Design of Face Tracking System Using Fixed 360-Degree Cameras and Flying Blimp for Health Care Evaluation

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Abstract

This paper proposes a system for tracking elderly people inside a nursing home. The system is constructed of a network of 360-degree cameras as fixed cameras and a flying blimp carrying a wireless camera as a moving camera. Fixed cameras are used for localization of people and the blimp and recording the area from a wider viewpoint. The position and orientation data are used to control the blimp to move closer to the target to obtain images from a closer viewpoint for the use of emotion estimation using facial images. The use of blimp helps reducing the risk of robot severely hitting the patients, extending the battery life, and reducing the effect of the presence of quadrotor on patient's emotion. The blimp has been constructed and tested with manual control, showing the ability of various movements with good maneuverability. The battery life is also significantly extended using the same battery, with the possibility of increasing the capacity of the battery. By adding positioning by 360-degree cameras, position control of the blimp would be possible as well as person tracking.

Keywords

Health care, face tracking, quality assessment, flying blimp

1 INTRODUCTION

In this paper, we propose a system using a network of fixed 360-degree cameras and a camera-carrying blimp for tracking and analyzing people's position and emotion in an elderly care house. Knowing the position, interaction, and emotion of each person, both patients and care givers, care manager can use the information to evaluate the outcome of the care provided to the patients and improve the care service provided to each patient individually to maximize the effectiveness of the care.

In conventional elderly care house, elderly people spend time doing activities together with supports from care givers. Meanwhile, care givers also observe their faces for the smile for their emotions, any irregularities or problems, as well as social interaction among elderly people and care givers. The obtained information is passed from care givers in one shift to the next shift and used for planning the care needed and evaluating the quality of the care processes provided to each person. However, requiring care givers to take care of the elderly people as well as observing their emotion can be difficult, resulting in errors and mistakes. Therefore, a system for keeping track of each person's position and face, recording and extracting important events is required for data acquisition to help improving the quality of health care system. With images and videos of patients' faces, together with other information such as positions and happenings during that period, care givers and care manager can review and understand the emotion of each patient at different time.

There are researches on tracking people using cameras and robots. (Wheeler, et. al, 2010) used fixed wider field of view camera to detect people and controlled a pan-tilt-zoom camera to obtain the facial images of each person for personal identification. However, in order to cover any direction, more cameras are needed in other directions. There are also works on face-tracking robots, such as those in (Bellotto and Hu, 2009) and (Vadakkepat, et al., 2008) which used ground mobile robot to track and follow human's face. The robots need to be in front of the person before tracking can start, otherwise searching process needs to be performed.

Previously, we have presented a similar system utilizing RGB-D camera's depth camera and a miniature quadrotor in (Srisamosorn, et al., 2014) for single depth camera and (Srisamosorn, et al, 2016) for multiple depth cameras. As quadrotor needs to keep the propellers rotating all the time to keep itself flying, power consumption level is quite high resulting in short battery life (approximately 7 minutes without attaching camera, and reduced to around 3 minutes when a wireless camera is utilized.) The presence of quadrotor in a living space, as well as the noise produced by the propellers, also affects people's comfort and make some people scared and distracted, therefore the obtained emotion may be disguised by the fear and anxiety created by the quadrotor. There is also chance that one of the quadrotor's propellers will hit a person or the propellers stop working resulting in the fall of the quadrotor, which can cause severe injury to the nearby people.

To overcome the aforementioned concerns, the use of neutrally buoyant blimp is considered. As blimp with adequate lifting gas can float without the need of external force, the motors can stop while the blimp is at the position where the person's face can be captured, resulting in lower energy consumption and noise from the rotating propellers. In case of fault or malfunctioning of the robot, the lifting gas would help keep the robot floating and avoid direct strong collision with people. Even in the case of damage to the blimp's envelope, the gas would gradually leak out and the robot would slowly fall down, avoiding serious personal injury. The look of a blimp is also friendlier to people when compared to a quadrotor, making them feel more comfortable upon co-existence as discussed by (Liew and Yairi, 2013).

2 SYSTEM DESCRIPTION

2.1 System overview

The proposed system consists of a number of 360-degree cameras fixed in the environment and a moving camera carried on a neutrally-buoyant helium blimp. Fixed cameras are used to record videos from broader viewpoint so that interaction between people can be observed, as well as provide information about each person's location and orientation and the moving camera's location. A blimp carries a camera and moves closer to the target person's face to avoid occlusion and obtain facial images with higher resolution and at better viewing angle for more accurate result. With propellers working only when movements are needed, length of tracking can be longer and noise from the rotating propellers can be reduced, creating less disturbance to the people. By analyzing the obtained videos, important events such as conversation or quarrel can be detected and the footage can be saved for further playback by care manager and experts, helping eliminate unnecessary record and save the review time. Facial images obtained by the blimp can also be processed for estimating the emotion on the face.

