Design and implementation of elderly assistant & custody system based on Kinect and Gizwits

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Abstract. Since most of the traditional elderly assistant system cannot achieve remote control and send immediate notifications to their families when falling of the elderly occurs, a somatosensory interactive and remote controllable elderly assistant & custody system is designed and realized based on Kinect and Gizwits in this paper. Old people’s falling can be detected via the depth images and skeleton information captured by Kinect sensor and notified to their family members through web service. Remote control of the simulated smart home appliance through the mobile APP can be achieved via Data Points set in Gizwits cloud platform. Because of the remote control of the domestic appliance and accurate identification of falling-down action, the presented system can provide the elderly people with great convenience and ensure their living safety.

1. Introduction

Nowadays, the pace of stepping into aging society is speeding up and the number of elderly people living alone is increasing year by year. Most of the elderly suffer from the deterioration of memory and physical conditions, and it is quite inconvenient to monitor the domestic electric equipment either at home or at a faraway place. Also, due to the unsteady walking conditions of the old, they are likely to fall down onto the ground (Bourke, 2007). If they cannot receive timely notice, there may be serious consequences. In recent years, the inconvenience and danger in old people's life have aroused people's attention. Hongshe Dang designed an assistant robot but the operation is too complicated to control for the old (Chan, 2009). Qiankun Wu presented a self-help system for disabled elderly but it cannot realize the function of remote control (Cook, 2003). Juan Luo illustrated a custody system for the old but it tends to reveal the privacy of the elderly (Dang, 2017).

At the same time, with the development of internet of things, advanced technology has been applied to interactive and assistant systems. For example, Kinect and RealSense 3D camera which are designed by Microsoft Corporation are used to detect people’s movement and do rehabilitation training for the disabled people (Han, 2013). Gizwits cloud platform, which is running by Gizwits IoT Company in Guangzhou, China, has provided the developers with much easier way to research and develop IoT products (Jin, 2014).

Based on the above problems and new technology, this paper presents a somatosensory interactive and remote controllable elderly assistant & custody system. Skeleton data of the elderly can be extracted by Kinect sensor, thus their movement can be estimated. Remote control of the domestic devices can be realized via the connection between Gizwits cloud platform and mobile APP. The old
people’s privacy can be greatly guaranteed due to the depth images, not the color images obtained by the sensor. Experimental results show that the presented system is able to improve both safety and quality of elderly people’s life.

2. Design

This elderly assistant & custody system consists of two main modules. One is the falling detection module and the other is remote smart home control module.

The overall design of the process is shown in Fig.1. Kinect sensor is used for the falling detection based on the interaction between elderly people and machine. By calculating the height of the center of gravity \( V > V' \) and the falling speed of the spine center \( V \) of the target, the movement of the old can be estimated. After the above two parameters are beyond the set thresholds, the system will do auto voice inquiry. If it is verified that the elderly people have fallen, their families would be notified by e-mail through Internet service. At the same time, all the simulative home equipment using a variety of sensors is connected to STM32 core control panel (Khoshelham, 2012), which is linked to Gizwits server by ESP8266 Wi-Fi module. Signal communication between hardware and software can be realized by setting Data Points in the specially designed APP under Gizwits frame. In that way, the status of all the simulative appliance can be uploaded and downloaded to the Gizwits platform in JSON string format and the remote control of domestic appliance by users can be achieved (Luo, 2017).

3. System related technology

3.1. Somatosensory interaction based on kinect

Kinect is a 3D somatosensory image capture sensor designed by Microsoft Corporation. Color image information, depth image information and human skeleton data can be captured by the embedded cameras. Also, voice input can be recognized and processed by a microphone placed in it. The structure of Kinect is shown in Fig.2. An RGB camera is in the upper-middle part of the machine, which can be used to get color images. An infrared emitter and an infrared CMOS camera, which form a 3D depth sensor together are at its left and right sides respectively. The four-element leaner microphone array is in the middle part of the machine to capture sound source within identified distance. A motor is at the bottom which can drive Kinect to rotate about 27 degrees to both left and right sides in order to implement focusing function. The established three-dimensional coordinates and joint data captured by Kinect is shown in Fig.3.
Through the processing of Kinect internal chip, depth images of the whole scene can be captured. On top of that, skeleton frame of people (up to 6) moving in the Kinect view field can be tracked by tracing 20 joint points of the human body (Noury, 2007). Noise and echo can be eliminated through the four-element linear microphone array and a variety of information within the effective range of the sound source can be traced by voice recognition service from Microsoft (Smisek, 2013).

