Caregiver's Eye Gaze and Field of View Presumption Method During Bathing Care in Elderly Facility

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Abstract. Japan faces a critical need for nursing care as its elderly population continues to grow along with a rise in dementia, the number of elderly people who are bedridden and require extended care. Bathing is one of the most important aspects of daily life in which provision of better quality care can improve quality of life. However, in many elderly facilities, bathing is fraught with dangers, such as falling and drowning in a big bath. Bathroom floors can be slippery and cause residents to fall, and the constant vigilance required can cause caregivers significant mental stress. Advancement in biomechanics along with the development of nursing care devices had reduced the physical stress on the caregivers. However, the efforts to relieve mental burdens are still insufficient, especially when caring with elderly people or those suffering from dementia, whose actions are rather unpredictable. By measuring the caregiver's eye gaze and field of view, we believe we would be able to locate the blind spots during bathing care. With the use of the data gathered we aim to develop a system to improve bathing as a good experience to the customer and a less stressful task to the caregiver. While measurement by video camera was considered optimal, we conducted the experiment using motion sensors due to privacy concerns. We performed four experiments to progress towards our final result set. This paper focuses on the second of these experiments.

Keywords: Caregiver · Elderly facility · Bath care assistance · Presumption method · Blind spot · Motion capture

1 Research Background

Japan faces a critical need for nursing care as its elderly population continues to grow along with a rise in dementia, the number of elderly people who are bedridden and require extended care. According to the 2014 White Paper on the Aging Society, 31.9

V.G. Duffy (Ed.): DHM 2015, Part II, LNCS 9185, pp. 524–532, 2015.
DOI: 10.1007/978-3-319-21070-4_53

million people, or 25.1 % of the entire Japanese population of 127.30 million, are senior citizens over the age of 65 as of October 1, 2013. That number is 14 %, highly above the 7 % threshold that defines a country as an aging society. Japanese society is entering the super aging society. Furthermore, a very high 12.3 % of the population is over the age of 75. Compared to other countries, Japan is facing the super aging society that no country has ever experienced until now. The aging of society has increased demand for nursing care, with 5.49 million people as of October, 2012 qualifying for some type of care in their daily life. This pressing social need necessitated specialized care in the nursing business. In 1987, the Certified Social Workers and Certified Care Workers Act was enacted to provide and maintain quality nursing care, giving specialized nursing care providers with national certification. This also had the effect of directing the spotlight on the overwhelming challenges of the families dealing with nursing care for their elderly, and a growing call for socialized nursing care led to the enactment of the long-term care insurance program in 2000, giving recipients a choice in the type of nursing care they receive. The first article of the long-term care act advocates for socially supported quality welfare services that recognize the right to a dignified life for all individuals. "So that individuals can lead independent lives according to their ability, so that we may grant the necessary medical and welfare services based on the principles of public and mutual solidarity, we put in place a long-term care insurance system, with necessary items applied toward that benefit so that we can provide our citizens with better medical care and welfare."

1.1 Bathing Assistance: Background and Issues

Bathing is indispensable for both hygiene and as part of Activities of Daily Living (ADL). It encourages blood circulation and promotes higher metabolism. It also relaxes the muscles, helps prevent bedsores and infections, regulates bowel movements and supports other such functions of the body. For many elderly people suffering from anxiety and tension, bathing is an important time for them to relax. It has the added mental benefit for the elderly, who consider bathing one of life's pleasures. Furthermore, cleansing the body of dirt and odors helps strengthen interpersonal relationships and encourages active social engagement. Bathing is thereby an extremely significant way to assist in the daily lives of the elderly, and in order to realize quality welfare service, effective bathing assistance is a necessity.

Bathing has many benefits – physiological, mental and social. And yet, it can be risky, fraught with such dangers as falling and drowning. The external causes of bathing accidents include exposure to the cold while dressing/undressing, the warm temperature in the bathtub or bathroom, and the hydrostatic pressure within the bathtub, which is considered to have a negative impact on the bodies of the elderly. In many cases, the elderly tend to suffer from multiple complications, such as high blood pressure and diabetes, as well as arteriosclerotic changes and a deteriorating autonomic nervous system response. Therefore, some of the internal causes of bathing accidents can be attributed to changes in blood pressure, dehydration and blood coagulation. These physiological changes expose the elderly to a higher risk of cardiac arrest, cerebrovascular disorder, dizziness and catapleptic attacks. A complex

mix of these factors heightens the risk of falling and injury, drowning or death from drowning. Delivering quality bathing assistance depends on overcoming a variety of issues.

