Vision-based Control of a Home Companion Robot

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To reduce the cost of health care and improve the quality of life of elderly people, more and more robots are being designed to interact with a human being to provide the kind of care that traditionally can only be offered by a health care professional. The goal of this research is to design and test a home companion robot that can interact with people in a natural way around the house to provide elderly companionship and help with daily activities. The first prototype was designed based on a DFRobot 4WD Arduino Mobile Platform. A Pixy vision sensor (CMUcam5) is used to provide fast vision feedback to the Arduino microcontroller so that the robot can interact with its user. Finally, the concept was proven to be effective through trials. It would have great potential to be used as an intelligent, low cost home companion robot to provide some of the elderly care that traditionally can only be provided by a home care provider. Ultimately, the home companion robot would be able to navigate autonomously in typical home environments to perform tasks such as smart medicine reminder, daytime activities manager, autonomous docking and recharging etc.

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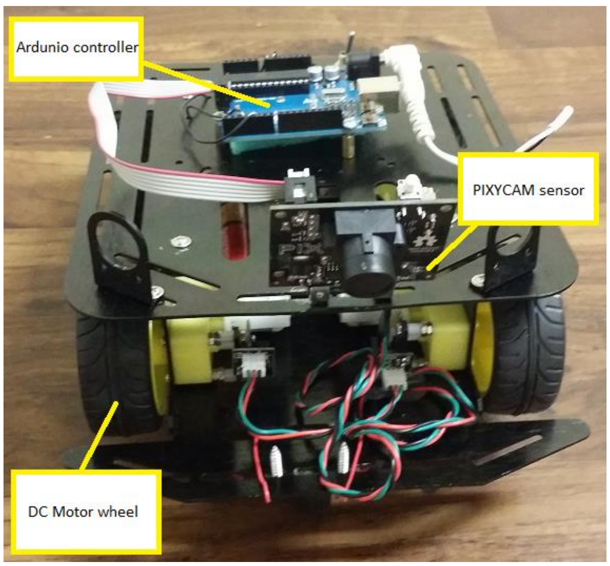
Introduction

To reduce the cost of health care and improve the quality of life of elderly people, more and more robots are being designed to interact with a human being to provide affordable and robust care at home that traditionally can only be offered by a health care professional. Through interviews with eight single autonomous elderly between 75 and 88 years old and 7 of their close relatives regarding the acceptability of a smart home voice interface, the researchers in France emphasized that a home companion device must try to bring more independence to elderly and avoid creating a less autonomous lifestyle [1]. About ten years ago, a group of researchers at MIT media lab designed a teddy bear alike therapeutic robotic companion called the Huggable that is capable of active relational and affective touch-based interactions with a person [2]. This type of therapeutic robot focuses on affective interaction between human and a robot, which is very similar to the health benefits provided by companion animals. This type of robots is short of the autonomous navigation and interaction with the human. A major goal of the home companion robot research is to engage an elderly person to encourage a subtle but stimulating effect in daily life. This challenge is explored through the design of a playful mobile interface to control a robot companion in a smart home environment [3]. To support independent living, robotic companion and the smart home environment need to be seamlessly integrated to create enhanced usability and satisfaction [4]. A group from Germany presented a real-time method for a mobile robot to understand the user's activities by extracting the user's pose and motion from camera images [5]. To reduce the length of patients hospitalization, a French group designed a scalable collaborative platform to handle specific tools for patients, their families and doctors. Visiophony tools are used to remote control a robot companion [6]. The goal of this project is to design a robot with imaging sensor that can identify colors and according to this color to make autonomous and smart decisions.

