EEL 5666

Intelligent Machines Design Laboratory

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Special Sensor Report

for

μCHIP

(Micro-Controlled High-tech Independent Putter)

Instructor: Dr. Arroyo

Student: Rob Hamersma

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Introduction

In order to play miniature golf, μCHIP will have to locate a golf ball, center himself over it, and locate the direction and distance to the hole. All of these tasks can be accomplished by using one special sensor: the CMUcam. The CMUcam is a small, relatively low-cost OV6620 Omnivision CMOS digital camera coupled with an SX28 microcontroller to provide simple high-level image processing data for end-user applications. These data can be accessed via RS-232 serial communication protocol by another microcontroller or a PC. The CMUcam can identify and track colored objects that fall within given RGB (Red, Green, Blue) values at up to 17 frames per second with 80 x 143 resolution. It can also provide information about the object such as the center, size (in pixels), and the confidence of detection. These qualities will be instrumental in helping μCHIP get a hole in one every time.

Initial Setup

After assembling the kit I received from Acroname (www.acroname.com), by soldering all the components onto the board, I was able to test the CMUcam with the PC java graphical user interface available from the Carnegie Mellon University website (http://www-2.cs.cmu.edu/~cmucam/). At first I was only able to see less than a quarter of the image when dumping a frame to the PC for viewing. This was remedied by adjusting the frame rate to be less than 9 frames per second, and this problem does not seem to affect any of the camera's other features. Once I was able to see a full captured image, I was able to focus the camera by adjusting the lens manually between frame dumps. Once it was focused, I tested the color tracking functionality with the built-in demo mode which involved mounting the camera to a servo and getting it to track the color it sees on startup. This seemed to work well, and it could track a bright orange 3-1/2 inch disc sporadically up to about 5 feet away.

Microcontroller Interface

Communicating with the CMUcam is easily accomplished by using the built-in UART in the Atmel AVR ATMEGA128 microcontroller and connecting directly to the camera's TTL level serial port. Setting the baud rate to the fastest rate of 115,200 seems to work well and will maximize the data throughput. The configuration settings I am using are: polling mode, raw mode, and middle mass mode. Polling mode disables the continuous streaming of data when tracking a color and returns only a single data packet when the track color command is issued. Eventually, it might be beneficial to attempt to process the streaming data and use it to perform running average calculations on the data for filtering. Raw mode is used to communicate with the CMUcam in actual data values instead of readable ASCII characters, and middle mass mode provides information about the center of the tracked object in the data packet. I will be using the track window command to calibrate for the color of the golf ball and hole marker (larger red ball mounted over the hole) to compensate for different lighting situations. This causes the camera to get the mean color values from the center of an object that is held in front of it. I can then use those values when searching for the ball or the hole marker using the track color command.

Experimentation

After preliminary experimentation, the CMUcam looks like it will live up to expectations, given the necessary tweaking and optimization. It seems to track the bright orange/red ball better than white, light blue or bright yellow (the only other colored golf balls I could find). This is consistent with information I have found about the camera responding best to red colors. Also, it seems to work better (in terms of confidence levels) on my white table top than on the green carpet I was hoping to use for my putting green. Hopefully this can be overcome, or at least will not pose enough of a problem in actual operation. For hole marker detection, it seems to respond well to a large red Frisbee (11 inches in diameter) placed 6' away, and less well to a smaller ping-pong paddle (6 inches in diameter), but it will still track it. The trick will be to find the right

size ball for the hole marker such that it will be large enough to be detectable from at least 6 feet away, but will also be small enough to not fill the entire view of the camera when up close. This would make it difficult for the camera to determine the exact direction of the hole as well as the size of the marker, which will be used to determine the distance to the hole. I am confident, however that a suitable size for the marker can be determined, and that with the appropriate optimization of the available parameters, the CMUcam should be able to detect an object under 6 inches in diameter from at least 6 feet.

Conclusions

In conclusion, the CMUcam should be an adequate sensor to provide the necessary information to locate a ball, center it under the platform, locate the hole marker, and determine the approximate distance to the hole. Lighting conditions seem to have a dramatic effect on how the camera sees color, so controlling the lighting as much as possible will be critical for optimal performance. Needless to say it will certainly work best, if not exclusively indoors, and I may need to add some ultrabright white LEDs near the camera so that it can provide it's own consistent lighting, at least at short range. Also, I may need to adjust some of the other camera setting such as auto-gain and white balance, and also experiment with YCrCb mode, which uses a separate variable for illumination intensity.