viewpoints mentioned above, we evaluated our solutions how it detects the characteristic outing movements of facility residents/users.

2.2 Features and Comparisons of Different Systems of Solutions

First of all, we outline the features of the three different systems, which are compared and examined below.

(1) Sensor-linked system

This system detects the outing of facility residents/users using human detection sensors (usually infrared sensors). However, the sensor with this system is not able to individually identify the facility residents/users. In order to detect characteristic outing movements it is necessary to use two or more sensors to detect the deviation between detected timings in order to specify the direction of movement. This system can be regarded as burden-free for the staff and residents/users alike in terms of its management. However, there is a drawback in its inability to identify individual facility residents/users.

(2) Sensor/RFID-linked system

In addition to the above-mentioned capability, this system detects the characteristic outing movements of a person by using sensors and identifies the individual facility resident/user by using an RFID system. It is required that the multiple sensors specify the direction of the movement in the same manner as with the above described sensor-linked system. When the facility residents/users are to be identified utilizing the RFID system, it is not practical to have them carry RFID tags due to the inevitable occurrence of loss or of intentionally taking them off. Therefore, the staff members carry RFID tags, and only when no RFID tag is detected although the sensor detects the outing motion, the system identifies it as the outing of a facility resident/user. Due to the characteristics of radio signals used by the RFID system, however, a false alarm may be sent when an RFID tag is not detected. This occurs for example when an RFID tag is in close contact with the user's body or when a part of the user's body shields the RFID tag from the radio antenna. In nursing care workplaces, the staff members often accompany a facility resident/user when he or she has to go out. Should this be the case, it is likely that the RFID tag carried by the staff may not be detected due to the interference from part of the resident's/user's body, resulting in a false alarm. In contrast, the reflection of radio signals may cause the system to detect the RFID tag carried by a staff member who is more distant than the one who is accompanying the resident/user, resulting in failure to recognize the outing of the resident/user. From the management viewpoint, this system does not impose a burden upon the facility residents/users; nevertheless, it puts stress on the staff in terms of the fact that they have to carry RFID tags while paying attention to properly wearing the tags so that they do not interfere with detection. If the sensitivity of the RFID tag is increased with a view to reducing this stress, it will increase the possibility of missing the outing of the facility resident/user as mentioned above. If the RFID tag is set to a less sensitive setting to decrease this possibility, false alarms will be more likely to occur. The trade-off between these two eventualities is of crucial importance.

(3) Image analysis-linked system

This system uses image analysis for both identification of the facility residents/users and detection of the characteristic outing movements. It uses face recognition to identify the facility residents/users. However, it can be expected that the facility residents/users will not always look at the camera, so face recognition is used to identify staff. In other words, when staff cannot be identified by the face recognition function although characteristic outing movements are detected by the motion detection function, the face cannot be detected or, even if the face is detected and it is not that of the staff, then an alert will be sent. By combining the face recognition and motion detection technologies among the image analysis technologies, this solution achieves both the identification of the facility resident/user and detection of characteristic outing movements. There is no burden on the facility residents/users from the management point of view; all that the staff have to do is to look at the camera. However, careful installation of the camera can reduce the burden of having to pay attention to the direction of the face. Of course, problems such as loss, theft, or forgetting to carry it would not happen. Therefore, this system can be considered less burdensome than the other two systems that use RFIDs.

The comparison of the above-mentioned properties is shown in the **Table**.

2.3 Development and Verification of Our Proposed Solution

The operational schematic of our proposed geriatric wandering prevention solution is shown in **Fig. 1**.

Our solution is comprised of a motion detection camera

Table Comparison of the 3 solutions.

Solution \ Compared property	Identification of facility resident/user	Detection of outing motion	Burden on the facility resident/user	Burden on staff
(1)	×	○	○	○
(2)	△	○	○	×
(3)	○	○	○	△

○: Excellent, △: Good, ×: Poor

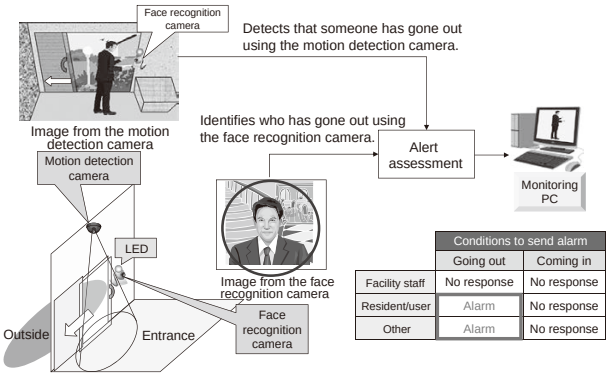

Fig. 1 Operational schematic of our system.

and motion detection module, a face recognition camera and face recognition module, and an alert assessment module that decides whether or not an alert is necessary by integrating the information from the aforementioned two systems. The alert assessment module also has a function that blinks an LED on the camera to notify the staff when his or her face is authenticated.

2.4 Configuration of the Validation Testing

We conducted a validation test of the wandering prevention solution. The test configuration of the system is described as follows. The system configuration built for the validation experiment of the wandering prevention solution is shown in **Fig. 2**.

