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A head position estimation method for a variety of recumbent positions for a care robot

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This paper describes a head position estimation method for a variety of recumbent positions for a care robot. First, the robot detects a fallen person using a laser range finder and moves there for getting a point cloud. The obtained point cloud is matched with those with head positions in the database using the ICP (iterative closest point) algorithm for estimating the current head position. Then, extracted head positions with matching scores above a threshold are clustered, and the center of the cluster with the highest accumulated scores is determined to be the head position. A human pose database construction system is also described.

1 Introduction

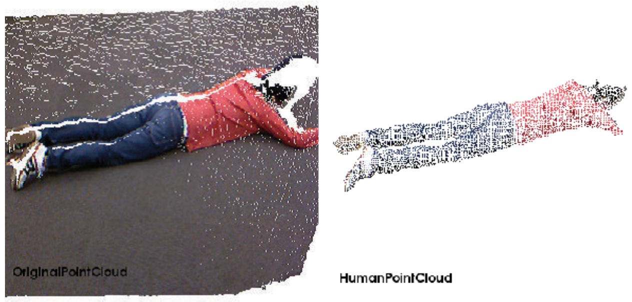
Shortage of caregivers has been a serious problem in many advanced countries which suffer from aging society [1]. In recent years, therefore, many research efforts on elderly care systems have been made. When a system watches elderly people, one of the most important functions is to detect abnormal conditions such as a fall by a heart attack.

Ardiyanto et al. [2] developed a system which detects a fall of a person and dispatches a mobile robot to the person for finding vital signs (e.g., carbon dioxide concentration in the breath and complexion). This system, however, requires a continuous person monitoring using, for example, cameras mounted on ceilings or walls, which might raise a privacy problem. It is, therefore, desirable to be able to detect abnormal states of a person using only cameras or sensors mounted on a mobile robot; this also improves the QoL (Quality of Life) of a person who receives cares.

To find vital signs, it is important to locate a head or a face position. For a person in standing or sitting postures, we can easily detect the head position using, for example, Kinect with the skeleton tracking capability [3]. It can also cope with recumbent postures, if it observes a falling motion from a standing/sitting posture. But this is not the case for our robot which goes round in the building and does not watches a single person continuously. In this paper, therefore, we develop a method of locating a head position for persons in recumbent postures.

2 Obtaining Person Point Cloud

We locate a head position from a point cloud corresponding to a person. The point cloud is extracted from RGB-D camera data (see Fig. 1(a)) and then downsampled using a voxel grid filter. We then remove points near the floor and cluster the remaining points into objects candidates. The candidate which has the closest size to that of person is selected as the person point cloud (see Fig. 1(b)).



(a)Input point cloud. (b)Extracted person point cloud.

Fig. 1 Obtaining person point cloud.

3 Construction of Human Pose Database with Head Position Annotation

Fig. 2 shows a system for efficiently collecting point cloud data of a person from all 360-degree viewing directions with 10-degree interval, namely, from 36 directions. The RGB-D camera on the right takes depth data while the person on the table is rotating. The table is controlled by an Arduino and its rotation angle is measured by the top camera. We manually assign the head position in one of the data and those in the others are calculated automatically. We collected data for one subject, 30 postures, and 36 viewing directions. All data are classified based on the principal axis of inertia into 24 groups (that is, every 15 degrees) in the database.

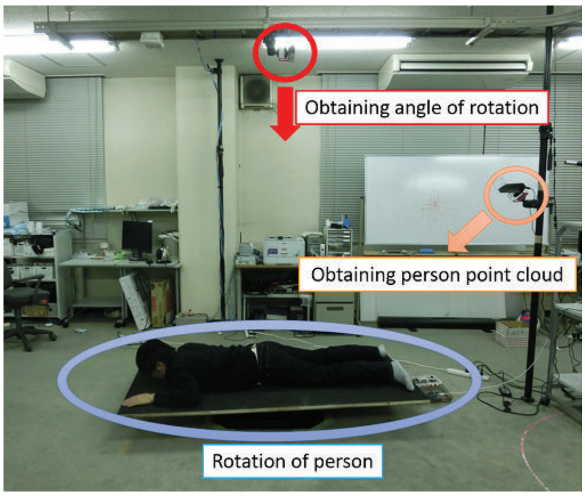


Fig. 2 A system for human pose database construction.

