Proposal of System to Prevent Sudden Infant Death Syndrome Using Kinect

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Abstract

The sudden, unexplained death of an infant is a tragic family event. Unaccustomed tummy sleeping increases the risk of SIDS. Babies who are used to sleeping on their backs and are placed to sleep on their tummies are 18 times more likely to die from SIDS. In order to prevent SIDS, Babysense and Snuz Hero are commercially available. They are useful products that can be detected at an early stage in the accident baby. However, it may become too late after the accident has occurred. Preventing before the accident occurs in the baby is desirable. In this study, we propose a new system to prevent sudden infant death syndrome using Kinect. This system can detect baby sleeping in a prone position from depth information and image of Kinect. First, this system recognizes the presence of a person from depth. Next, this system recognizes that the person is sleeping in supine or prone position by using the difference in depth with the other. Finally, this system recognizes that a person is sleeping in prone position by face recognition. By preventing baby sleeping in a prone position, the incidence of SIDS is greatly reduced.

Keywords: sudden infant death syndrome, Kinect, sleep in a prone position, OpenCV, face recognition.

1. Introduction

The sudden, unexplained death of an infant is a tragic family event. Sudden infant death syndrome (SIDS) is just one of several causes of sudden, unexplained death in infancy, but it is the most frequently reported⁽¹⁻³⁾. Unaccustomed tummy sleeping increases the risk of SIDS. Babies who are used to sleeping on their backs and are

placed to sleep on their tummies are 18 times more likely to die from SIDS⁽⁴⁻⁵⁾. SIDS is the leading cause of death for infants between 1 month and 12 months of age. SIDS is most common among infants that are 1-4 months old. However, babies can die from SIDS until they are 1 year old. A study was conducted to clarify the preventive strategies for accidents of infants and awareness of SIDS⁽⁶⁾. According to this study, 46 % of the mothers lay their infants on their face.

In order to prevent SIDS, Babysense⁽⁷⁾ and Snuz Hero⁽⁸⁾ are commercially available. Babysense is a highly sensitive non-touch baby Breathing Movement Monitor. Now parents can get the piece of mind while their baby sleeps. Babysense is intended for detection of respiratory cessation (apnea) in babies. It constantly monitors baby's breathing micro movements through the mattress during sleep and gives an alert to caretakers if breathing stops or becomes irregularly slow, giving critical time to intervene. Snuz Hero is a mobile and easy-to-use movement monitor which clips onto baby's diaper to ensure that normal movement is maintained. Hero detects even the slightest movement and will alert you if your baby's movements are very weak or fall to less than 8 movements per minute. If no movement at all is detected for a period of 15 seconds, Hero will vibrate gently. Often this vibration is enough to rouse the baby, and Hero will revert to monitoring mode. After three vibration/rouse incidents, the Rouse Warning will alert you to the fact that your baby's movements have stopped for 15 seconds on three occasions. If no further movement is detected for another 5 seconds, an alarm will sound to alert you. They are useful products that can be detected at an early stage in the accident baby. However, it may become too late after the accident has occurred.

Fig. 1. Structure of this system.

Preventing before the accident occurs in the baby is desirable.

In this study, we propose a new system to prevent sudden infant death syndrome using Kinect. This system can detect baby sleeping in a prone position from depth information and image of Kinect. By preventing baby sleeping in a prone position, the incidence of SIDS is greatly reduced.

2. System to Prevent Sudden Infant Death Syndrome Using Kinect

2.1 Structure

The structure of this system is shown in Fig. 1. Kinect is installed on top of the crib. This system gets depth information and image of the baby on the crib using Kinect. The pixel number of depth information and image from Kinect is 640 *480 pixels.

This system estimates the state of the baby from these data as shown in Fig. 2. First, the system recognizes the presence of a person. Next, this system recognizes that a person is sleeping in supine or prone position. Finally, this system recognizes that a person is sleeping in prone position. These methods are described in Section 2.2-2.4.

If this system determines the baby is sleeping in a prone position, this system can prevent SIDS by notifying parents the hazards.

2.2 Recognition of Person

First, this system recognizes the presence of a person. Procedure is shown below:

- (a) Measurement of depth of background subtraction

Depth of the background is measured by Kinect in advance. As an example, an original image and a depth

Fig. 2. Flow of processing.

Fig. 3. Recognition of person.

image are shown in Fig. 3a and 3b. Difference between depth of measurement and background is obtained.