Assisting with bathing is extremely hard work and has been an issue at welfare facilities for the elderly. There have been numerous reports published about the level of burden incurred in the work of bathing assistance (Fujimura 1995). One of them (Nagata 1999) involves a survey of caregivers who work in the nation's 969 nursing facilities for the old. According to the survey, the most physically taxing aspect of care is bathing assistance, followed by diaper change and transfers. The burden incurred by bathing assistance is threefold: physiological, physical and mental. First, the high temperature in the bathroom is demanding on the caregiver's body, and that causes physiological challenges. According to a study by Kawahara and his team (Kawahara 2010), caregivers showed high cortisol levels – a benchmark for stress-response – after assisting with bathing, linking the activity with high physiological stress.

The high stress level can be tied in part to working assembly-line style in a high-temperature bathroom, but also handling a lot of transfers from one place or position to another in that process, namely, supporting the elderly in an upright position while he or she dresses or undresses, transferring from the wheelchair to the bathtub and back, among others. These are all tough on the back. Bathing assistance in a nursing care facility with a large bath involves not only horizontal, but lots of vertical movements that impact and stress the musculoskeletal structure, which in turn invites fatigue. Also, with the progressive bathing system most widely used in care facilities, caregivers end up with five manual transfers of an elderly from one location to another, including the move from the bedroom to the bathroom, which again causes stress to the caregiver.

Because bathroom floors can be slippery and trigger a fall, constant vigilance can cause mental stress to caregivers. According to a survey by Nagata (1999), 18 % of the caregivers cited "fear of a fall" as their biggest mental stress while assisting with bathing. Furthermore, the survey revealed that bathing assistance is the most conducive to feeling negative about nursing care (Kawahara 2010).

As detailed above, bathing assistance is extremely taxing work and is believed to be one of the main reasons why some people leave the job. The turnover rate for care jobs was 18.7 % in 2008, which is high compared against the industry's rate of 14.6 %. With regards to active job-opening ratios, the number declined to 1.34 in September 2009, after peaking at 2.53 in December 2008. To this day, the ratio continues hovering above 1 – a big issue to consider in delivering quality care.

1.2 Research Trends in Bathing Assistance

To tackle the above-mentioned problems, fundamental and practical research is being done, with some of the research showing promise of mitigating the physical toll of bathing on the elderly. For instance, Kanda (1991) published the results of his research involving the physiological burdens of bathing in the winter and in the summer. Nagahiro's research (2006) on the impact of bathroom temperatures on the circulatory

system of healthy elderly people shows temperature levels that promote lower blood pressure after bathing.

On the other hand, numerous studies conducted in the areas of sanitary engineering and structural engineering have contributed to the development of comfortable clothing and structural improvements in buildings to reduce the physiological impact of care-giving on care workers.

In terms of dealing with the physical stress, caregivers are provided with ergonomic and biomechanic suggestions and nursing equipment that help reduce back strain. For instance, when comparing the efficiency between the use of a mechanical lift and a manual lift when transferring a fully dependent care receiver to a wheelchair, a Tomioka study (Tomioka 2007) showed that the mechanical lift reduced the work time considerably after a period of training and that the mechanical lift was effective in reducing the caregivers' back strain. Furthermore, after analyzing the burden on the back by studying the angle of the upper body and results of an electromyogram, the Tomioka report (Tomioka 2007) showed that using the mechanical lift to get in and out of the bathtub reduced the caregiver's forward-leaning posture and strain on the muscles – all of which contributed to an overall reduction in work-related stress. The report also pointed to increased back strain that comes from bending forward when the caregiver has to wash a care receiver or help her dress/undress while she remains seated, or when adjusting the footrest on the wheel chair.

1.3 Identifying Problems

There's been a lot of research done for the purpose of lessening the physiological and physical burdens of both the caregivers and the care receivers, many of them outlining specific nursing techniques and new policies.

On the other hand, because bathing assistance is more prone to accidents, the caregiver must be on constant alert, especially when dealing with senior citizens with dementia, who often move and act in unpredictable ways. When it comes to easing the mental burdens, however, basic research doesn't go far enough, and there are as yet no solutions.

Creating a safe way to offer bathing assistance than can prevent falls or drowning accidents is in a way reducing mental stress. This could achieve "peace of mind," and make quality nursing care a reality.

We have identified the main issue in our research as reducing the caregivers' mental stress by preventing accidents, such as falls and drowning.

2 Factors of Occurrence of Falls

Kawamura (2003) pointed out that near-accident occasions surrounding nursing care mostly involve falls. Not just limited to bathing time, falling accidents by elderly people can severely interfere with their health, for instance forcing them to be bed-ridden. A large number of studies have been conducted on the link between fitness

levels and falling accidents of an elderly person. Accident-prevention programs based on those findings have been shown to be effective.

