ENSC 351: Embedded Systems

Project Write Up

To: Dr.Brain Fraser, Fall 2022.
Group Name : S.I.N.K
Project Name: Video Security

Group Members
Nick Chu
Aleksandr Kopylov
Kunal Gossain
Shravan Gupta

1.System Explanation

Objective:

The expectation of the system is to perform video processing, facial detection and facial recognition in real time and, by means of the servo motor and LED matrix, to let the user know if it recognized the person in the frame or not. The main objective of this system is to be used as a security device for companies or at home.

Challenges:

One of the main challenges as part of the project was facial detection and facial recognition. Although the model was trained with the group members' faces for affirmative recognition, it would sometimes not be able to recognize the group member in the image. This is partly due to lighting conditions, the angle of the camera and the stillness of the subject in the frame. Additionally, the camera had approximately a 6 second delay, which was cut down to about 1.5 seconds with optimizations.

The other challenge we experienced during the project was to get the program running on systemd and cross compilation. The problem occurs when we try compiling C, C++ and a non-native C++ library (openCv) together. To get facial recognition and detection working we compile natively on the beaglebone instead of cross compilation.

The minor challenges we faced as part of the project was the failure of the power supply on the demo day. Although the power supply gives an accurate reading when connected to a multimeter, it was unable to power the Neopixel LED matrix and distance sensor on demo day. The way around this was to demo the project in the lab with lab power supply.

Achievements:

The system encompassed four major items: The distance sensor, the USB camera, two servo motors, and the Neopixel 8x8 LED matrix. The distance sensor would turn on the camera upon recognizing an object within 60cm, at which point real time facial recognition would occur. The Nexopixel led mounted on the servo motors would display where the face is from the camera's point of view. The servo would also move to face the person seen by the camera. Upon recognizing the person, an interactive motion and display would be shown by the servo motor and the matrix. More details are provided in section 2.

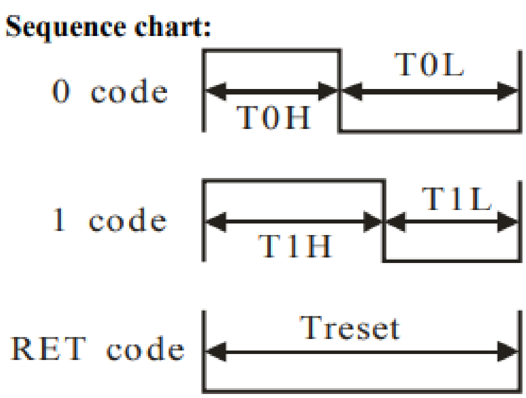
2. Feature Table

Description	**Host/Target**	**Comp**	**Code**	**Author**	**Notes**
Camera	T	4	C/C++	Nick/Kunal	openCV documentation
Servo	T	5	C	Nick	
Neopixel Led Matrix	T	5	C	Alex	Mark Yoder Guide and GitHub used for guidance
Distance Sensor	T	4	C	Alex	General functionality understood from Derek Molloy's book. Code is 100% ours, however

1. **Camera**
   The usb camera captures images and performs facial detection and facial recognition with openCV on these images in real time. We trained our model to recognize the four people in the group. For each image, if a person is recognized, the confidence level increases until it passes a threshold, at which point they are accepted into the system as a known person. If the person is not recognized after 15 taken images, the system declines them as a recognized person, i.e. an intruder.
2. **Servo**
   High level control over the servo was implemented. We are able to input two angles (in units of degrees) to control the horizontal and vertical position of the servo mounting bracket, and move to that angle at a certain speed. The servo works along with the camera, where the servo will move to point the LED to where your face is. The

servo will also shake its ‘head’ horizontally if you are not recognized, and nod its ‘head’ vertically if you are recognized.

3. **Neopixel Led Matrix**
The RGB 8*8 led matrix display is the main output device showing interactive faces on recognition and shows the position of the person in frame. It runs on a PRU due to the very critical hard-time nature of this device. The leds uses a single-wire protocol which can effectively drive all the 64 leds in series (or even many more) but requires a very high-frequency signal. The timings (in the order of hundreds of nanoseconds) are taken from Mark Yoder’s guide and provided below:



Label	Time in ns
T0H	350
T0L	800
T1H	700
T1L	600
Treset	>50,000

Each of the 64 leds requires 24 bits of data sent in series (8 bits for the intensity of each Green, Red, Blue in that very order, which looks like 0xGGRRBB in hexadecimal).

The PRU code simply runs in a loop and waits for the input from the main (linux) program. Then it uses its own functions to convert the array of bits into the sequence of pulses to the led.

The linux program has all the necessary high-level functions that can display everything we want on the matrix, and write the values into the shared struct with a PRU.

4. **Distance Sensor**
The ultrasonic motion detector identifies an object approaching the system and turns the camera on for facial recognition and detection, when the distance to the closest obstacle becomes less than 60 cm.

Due to the nature of this RCWL-1601 ultrasonic sensor, it also requires a PRU to drive the trigger.

According to the book by Derek Molloy, in order for the sensor to activate, we have to send a precise 10 microsecond trigger to the “Trig” pin of the sensor. After that we have to wait for the “Echo” pin to turn ON, and count the number of cycles it stays ON, which also makes a PRU a great candidate for the job.

The linux program starts a thread which sends a trigger every 1 ms and is constantly updating the distance (ignoring unrealistic values below 1 cm) using exponential smoothing with a=0.05(weight on the current value), thus smoothing the spikes that sometimes happen. Thus the main program can always do getDistance() to retrieve the current value, which is rather accurate.

The sensor’s robustness could be improved by analyzing cases when something is too far/close from the sensor, and coming up with a more accurate function to convert from cycles to cm. Right now it’s just assumed to be a constant 4000 cycles/cm.

3.Extra Hardware & Software Used: openCv, Logitech C270 USB camera, Servo Pan/Tilt kit, NeoPixel 8x8 RGB LED Pixel Matrix, Ultrasonic Distance Sensor

4. Pictures and video links : Youtube Link1 , YouTube Link2