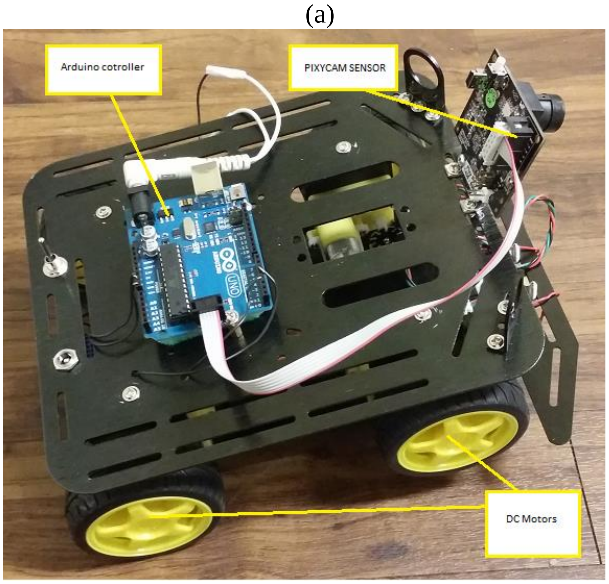
System Design

The goal of the project is to design a robot with image sensor that can identify colors and make decisions accordingly. The robot platform was constructed and designed based on a DFRobot 4WD Arduino Mobile Platform. The sensors we use to help the robot interact with the surrounding environments is a vision sensor called Pixy (CMUcam5). Pixy is a fast vision sensor you can quickly "teach" to find objects, and it connects directly to Arduino microcontrollers. The Pixy CMUCam5 image sensor has a powerful processor that can be programmed to only send the extracted information so the microcontroller will not be overwhelmed by data. The Pixy CMUCam5 uses hue and saturation as its primary means of image detection - rather than the normal RGB. This means that lighting or exposure won't affect the Pixy's detection of an item - which is a frustrating problem with many image sensors. It can also remember seven different color signatures, find hundreds of objects at the same time, and is superfast - processing at 50 frames a second.

After mounting the Pixy camera to the platform, we use an Arduino microcontroller to collect the sensor data and then organize and send to the actuators for navigation. In our robot we will assign and define a color with the Pixy cam and start receiving its orientation as x, y and z values and some other data such as object wide and shape. By knowing all this data and passing it through the controller, the controller can control four DC motors to carry out the assigned tasks. The final assembly of the home companion robot is shown in Figure 1 below, which mainly includes the robot frame, four DC motors, Pixy camera and Arduino microcontroller.



(a)



(b)

Figure 1. Robot final assembly: (a) front view and (b) side view

Using properly designed algorisms, one can make image sensor detect surrounding environment. Image sensors are one of the important sensors that have been used in robotics industry thanks to their flexibility, however there are two major drawbacks with image sensors: 1) they output lots of data, dozens of megabytes per second, and 2) processing this amount of data can overwhelm many processors. And even if the processor can keep up with the data, much of its processing power won't be available for other tasks. Pixy cmucam5 solves these problems by combining a powerful dedicated processor with the image sensor. The processor processes images from the image sensor and only sends the useful information to the microcontroller. Therefore, it is easy to connect Pixy with Arduino microcontroller and still have plenty of CPU processing power available for other tasks.

Validation Test

To test the image sensor based control, a simple task was first designed for the robot to track a tennis ball based on color of the image feedback. The algorithm used is presented in Figure 2 in the form of a flow chart. Through the understanding of how Pixy camera identifies object and detects the orientation, width and height of an object, we were able to use the sensor information to track a tennis ball after assigning the color of the ball. Pixy camera uses the hue-based algorithm to identify the size of the object as width and height as shown in Figure 3.

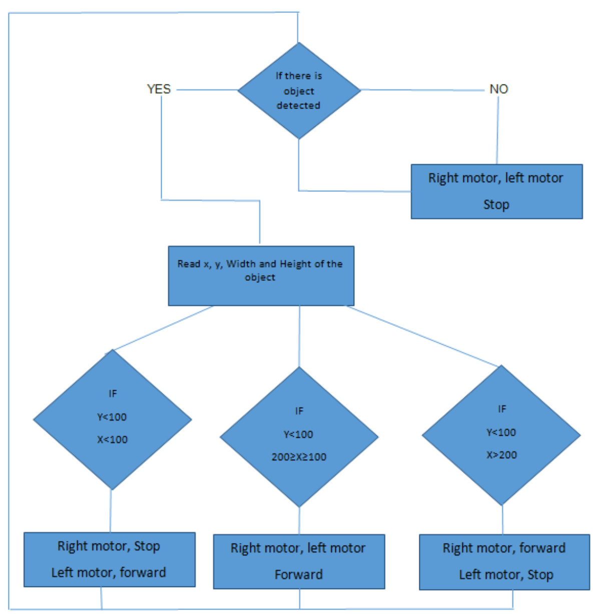


Figure 2. Tennis ball tracking algorithm

The response of the robot to the control strategy was successful as it can follow the tennis ball in a smooth motion with no noticeable delay. In the future, we plan to attach a color sign to a human user's lower leg, thus the robot would be able to follow the human user in a home environment.