There are three factors that can lead to falling accidents care-receivers' physical conditions, these caused by the caregivers, and the environmental factors. The physical factors of care-receivers include there age, diseases and muscle weakness, related to the decline of physical functions. Also some medications such as acesodyne, soporific, diuretic, psychotropic medication, may induce dizziness or unsteadiness. The factors relating to caregivers include the lack of awareness to risks and lack of sufficient Understanding in the risk levels. Also this factor is greatly influenced by his/her skill and awareness. The environmental factors include steps, slippery floors, and tripping caused by slippers or dim light. These factors can be prevented by removing dangerous places and objects. More than other industries, nursing care must be done under the appropriate condition where manpower, works, equipments and environments are well coordinated. It also requires flexibility in dealing with care-receivers' sudden movements, making it a difficult field to work. The nursing care field is always short of staff, so the caregivers cannot devote sufficient time to each care-receiver. Also there are many blind spots existing in the elderly care facilities. Some facilities installed security cameras in order to prevent the accidents caused by the seniors' action for research purpose. This research contributes to the elimination of blind spots inside the facilities.

It is desirable for the nursing field that the development of new technology in human engineering is carried out based on its core philosophies, such as supporting independent life, normalization, respect for fundamental human rights and supporting self-realization. Thus, in case of video surveillance for the research purpose of blind spots, we must respect and consider the human rights of care-receivers first, and then quantify the blind spots during the daily nursing cares. The research for quantifying blind spots has just started. Further developments are expected in this filed, including the quantification of blind spot in bathing care and the proposal for optimal positions between care-receiver and caregiver, that does not lead to blind spots.

2.1 Solving Problems

This research recommends that in order to prevent a fall during a bath, a practical system be instituted whereby neither a caregiver's gaze nor the care receiver end up in a blind spot. For that to happen, the caregiver's and care receiver's location in the bathroom or changing room has to be recorded in a timed series. As for the caregivers, tracking their gaze in a timed series can help quantify blind spots, potentially even turning the caregiver's monitoring skill into data.

3 System Outline

In order to solve the above-mentioned problems, we propose the method using the motion sensor. This method enables the approximation of the location and vision of the monitoring targets. The motion sensor has been advance by MEMS technology, and

now it has been downsized and made cost efficient. With motion sensors attached to the necessary parts of the target's body, it enables the easy measurement of the rotational movement of physical parts and translational movement. Without using video recording, as this method enables to approximate the location and the vision, it draws high expectation in terms of respecting privacy.

This is a system that uses motion sensors to estimate position and visual field data. Calculating the caregiver and the care receiver's position within 10 cm of accuracy in the bathroom, then making an estimate of the caregiver's visual field data in the direction that the caregiver is facing (front) is thought to be helpful for the caregiver. Position estimation by motion sensors is not new. However, methods for estimating visual fields have yet to be tested and are considered something of a novelty. By dispensing with videos in the process, the system makes no privacy breaches, making it a strong candidate for use in welfare care studies, psychology, ergonomic and other areas of research. Furthermore, the skills caregivers apply during bathing – assisting and monitoring – have always been ambiguous. Quantifying those skills from eye-gaze data offers an unprecedented viewpoint. This research is being used for system development intended as feedback to care sites and has a practical application: reducing mental burden is effective in improving the work environment of care sites.

Using this system will more clearly reveal the difference in bathing assistance and monitoring skills between veteran caregivers and novice caregivers. The system can eventually develop into one that supports skill development and offers assessments that can help with monitoring skills to better assist with bathing. The existence of blind spots in bathing assistance work has been made clear, paving the way for smarter staff appointments. Clarifying policies that promote safe bathing assistance by observing the location and movements of the caregivers and care receivers also contributes to the safe management of care welfare facilities.

3.1 General View of New System Proposal

This study consists of four experiments; experiment 1 and 2 in basic research and experiment 3 and 4 in the applied research. In the previous experiment 1 in the basic research, we established the reliability and validity of motion sensor based on the data obtained from the measuring devices of optical motion and eyes movements.

In the experiment 2 in the basic research of this study, the live bathing care was recorded by a video camera. The 43 min and 58 s long footage which was pre-treated with mosaic effect, the professional technician analyzed the footage and pointed out 8 moments with possible risk. As for the multiple hazard locations that the technician pointed out, we simulated these scenes in the laboratory with actors playing the roles of care-receiver and caregiver. The 3-points reflection markers were attached on the head of the subjects. The optical movement measurement equipment captured the motion data and measured the three-dimensional coordinates of the target's vision, to clarify the validity of the data. The experiment 1 and 2 in the basic research was conducted in the laboratory. (Figure 1).