- (b) Creating a binary image by thresholding

Binary image is created by thresholding from depth of background subtraction. As an example, the binary image is shown in Fig. 3c. In order to recognize person of any posture, threshold is determined to 50 millimeters.

Fig. 4. Recognition of sleeping in supine or prone position.

(c) Noise rejection

There is a lot of noise in binary image that was created. Noise rejection is performed in the following procedure.

- i. Dilation of 3 pixel
- ii. Erosion of 5 pixel
- iii. Dilation of 3 pixel
- iv. Labeling
- v. The largest area extraction from areas over 2000 pixel

By the above processing, the area of a person is extracted. As an example, the image after noise rejection is shown in Fig. 3d. If the area is not extracted, this system recognizes that there is no person.

Fig. 5. Recognition of sleeping in prone position.

2.3 Recognition of Sleeping in Supine or Prone Position

The height of sleeping in supine or prone position is lower than that of sleeping sideways or sitting. In this section, this system recognizes that a person is sleeping in supine or prone position by using this difference. Processing similar to Section 2.2 is performed. Threshold of creating a binary image is only changed. In order to detect person except sleeping supine or prone position, threshold is determined to 200 millimeters for baby. In this paper, adults try this system. Threshold is determined to 300 millimeters for adult. By this processing, the area of a person except sleeping supine or prone position is extracted as shown in Fig. 4. If a person is recognized in the processing of Section 2.2 and a person is not recognized in the processing of Section 2.3, this system recognizes that a person sleeping supine or prone position is present.

2.4 Recognition of Sleeping in Prone Position

In this section, this system recognizes that a person is sleeping in prone position by face recognition. This recognition uses face recognition, but accuracy of face recognition is not high. By performing face recognition on the image that is extracted around head, accuracy can be improved. Image is obtained from the Kinect. Image of the area of the person obtained in Section 2.2 are extracted. Since baby is about three-head figure, image of 40 % is extracted from the head. In this paper, image of 25 % is extracted from the head because adults try this system.

Orientation of the head is determined in advance. Face recognition is performed on the extracted image as shown in Fig. 5. In this study, the classifier of `haarcascade_frontalface_default.xml` in OpenCV is used for face recognition. If face is recognized as shown in Fig. 5c, this system recognizes the person is sleeping in supine position. If face is not recognized as shown in Fig. 5d, this system recognizes the person is sleeping in prone position. If the situation of sleeping in prone position continues over 10 seconds, this system notifies parents the hazards.

3. Experiment

Three experiments were performed in this chapter. Kinect was installed on the ceiling of about 2.4 meters in height. Height of the bed was about 0.7 meters. Ten people tried the following experiments. Each person posed as following with and without bedding;

- sleeping in prone position,
- sleeping in supine position,
- sleeping on them right side,
- sleeping on them left side,
- sitting.

3.1 Experiment of Recognition of Person

In this section, this system tried to recognize the presence of a person. Processing of Section 2.2 was performed in each condition. As a result, this system correctly recognized the presence of the person in all conditions. Therefore, the recognition rate in this section is 100 %.

3.2 Experiment of Recognition of Sleeping in Supine or Prone Position

In this section, this system tried to recognize that a person was sleeping in supine or prone position. Processing of Section 2.3 was performed in each condition. As a result, this system correctly recognized the state of the person in the conditions of sleeping in supine position, sleeping sideways and sitting. In the conditions of sleeping in prone position, this system correctly recognized the status of nine people, but this system recognized a state of one person erroneously. Therefore, the recognition rate in this section is 99 %.

Cause of erroneous recognition was because he was a large man. Since individual differences in body size of baby is smaller than adult, possibility of erroneous recognition by this cause is low when this system recognize baby.

3.3 Experiment of Recognition of Sleeping in Prone Position

In this section, this system tried to recognize that a person was sleeping in prone position. Processing of Section 2.4 was performed in conditions of sleeping in prone and supine position. Nine people that were recognized correctly in Section 3.2 tried this experiment because this process is not performed for the person that was recognized erroneous. As a result, this system this system correctly recognized the state of the person in all conditions. Therefore, the recognition rate in this section is 100 %.

From the above results, high recognition rate was obtained in all experiments. When this system will use for baby, we expect that the recognition rate almost 100% will be obtained.

4. Conclusions

In this study, we proposed a new system to prevent sudden infant death syndrome using Kinect. As results of experiments, it was confirmed that this system could detect that a person was sleeping in a prone position from depth information and image of Kinect. By preventing baby sleeping in a prone position, the incidence of SIDS is greatly reduced.

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