4 Locating the Head Position based on ICP

To locate the head position in the current person point cloud, we first search for records in the database which have similar postures with the input posture. This search is done by first identifying the group in the database which has a similar principal axis of inertia with that of the current data, and then applying an ICP (Iterative Closest Point) algorithm to the current data with each of the records in that group. From a set of matched records, we can calculate a set of head position candidates with a degree of matching as a weight. The degree of matching is the residual error in the ICP and the weight is calculated by:

$$Weight = \exp\left(-\frac{|err - err_{best}|}{err_{best}}\right), \qquad (1)$$

where err and err_{best} are the current and the best (i.e., smallest) residual error, respectively.

Fig. 3(b) shows an example set of estimated head positions with weights shown in colors for the input data in Fig. 3(a); a large weight is shown in red, while a small weight in blue.

We then remove the estimated head positions with the weight less than 0.1, and cluster the remaining positions with distance threshold of $2cm$ (see Fig. 4(a)). We choose the cluster with the maximum sum of weights, and calculate the weighted mean position as the head position (see Fig. 4(b)). Fig. 5 shows the results for a person who is the subject in data construction with poses similar to the recorded ones; in this case, the estimation is fairly good. Fig. 6 shows the results for a person who has a very different body shape from the subject and Fig. 7 shows the ones for poses which are largely different from those in the database; in these cases, the estimation results is not very good but is acceptable because the estimated head position is sufficiently near to the real head position. For further increasing the accuracy, we need to collect more data for various persons and postures.

5 Summary

This paper has proposed a method of locating a head position of a person in recumbent postures using an RGB-D camera and a human pose database with head position annotation. For improving the performance, we are planning to extend the database with a more variety of subjects and postures.

6 Acknowledgment

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References

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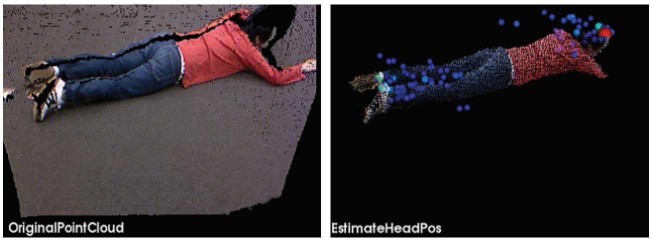
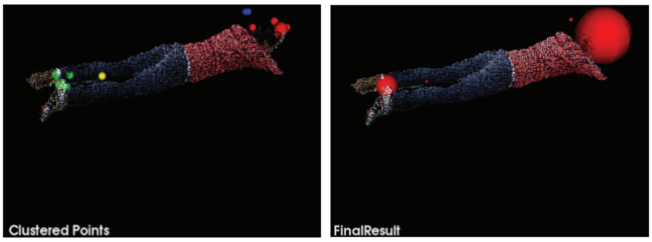
[3] Jamie Shotton, Andrew Fitzgibbon, Mat Cook, Toby Sharp, Mark Finocchio, Richard Moore, Alex Kipman, and Andrew Blake "Real-Time Human Pose Recognition in Parts from a Single Depth Image", *Computer Vision and Pattern Recognition 2011 (CVPR2011)*, 2011.



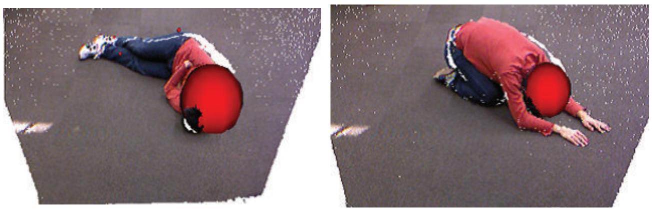
(a)Input point cloud. (b)Weighted estimation point.

Fig. 3 Derivation of weighted estimation point.



(a)Extraction and clustering. (b)Final estimation point.

Fig. 4 Result of head position estimation.

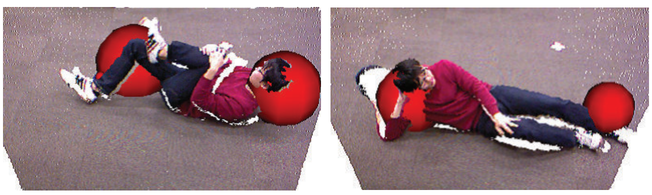


(a)Lying. (b)Crouching.

Fig. 5 Known subject and posture in the database.

(a)Lying on the back. (b)Lying with pressing stomach.

Fig. 6 Unknown subject with known posture in the database.



(a)Pressing right knee. (b)Watching TV.

Fig. 7 Known subject with unknown posture in the database.