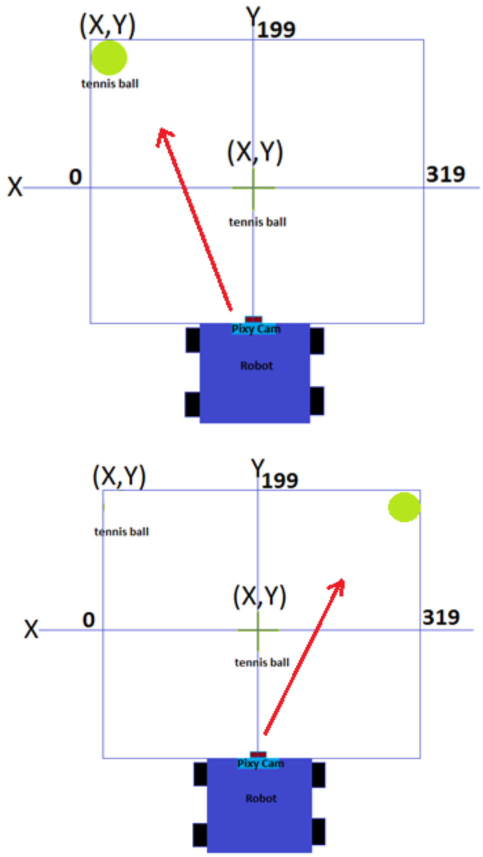


Figure 3. Pixy camera identifying the tennis ball

Human Robot Interaction

User can also interact with the companion robot using basic hand gestures. So far, this project has been mainly focusing on two preliminary tasks with the ability to be advanced in the future for more and more tasks. The first task of using our system is to track a tennis ball. This principle will be modified to recognize any kind of color marker so that the robot can follow people around and help them with different life aspects. The second application involves controlling the robot using a color glove (Figure 4) to generate various motion commands. By focusing on these two tasks, a small home companion robot will be designed and tested that could eventually provide elderly companionship and help with daily activities. The concept has been proven to be effective through trials. It would have great potential to be used as an intelligent, low cost home companion robot to provide some of the elderly care that traditionally can only be provided by a home care provider.

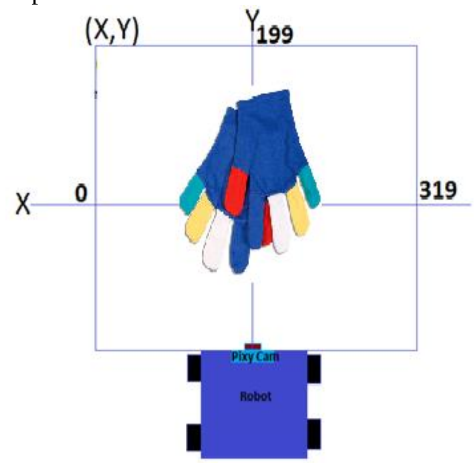


Figure 4. Robot controlled by a color glove

The color glove control algorithm is depicted in Figure 5. The glove we used contain three different colors; yellow, red, and green. Pixy recognized those three colors and saved them as color signatures. Each color was assigned to color signature by pixy, and pixy was trained to recognize each color and know its signatures. Based on this signature system, different motions will be commanded. Red color was assigned to signature 1, which commands the robot to turn left. Green was signature 2, which commands the robot to turn right. The third color is yellow, which commands to robot to go forward. The robot responded to the color glove successfully in many trials as shown in Figure 6.