In addition to blimp, we also introduce the use of 360-degree camera, such as fisheye camera, instead of Kinect sensors. This replacement improves the ability to record color videos in wider area and remove the noise created by the infrared interference cancellation system which uses vibration to blur infrared patterns from other cameras, helping the infrared sensor sees only its own pattern. A fisheye camera can be put above each activity area to record the activity and interaction as a whole, and videos from multiple cameras can be used for locating people and blimp using triangulation, which can be used for the control of the blimp to perform tracking of people. Figure 1 shows the illustration of the proposed system.

In the similar manner with our previous system, 360-degree cameras will be used as the fixed cameras for locating the position and direction of each person as well as providing the location of the moving cameras, in this case a blimp. The blimp will carry a camera and work as a moving camera. The camera system keeps track of the position of each person. When there is a command from the nurse to track a specific person, that person's track will be used to

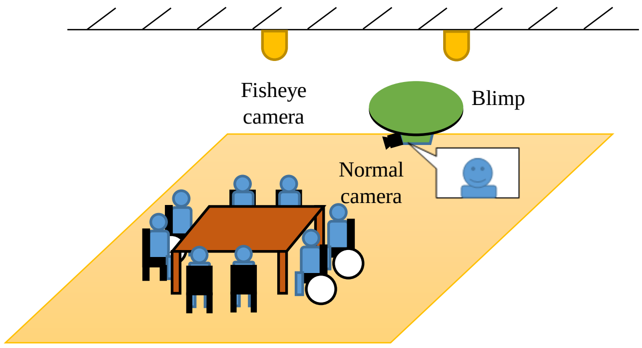

Figure 1: Image of the proposed system with blimp

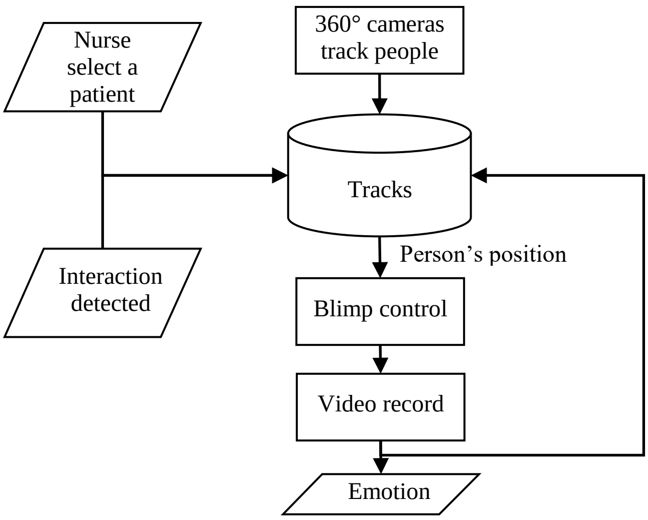

Figure 2: Flowchart of the proposed tracking process

control the blimp to move closer and take the video of the person's face. With this configuration, the blimp does not need to blindly search for the people to be tracked. Other uses can include moving the blimp to record an interaction when it is detected by the camera system, or following a patient going to toilet and sending out alarms if some accident occurs. Figure 2 shows the flowchart of the process.

2.2 Blimp Construction

There are a number of researches done on construction of blimps and airships, mostly largely sized for more payload and outdoor operation. Among available indoor blimps, compact size blimps include (Furukawa and Shimada, 2014), which used a tear-shaped envelope with two rotatable propellers for controlling horizontal, vertical, and rotation movements, and (Tao, et al, 2015), which used round-shaped envelope and four fixed propellers, two of which pointing in vertical orientation and the other two pointing in the horizontal orientation. Detailed information about the construction of both blimps are not available. The appearances of the blimps are used as the ideas to construct our blimp.