It is essential that the motion detection function accurately detects a person who is going out of the facility without omission and does not detect a person who is entering from the outside or who is just hanging around. For this reason, we made an evaluation based on the under-detection rate of the people going out. In the meantime, we also made an evaluation based on the over-detection rate. The face recognition function was evaluated also based on the face recognition rate.

2.5 Results

As a result of our tests, we found the under-detection and over-detection rates of the motion detection to be 0.1% or less

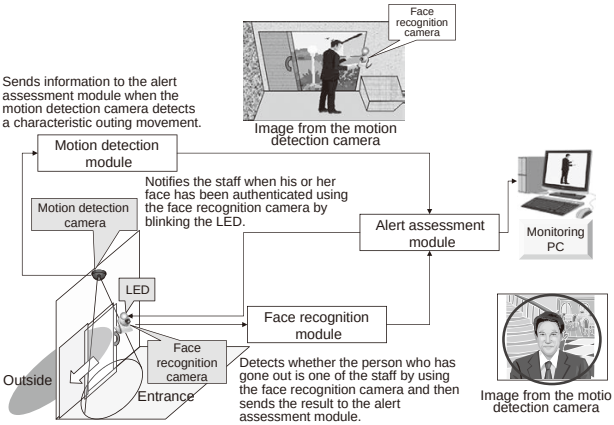

Fig. 2 System configuration.

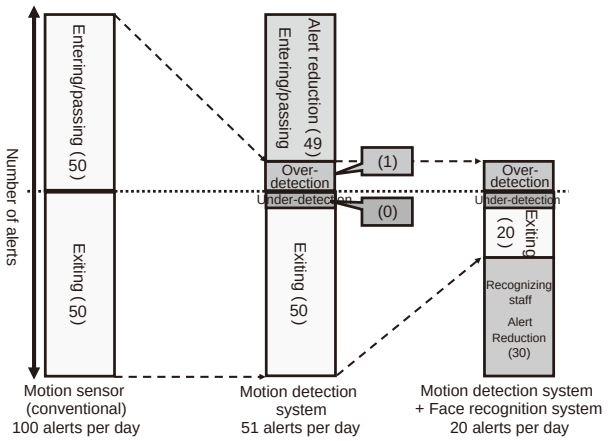

Fig. 3 Alert reduction effect.

and 2% respectively, and the face recognition rate was 61%.

As for the motion detection function, there was, in particular, no under-detection during the test, showing a very good performance. Besides, the over-detection rate, which is in a trade-off relationship with the under-detection rate, remained as low as 2%, which allows it to be considered also as a very good performance. From the viewpoint of ensuring safety and reliability, it is of the most vital importance that the under-detection be suppressed as low as possible. The fact that, while this hurdle was cleared, the over-detection rate was successfully suppressed at a very low level allows it to be considered as a very favorable result in view of actual operation.

Meanwhile, although the face detection rate was 61%, there was no case where a facility resident/user was falsely recognized as a facility staff. For this reason, the system can be deemed to be functioning properly in terms of accident prevention.

Now, let us examine the results we have obtained from the viewpoint of the alert transmissions. **Fig. 3** assumes that the

exits and entries at the entrance are 50 per day, respectively. If only a human motion sensor had been used as is the case in the conventional systems, there would have been 100 alert transmissions per day in total. However, the use of the motion detection system made it possible to decrease the alert transmissions to 51 (about half). Furthermore, when the face recognition system was incorporated, the total alarm transmissions were decreased to 20 per day (1/5th that of the conventional system).

2.6 Discussion

The cases of alert transmissions were all caused by the incapability of recognizing the faces of the facility staff. With a view to further reducing alerts, we examined the instances in which the face recognition did not function as it was supposed to and found the causes as follows.

(1) The subject's face was looking down or sideways, making shooting from up front impossible.
(2) The subject passed in front of the camera so quickly that the image of his or her face was blurred.
(3) Outdoor daylight beamed upon the subject's face, whiting out the facial image.
(4) When the light was turned off at night, the subject's face was not shot with sufficient brightness.

Countermeasures for dealing with these issues need to be examined in terms of both technical and management aspects.

Firstly, the technical measures include the following: For (1), the same person's face should be shot in various lighting conditions and with face directions including looking obliquely. For (2), (3), and (4), a camera with adjustable shutter speed, gain, and measuring point should be used.

Next, the management measures include the following: For (1) and (2), the facility staff should be attentive, for example, being conscious of the camera. For (3), care should be taken to adjust the brightness in the entrance by using curtains or blinds so that it does not get too bright. For (4), the facility should take consideration of any extension of lights out.

After having implemented the technical measures, we conducted more tests, assuming the same conditions, and found that the alerts could be reduced to 2 or less per day.

3. Conclusion

We believe that the development of our system has achieved a solution for detecting outings of facility residents/users without any omissions while reducing the burden on the facility staff. We look forward to this solution being adopted as standard equipment in nursing care facilities.

Nonetheless, there are various accidents in nursing care facilities in addition to geriatric wandering. At NEC, we are also applying the image analysis technology to develop a solution for the detection of falling down incidents and crowds (gathering of people at the occurrence of an accident).

We are confident that with the support of such solutions we will be able to contribute significantly to achieving safety and reliability in dealing with issues of the aging society.

Reference

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