

ECEN5623, Real-Time Systems:

Exercise #6 – Real-Time Software Systems

Aaresh Bachana , Abhilash Manjunath, Harshil Sheth, Shrivathsa Murthy

- 1) [15 pts] Implement at least 2 services from the overall service set design and execute them on a TI Tiva TM4C using FreeRTOS or Cyclic Executive; or on a De1-SoC or Jetson board with SCHED_FIFO and trace request time and completion time with a continuous periodic request for each service using fixed priority preemptive scheduling (and processor core affinity if applicable). Present the results along with a description of how predictable the responses are relative to the request times as well as how constant the request frequency is for your system design. Use of other boards or RTOS require written approval from the instructor.

Answer:

The Completion time indicated by the Average Execution Time for all the five services are shown in the screenshot below:

```
Breaking out of motor_control
Break out of GPS
End-#5---Average execution time = 693.750798ms
End-#5---Gps jitter = -5606.249202
Break out of ultrasonic read
End-#3---Average execution time Path Finder = 18.059909ms
End-#3---Frame rate Ultrasonic = 55.371264
End-#3---Frame jitter Ultrasonic = -431.880203
Break out of Face Recognition
End-#1---Average execution time Face Recognition = 837.555749ms
End-#1---Frame rate Face Recognition = 1.193950
End-#1---Frame jitter Face Recognition = -8106.017919
Break out of Path Finder
End-#2---Average execution time Path Finder = 150.243711ms
End-#2---Frame rate Path Finder = 6.655853
End-#2---Frame jitter Path Finder = -1048.414758
root@tegra-ubuntu:/home/skmurthy/Desktop/rtes_project/pthread_face#
```

Table for Request Time for each service:

Thread	Request Time
Path Finder	3927ms
Face Recognition	3858ms
Ultrasonic Sensor Read	803ms
Motor Control	804ms
GPS	2684ms

Request Frequency for the System Design:

```

^CBreaking out of motor_control
Request time for motor control = 804.009033ms
Break out of GPS
End-#5---Average execution time = 693.750798ms
End-#5---Gps jitter = -5606.249202
Request time for GPS = 2684.293945ms
Break out of ultrasonic read
End-#3---Average execution time Path Finder = 22.619075ms
End-#3---Frame rate Ultrasonic = 44.210472
End-#3---Frame jitter Ultrasonic = -425.804743
Request time for ultrasonic sensor = 803.967285ms
Break out of Face Recognition
End-#1---Average execution time Face Recognition = 925.614231ms
End-#1---Frame rate Face Recognition = 1.080364
End-#1---Frame jitter Face Recognition = -6074.385769
Request time for Face Recognition = 3858.156494ms
Break out of Path Finder
End-#2---Average execution time Path Finder = 127.679738ms
End-#2---Frame rate Path Finder = 7.832096
End-#2---Frame jitter Path Finder = -1038.986928
Request time for Path Finder = 3927.452637ms
root@tegra-ubuntu:/home/skmurthy/Desktop/rtes_project/pthread_face#

```

Thread	Average Execution Time (ms)	Deadline (ms)	Request Time (In ms)	Request Frequency
Path Finder	200	1200	1/6	6
Face Recognition	1500	9000	1/6	6
Ultrasonic Sensor Read	75	450	1/6	6
Motor Control	4000	32000	1/8	8

GPS control	700	6300	1/9	9

$$\begin{aligned}
 \text{Total Utilization (U)} &= 200/1200 + 1500/9000 + 75/450 + 4000/32000 + 700/6300 \\
 &= 1/6 + 1/6 + 1/6 + 1/8 + 1/9 \\
 &= 0.73611
 \end{aligned}$$

Rate Monotonic Analysis:

$$\begin{aligned}
 \text{RM LUB for 5 services} &= m \cdot (2^{1/m} - 1) \\
 &= 0.74349
 \end{aligned}$$