In the experiment 3 in the applied research, we simulated bathing assistance with a bathtub filled with hot water, to estimate the liability and validity of the range of

Fig. 1. The experimental scenes in the laboratory

eye-vision information by gathered by motion sensor. In the experiment 4 in the applied research, we estimated the location and visual information of the care-receiver and caregiver in the actual bathing assistance scene. And then evaluated the individual monitoring skills and blind spots quantitatively.

4 Characteristics of Hazard Locations

The Fig. 2 shows the layout of the bathroom in order to showing the schematic diagram of hazard locations. The Fig. 2 shows the image taken by video.

Fig. 2. ① Washing Place ② Bathtub ③ Steps ④ Slope

The Fig. 3 shows the schematic diagrams of the hazard locations identified in the 8 cases. The red dot represents the caregiver and the red arrow shows the line of view of the caregiver. The blue dot represents the care-receiver and the blue arrow shows the line of his view. The black arrow shows the walking directions of both the caregiver and the care-receiver. The yellow mark represents the hazard locations.

(Scene 1) The care-receiver was moving to bathtub alone, but the care-receiver did not watch him. There was high risk of falling accident.

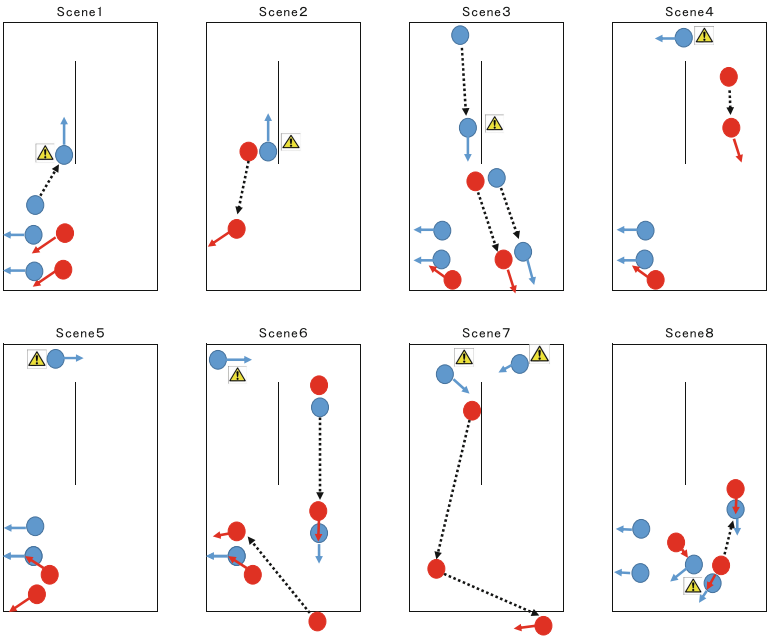

Fig. 3. The schematic diagrams of the hazard locations

(Scene 2) While the caregiver was helping the care-receiver to the bathtub, the caregiver suddenly left the care-receiver because he remembered to do something else.

(Scene 3) The caregiver left the care-receiver alone and helped the other care-receiver to bathtub. While the caregiver was away from him, the first care-receiver tried to get out from the bath tub. Since the floor was wet and slippery, this movement had the high risk causing an accident. Other caregivers in the bathroom also did not notice his movement.

(Scene 4) While the caregiver was watching the safety of care-receivers in the bathroom, he looked away from the care-receivers in order to remove the dust floating in the bathtub.

(Scene 5) Although two caregivers were in the washing place, they did not watch the care-receivers in the bathtub. There was high risk of drowning accidents.

(Scene 6) Although multiple caregivers were in the bathroom, they were looking away from the care-receivers. There was high risk of drowning accidents.

(Scene 7) The caregiver left the two care-receivers in the bathtub for a long time. This increases the risk of drowning accident.

(Scene 8) The caregivers could not switch positions smoothly. This increases the risk of collision accident.

4.1 Results and Discussion

After identifying the dangerous locations, we simulated the care process with subjects playing a care-receiver and caregiver's roles, and collected data. The data collected by this method is highly significant. And in the 8 cases indicated in 4.1, there were 6 occasions where the caregiver looked away from the care-receiver among the 8 scenes. This is very high rate. Especially the caregivers tended to look away from the care-receiver who does not require the physical support. We presumed that the caregivers were overconfident, because these care-receivers were physically more stable, so they felt unnecessary to watch them all the time. Even though they seemed stable in physical condition compared to other care-receivers, there is a possibility of their condition changing suddenly. Thus, the caregivers always need to be careful regardless of care-receiver's physical conditions.

5 Conclusion

The research above enabled us to comprehend the nature of the hazard locations during bathing assistance. As shown in the result of 4.2, with the validity of the data also confirmed, we will proceed to the next experiment step 3 of applied research with simulating the bathing assistance in the actual bathing situation.

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