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Smart Fan: Self-contained Mobile Robot that Performs Human Detection and Tracking using Thermal Camera

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Abstract

The intelligence within these systems has been developed so that the products are autonomous. Among them, we especially focused on the air conditioning control with smart products. This paper proposes a smart fan robot that detects and tracks a person by using a thermal camera and RGB-D camera.

Categories and Subject Descriptors (according to ACM CCS): H.1.2 [Information Systems]: User/Machine Systems—Human factors H.5.2 [Information Systems]: User Interfaces—Interaction styles

1. Introduction

Expanding an already existing product by giving it intelligence can be an important factor in enriching our lives. For example, M. Yuasa et al [MY14] have developed a flowerpot which automatically moves to the place where the sunlight is lit for efficient photosynthesis of the plants. The movement of the flowerpot is controlled by using the information of illuminance sensors and temperature sensors attached to the flowerpot. M. Kurata et al [**?**] have developed a system for garbage collection. First, they have equipped wheels to a wastebasket. When a user throws trash, the wastebasket automatically moves to the dropping point. They use RGB-D camera to detect the movement of the trash. As mentioned above, the intelligence within these systems has been developed so that the products are autonomous.

Among them, we especially focused on the air conditioning control with smart products. In many air conditioning systems, there are some problems that a temperature setting is determined in each room and that an effective temperature of the room is different depending on the person. So, K. Watanabe et al [KW12] have developed a system to control a fan. Their proposed method used RGB camera with fan to detect motion of a user and to control the fan interactively. Mitsubishi Move Eye [201] is an air conditioner attached to a thermal camera. The thermal camera is used for the human detection and control for sending wind efficiently.

As mentioned above, the control of air conditioning is an important factor. Although current research and products are able to control the strength and the direction of the wind, they have yet to be able to control the source of the wind itself.

Figure 1: *Smart Fan*

Many researchers use not only RGB cameras, but also thermal cameras for human detection. S.Y. Cheng et al [CPT05] have developed a 3D body tracking system by using multiperspective thermal camera and video arrays. K. Yasuda er al [YNH04] have used a thermal camera as a filter for RGB camera images. First, they calibrate the position of the thermal camera with the position of the RGB camera. The human region is extracted from the RGB camera image by using the thermal data and is superimposed on another

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background image. Our proposed method also uses a thermal camera and RGB-D camera to detect the human region and use that information to control the movement of the fan.

2. Smart Fan

This paper proposes a smart fan robot that detects and tracks a person by using a thermal camera and RGB-D camera.

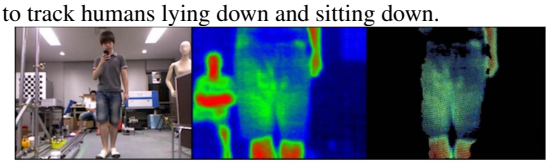
2.1. System Configuration

Figure 1 shows our system configuration. First, we mounted a fan, a notebook PC, a control circuit of a fan, a RGB-D camera and thermal camera on the robot. In this paper, we used Roomba 500. We used NEC Avio's Thermal Shot F30 with a resolution of 160 X 120 and a framerate of 8 img/s. The vertical and the horizontal values of the field of view are 31 degrees and 41 degrees. And We used Kinect for windows v1 as a RGB-D camera. The spec of resolution of color camera is 640 X 480 and that of depth camera is 320 X 240. The framerate is 30 fps. The vertical and the horizontal values are 43 degrees and 57 degrees.

2.2. Proposed Method

2.2.1. Human Tracking

At first, We used a RGB-D camera to calculate the distance between the smart fan and the objects. The object which is more than 3.0 m away is excluded from human detection. Then, with the remaining objects, we searched for objects that has the similar temperature as human body using thermal camera. At this time, small areas are ignored. Also, when more than one area is detected, the robot chases the object with the highest temperature. Figure 2. shows an example of the human detection. The coordinate of the detected human region is converted to the RGB-D camera coordinate system. Then the center of gravity of the human region is calculated and the smart fan moves to keep the distance between the point and the robot at a fixed distance. The smart fan turn and move forward and backwards. By using the thermal camera, this systems is able to track humans more robustly compared with just using the RGB-camera. It is able to track humans lying down and sitting down.



(a)RGB camera (b)thermal camera(c)detected human region

Figure 2: *Human Detection*

2.2.2. Controlling of Fans

The fan is controlled by microcomputer and the airflow is controlled according to the temperature of the person and also the distance between the smart fan and the person. If the distance is long, the airflow will increase.

2.3. Calibration

We use a circle dot pattern to calibrate the reference position of thermal camera and RGB-D camera. The calibration board consists of two parts: the lower plate which circle patterns are printed and the upper plate designed to plug onto the lower plate. The lower plate is printed in black and the upper one is printed in white. Only the lower plate is heated to make it visible from the thermal camera. Then we combined these two plates.

2.4. Conclusions

We developed the smart fan that detects and tracks a person automatically. By using thermal camera, we implemented robust human detection. Following are some examples of use scene. The smart fan is used effectively at the places where the temperature becomes high drastically such as kitchen. Also the smart fan can track a person using vacuum cleaner which makes cleaning more comfortable.
A combination of a system that controls the direction of the wind such as Airsketcher [KW12] with our proposed method will enable designing the air more freely. Also by combining of a transmission of the temperature images taken by the thermal camera and the remote operation of the robot at a remote with our system will enable looking at the health of the family and house pets from remote locations, and controlling air condition to avoid some disease such as heat stroke.

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