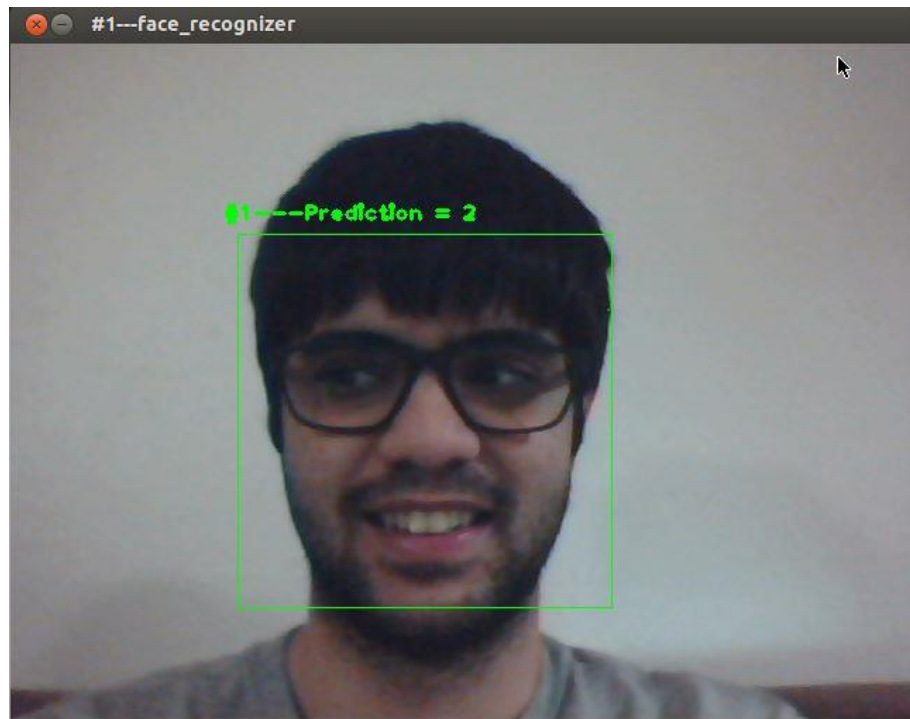
Therefore, $U < \text{RM LUB}$.

The above values for each service ensures that the system design not only successfully passes the Feasibility and the Completion Tests but also ensures that the total CPU utilization does not exceed the RM LUB value for five services. The RM LUB test however is pessimistic. Thus, to ensure maximum CPU utilization, we adjust the deadlines such that the design successfully passes the Feasibility and the Completion Tests but exceeds the RM LUB. The updated values are given below:

Thread	Average Execution Time (ms)	Deadline (ms)	Request Time (In ms)	Request Frequency
Path Finder	200	900	2/9	4.5
Face Recognition	1500	8000	3/16	5.33
Ultrasonic Sensor Read	75	450	1/6	6
Motor Control	4000	24000	1/6	6
GPS control	700	4000	7/40	5.71

Test Cases:

1. Face Recognition:



The face recognition algorithm was trained for multiple faces and we realized that the lighting of the image affected the accuracy of the detection. Thus, the algorithm was trained with images of variable brightness and the accuracy was tested with Aaresh's image as shown in the figure,

2. Object tracking (indicating Path Finding)



The path finding algorithm is based on adjusting the algorithm for a fixed shade of gray in the image (indicating a road). Thus, to test the algorithm, we adjusted the threshold such that it tracks Abhilash's face and always calculates the X and the Y co-ordinates of the detected image.

3. Ultrasonic Sensor:

Tested the Ultrasonic Sensor for a threshold of several distances ranging from 5 inches to 15 inches. After rigorous testing, we decided to keep 10 inches as our threshold. We also tested the motor control thread depending on the obstacle distance.

4. GPS testing:

We compared the GPS data with the data that we received on google maps for each point in the path of the destination and noticed a difference of around 1.71% between the two data values and this was accounted for in the code.

5. Motor Testing:

Motors were tested separately for directions forward, backward and their combinations to achieve right and left. Their integration was performed and timing was calculated.

Code: Please find the code in the attached zip folder pthread_face