Assistive Adjustable Smart Shower System

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***Abstract*—Bathing is an important part of daily activities for people of all ages. However, existing shower systems designed for healthy adults can be a challenge for elder adults with limitations or people in wheelchairs. We propose an adaptive assistive smart shower system, which is capable of detecting the user's abilities and disabilities, and then provides the necessary aids automatically. The shower system considers three user classes: normal healthy user, slow walking user and a user in a wheelchair. A wearable Angel Sensor is utilized to collect the user's health data. A computer then processes the data and classifies the user. The shower system provides the necessary assistance based on the classification result. The average classification accuracy is 95. 2%.**

Keywords—Smart; adjustable; assistance; shower system

I. Introduction

Elder adults with health issues may have trouble in bathing, which makes independent living more difficult. In order to provide a safe bathing environment, some assistive devices are introduced [1][2]. The existing assistive equipment such as the bath lift [2] is very helpful for a person to get in and out. However, some elderly people might still find it difficult to use because it requires a helper or caregivers with a bit of work. Some shower seats such as wall mounted folding models [3][4] without legs could also help a user taking a shower, but the user might still need to walk out or onto the slippery surfaces of the bathroom which creates more possibility of falls. Unlike existing equipment, we propose an adjustable assistive shower system to help elder adults enjoy bathing more without worrying about using the shower or even the risk of falling. The adjustable assistive shower system is able to detect the user's abilities and disabilities and then provides the necessary aids automatically and adaptively, making itself flexible given that the aging user may live with others who do not have disabilities or limitations. The system includes an automatic shower curtain system, an adjustable shower head and a movable chair system. The system allows aging adults who might need some extra support with bathing to be able to remain independent, especially in bathing.

II. Implementation

Different elder adults desire various degrees of assistance based on their own health status. Thus, a robust bathing system should provide different levels of automation to accommodate user needs. To this end, our system is designed to adjust the automation degree of each controllable component based on the current user's health status collected from a sensor worn by the user. The system consists of an Angel Sensor, a computer, an Arduino board, an adjustable shower head, a controllable curtain and a movable chair. In order to provide proper assistance to the user, the shower system needs to understand the health status of the user. The Angel Sensor [5] (Fig. 1) is used to collect a user's acceleration magnitude with a Bluetooth smart connection. A computer is used to receive and process the acceleration data from the Angel Sensor; it then sends instructions to the Arduino board, which serves as the microcontroller to control the hardware components.

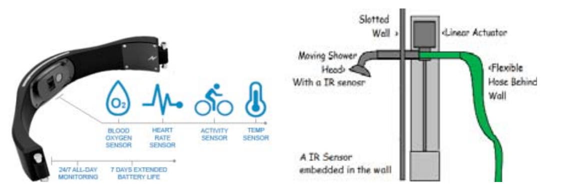

Fig. 1. The Angel Sensor is shown in the left figure and the shower head design is shown in the right figure.

An adjustable shower head and a controllable curtain are integrated in the shower system (Fig 1). A sensor embedded in the wall of the shower close to the floor detects the presence of a person entering the shower space; this can also be used for closing the curtain for frail seniors. Attached to the showerhead is an infrared sensor that can detect an object in front of the showerhead. The showerhead is attached to a linear actuator that carries it slowly downward until it stops at a comfortable distance from the user's head. It then remains still until the user steps away from the shower, or moves downward from the showerhead. If the user is still detected in the shower, but the sensor attached to the showerhead no longer sees the user, then the downward scanning behavior begins again. Once the showerhead has reached its lowest allowable point of travel and its infrared sensor does not detect anything, but there is still a person detected by the sensor embedded in the wall, it can be assumed that the person has fallen, and the system will deactivate the water and trigger an alarm for help.

A movable aid chair system includes pushbuttons, one IR distance sensor and a step motor and a servo motor as actuators. The waterproof button on the arm of the chair provides the ease for the user to control the movement of the chair in three modes: forward, backward and back to original position. Moreover, the servo motor is used to provide the folding function to the chair to save space for people without any disabilities, and the IR distance sensor detects when the user is approaching the chair.

In the prototype system, user movement acceleration data are collected from an Angel Sensor and transmitted to the computer. The computer extracts features from incoming data, reduces the dimensionality and then classifies the user into one of three types: normal walking person, slow walking person and wheelchair person. The classification conclusion is then sent to the microcontroller, an Arduino board, which generates the

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corresponding control signals for each component to accommodate the user's type.