We designed the prototype of the blimp robot as shown in Figure 3. Two propellers are attached to a shaft connected to a servo motor such that the thrust angle can be controlled. This motor configuration can provide the motion in the forward/backward direction by setting two propellers on the horizontal orientation, up/down direction by setting them to

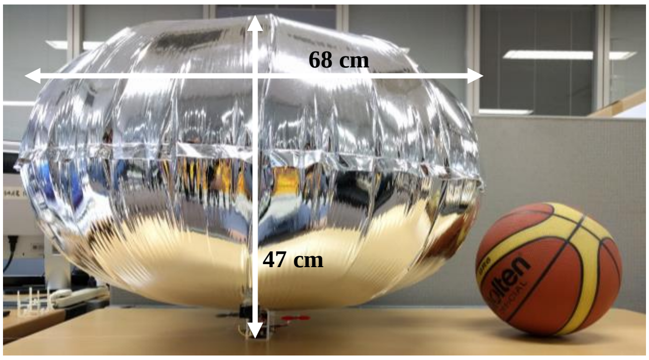

Figure 3: Prototype of the blimp compared to a basketball

vertical orientation, and rotational motion by providing opposite thrust while the propellers are in horizontal orientation. The quadrotor's control board is used as the main controller for the blimp due to its functionality, size and weight, and programmability. Communication system is already implemented, as well as various sensors such as inertial measurement unit (IMU) and barometer. Firmware of the controller is also open-sourced and can be modified.

The shape of the gas-containing envelope was chosen to be circular, i.e. inflating two sealed circular sheets into a flattened sphere. This shape has an advantage over the conventional airship shape that it is symmetric, so it is not so offensive to people who may feel uncomfortable with a blimp tracking them. The material used to construct the envelope is biaxially-oriented polyethylene terephthalate (BoPET), which is the same as those used in the commercial helium-filled balloons. This sheet, also known by the commercial name of Mylar, may be heavier than a normal rubber balloon, but has the benefit of better Helium containment, inflexible volume when fully inflated, and low risk of sudden explosion which can cause danger to people. The size of the envelope was calculated according to the weight of the whole robot, resulting in 68 cm diameter and 41 cm height when fully inflated. Electronic and mechanic parts are concentrated at the center of the blimp below the envelope, with the camera placed in the front closer to the edge of the envelope for better view of the person.

3 CONTROLS AND EXPERIMENT

At the current implementation, the blimp is controlled by two joysticks on a console game controller. Commands from the controller are processed on a computer and sent wirelessly to the receiver on the blimp in the form of forward/backward movement, up/down movement, and rotation movement. These movements can be combined and actuated at the same time. The blimp's firmware then processes these commands into the power of each propeller and the angle of the servo motor, actuating the motors to move the robot. On-board IMU sensor provides the rotation angle (yaw angle) of the blimp, which is used by a proportional-integral-derivative (PID) controller to control the rotation of the blimp at a desired direction.

Figure 4 shows snapshots of the manual control experiment with yaw control. In the test, we flew the blimp around the area for around 11 minutes with continuous video transmission and regular movement, and there was still some battery left. A snap of the face obtained when the blimp was flying in front of a person is shown in Figure 5 Yaw control also helped keeping the blimp moving in a

Figure 4: Sequences of the blimp under manual control

Figure 5: Image from the camera on the blimp

straight line when it was thrusted forward or backward. During the flight, the blimp also hit the wall or some obstacle objects, but it could recover quickly, which is not possible in case of a quadrotor. However, position control of the blimp by manual control was quite difficult due to its large inertia. Setting up cameras and further image processing can provide position of the blimp and be used for position control.

4 CONCLUSION AND FUTURE WORKS

This paper proposes the use of a blimp robot for tracking people's face in indoor environment together with a system of fisheye cameras for health care evaluation in elderly nursing home. Changing from a quadrotor to a blimp provides the benefits of longer tracking time, safer implementation, and quieter and friendlier robot for usage with people. In the final system, we expect to locate the position of each people present in the area and command the blimp to track a desired person by selecting the person through some device. The current progress includes the construction of the blimp. The experiment of manual control of the blimp shows some movements achieved by the constructed blimp, as well as improvement in the battery life and safety issues. With the same battery being used with the quadrotor, the flight time can be increased from around 3 minutes to more than 11 minutes, and it is also possible to increase the capacity of the battery to extend it further. Setting fisheye cameras in an environment can be the next step to provide position control of the blimp around the environment, as well as provide the position of the target person we want to track. Detection of objects in each camera's image plane will be used to obtain each object's

3D position using triangulation. 3D position and direction of each person will set up the position of the blimp so that it can provide good view of the person's face. 3D position of the blimp estimated from the camera system will be fed back for the position control of the blimp to track the face.

5 ACKNOWLEDGMENTS

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