3.2. Remote control of smart home based on gizwits

Smart home is an important application area of embedded system based on IoT. In this paper, a remote controllable smart home module is designed in order to provide convenience for the elderly people to check and switch the state of domestic device. Gizwits is a one-stop intelligent hardware development and cloud service platform designed for individual and corporation developers by Gizwits IoT Company. Flow of data in Gizwits is shown in Fig. 4. Both of the simulated and actual electric devices are linked to MCU, which is connected to GAgent. GAgent is the data transmitted tool through Data Points, which are the abstraction of functions set in this framework. By using SDK and API, GAgent can realize the data transmission among APP, data from the devices and Gizwits cloud platform. Gizwits server is the control core and data storage structure of the whole system. It is also the data transmission bridge between Wi-Fi module and mobile APP. Data could flow in the components of the structure and in that way, the old people can get the information and make adjustments to the domestic appliances in a faraway place.
4. Implementation of system

4.1. Falling detection based on kinect

In this system, the height of the gravity center and the falling speed of the elderly people can be figured out by Kinect sensor (Su, 2017). Specially, we define that the height of gravity center is the difference between the height of hip center and the average height of left foot and right foot. The calculation method can be presented as follow:

\[ H = \text{HipCenter}_Y - (\text{LeftFoot}_Y + \text{RightFoot}_Y) / 2 \]  \hspace{1cm} (1)

In the formula above, \( H \) stands for the calculated height of gravity center, \( Y \) is the \( Y \) value of joint HipCenter, \( \text{LeftFoot}_Y \) and \( \text{RightFoot}_Y \) represent for the \( Y \) values of left foot and right foot joints respectively. All of the data can be gained and calculated automatically by Kinect sensor. Due to the majority of falling gestures are sit-down and knee-down postures, the height of gravity center can be low (Silva, 2017). In this system, we define \( H' = 0.2m \) as the threshold for \( H \). The moving speed of the center of spine \( V \) is calculated every 10 frames. According to previous experiments (Wang, 2012), it is likely that falling occurs when the speed is between \( 1.21m/s \) and \( 3.05m/s \). In this system, we choose \( 2.05m/s \) as the threshold for \( V \). When it meets both of the conditions \( H < H' \) and \( V > V' \), voice confirmation will be done by the system. If the elderly people can make actions according to the presentation, then the falling alarm can be canceled. Otherwise, e-mails will be sent to their family members to help the elderly people get the first-time aid.

The flow chart of falling detection is shown in Fig.5. At the beginning, Kinect sensor is turned on to obtain depth images and the set depth threshold range is 1.2-3.5m. At the same time, each frame image obtained is turned to binary depth image in order to do human target recognition. After the extraction and segmentation of human body, the images will be smoothed and denoised to improve the motion recognition accuracy. Then, the calculation of the height of gravity and moving speed of the spine center will be done. Also, judgements according to the pre-set thresholds will be carried out. After the confirmation of the falling, e-mails will be sent to their families. Depth information and joints data are shown in Fig.6.
4.2. Design of the simulation of smart home and data points based on gizwits

Data Point is one kind of functional abstraction of electronic devices linked to Gizwits and it is used to describe the functions and related parameters of the devices (Wu, 2017). After the creation of data points, data format of communications between devices and cloud platform can also be determined (Tong, 2010). In that way, data for communication can be recognized by both the devices and Gizwits platform. The basic components of Data Point are Display Name, Identification Name, Read-write Type, Data Type and Remarks. Especially, Display Name is the name of the device shown in APP. Identification Name is used in Application Transport Layer during the client development stage. Read-write Type consists of Read-only, Writable, Alarm and Fault types and Data type consists of Boolean, Enumeration, Numerical and Extended types. Remark is optional, which contains a paragraph to describe the function of a certain data point. Table 1 below is the Data Point formation of simulative domestic devices and sensors in this assistant & custody elderly system.

When the elderly people make switches on the domestic devices either manually or automatically, the real status and display status can be synchronized following the protocol (Xiao, 2012). In that way, the elderly people can have an inspection and operation on the conditions at home in a remote place, which makes their life much more convenient. Part of the simulated domestic devices are shown in Fig.7.
Table 1. Definition of data points via Gizwits

| Display Name | Sensors | Function | Identification Name | Read-write Type | Data Type | Data Range |
|--------------|---------|----------|---------------------|----------------|-----------|------------|
| Auto Window  | Electric machinery/Infrared emitter sensor | Open/Close | window_state | Writable | Boolean | 0,1 |
| Auto Door    | Electromagnetic relay | Open/Close | door_state | Writable | Boolean | 0,1 |
| Auto Socket  | Current Sensor/Relay | Turn on/off | socket_state | Writable | Boolean | 0,1 |
|              | Buzzer | Socket overload | socket_alarm | Alarm | Boolean | |
|              | Current Sensor/Relay | Socket overload cutoff | socket_cutoff | Alarm | Boolean | |
| Smart Lamb   | LED1   | Turn on/off lamb1 | lamb1_state | Writable | Boolean | 0,1 |
|              | LED2   | Turn on/off lamb2 | lamb1_state | Writable | Boolean | 0,1 |
|              | LED3   | Turn on/off lamb3 | lamb1_state | Writable | Boolean | 0,1 |
|              | LED1+LED2 | Turn on/off Romantic mode | lamb_romantic | Writable | Boolean | 0,1 |
5. Conclusion

An elderly assistant and custody system based on Gizwits and Kinect is presented in this paper. System framework and the way of implementation have been detailedly described. Unlike traditional smart home systems, cloud server is used to realize the remote regulation and control. Apart from that, Kinect sensor is used to obtain depth images and skeleton information of the elderly to detect their falling motions and send notifications to their family members. In addition, the falling detection is based on depth data, which makes up for the inconvenience of collecting information by wearable devices and ordinary cameras. Interference of visible light and background information can also be eliminated (Zhao, 2016), which improve the reliability and accuracy of the system to a large extent. By verification, the elderly can remotely query and change the device status at home and their falling-downing can be accurately detected.

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