If the user is a normal walking person (Fig.2.), it is assumed the user is in a good health status; thus, no special assistance is needed. Therefore, the components in the shower system will be set to be operated by the user manually. In this case, the system has the same setting as the normal bathroom. The user needs to open the curtain to enter the shower space and adjust the height of the showerhead manually.

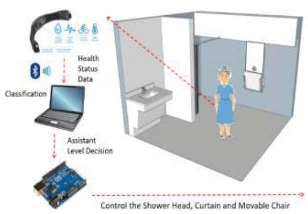

Fig. 2. Assistance level for normal walking users.

If users fall into the slow walking case (Fig.3.), then they will have difficulties to perform some movement. Thus, the curtain will automatically open when the user enters the system and close when he/she stands in front of the shower head. The height of shower head adjusts based on the user's standing height. But the chair is still folded.

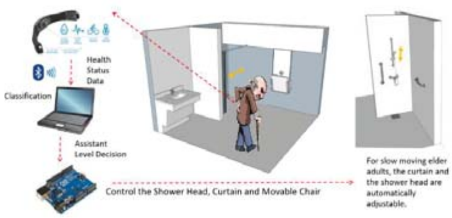

Fig. 3. Assistance level for slow walking users.

If the user needs a wheelchair (Fig.4), the shower chair will be unfolded upon the user's approach. After the user sits on the chair, he/she can be moved into the shower space by using the control panel on the chair arm. Meanwhile, the curtain will automatically open when the user enters the space and close after the user gets into the space. The showerhead will adjust its height based on the user's sitting height.

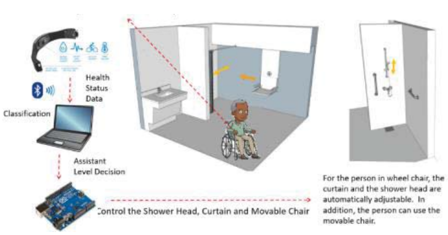

Fig. 4. Assistance level for the user who needs wheelchair.

III. Results

We have made a small-scale prototype of the proposed adjustable shower system. The prototype system successfully performs personalized assistance based on user data.

A. User Health Data Classification

We collected 36 Angel sensor datasets from normal walking, slow walking, and wheelchair subjects; each case has 12 samples. Four features are used to describe the data, including amplitude, mean of peaks and peak width, and number of peaks. To visualize the KNN classification (K = 4) result, the PCA [6] method is applied to reduce the dimension to both 2D and 3D as shown (Fig. 5); three classes are separable. We use half of the data as training and half as validation. The KNN classification accuracy on 3D data is 95.2%.

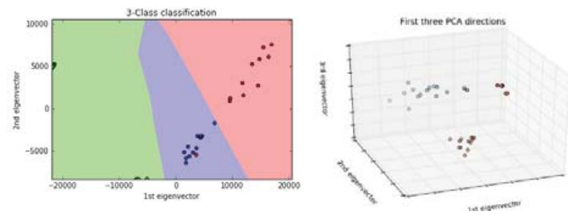

Fig. 5. Classification results of 2D and 3D PCA data; three cases are separable.

B. Adjustable Assistance System

Based on the user's health status, the shower system will provide different assistance. We tested the system and the results for different user types. The slow walking case and the wheelchair case are shown in Fig. 6.

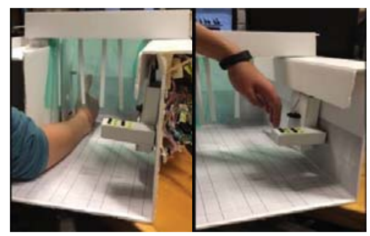

Fig. 6. System test in the slow walking case (left) and the wheelchair case (right). The hand represents the user. In the slow walking case (left), the user is standing in the shower system with the curtain closed, and the shower head adjusts to the correct height based on the user's height. In the wheelchair user case (right), the user approaches the chair and the chair unfolds for loading.

IV. Discussion

The smart shower system is able to provide different levels of assistance based on the user's health status. Currently, only the curtain, showerhead and chair are adjustable. In future work, more devices can be controlled to meet the user's needs. For example, the temperature of the shower water can be adjustable based on the user's skin temperature, and more IR sensors can be embedded to acquire the user's position, leading to more accurate actions of the system.

References

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