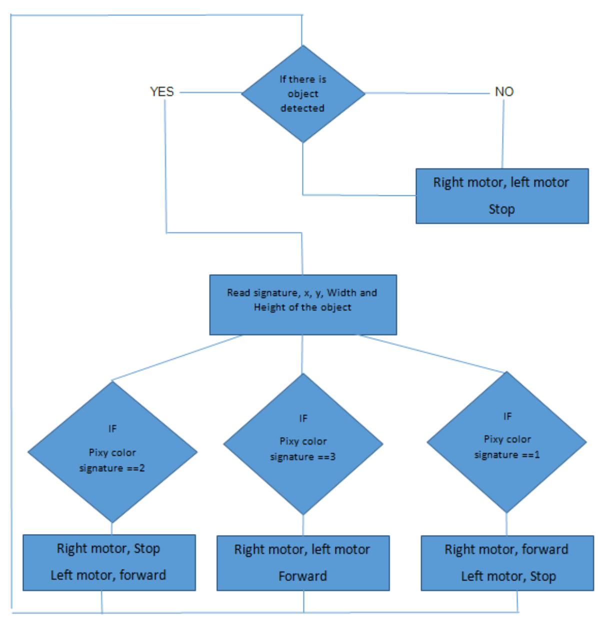


Figure 5. Color glove hand gesture control algorithm

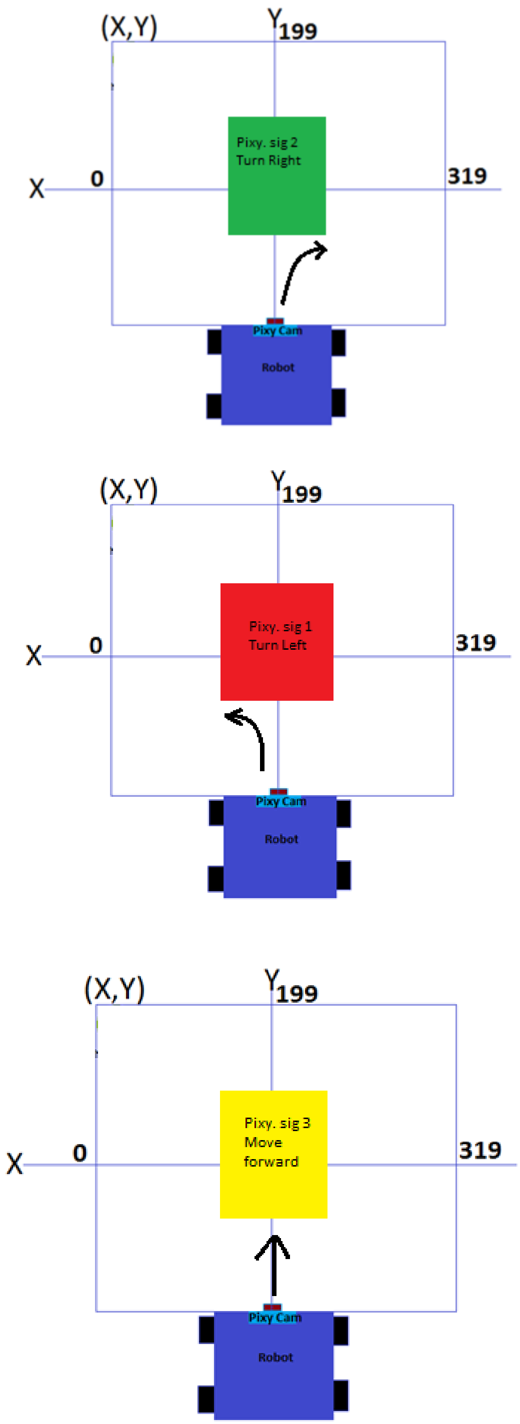


Figure 6. Robot responding to three different colors

Conclusions

This project focuses on vision feedback control of a home companion robot. Through our project we assemble, control, and test our robot to carry out two preliminary tasks using vision feedback. The results indicate that the low cost home companion robot can successfully follow feedback signals from our sensor very smoothly. This system can be easily advanced in future, as we think about home companion robot that can follow and track people around and help with different life aspects.

The main idea of this prototype robot is to be developed in the future to help and companion elder people and track their health issues. Furthermore, there are many other applications that can be applied to using the prototype robot. Since this robot prototype is still in its first stage and can be improved to fit many tasks we can think about in the future.

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