CprE 458/558: Real-Time Systems

Homework 1   50 points

Question A (10 points):

For the following robotic application, identify the precedence relation among tasks (i.e., show the precedence graph).

`Robotic Application:` A number of objects moving on a conveyor belt must be recognized and classified using a stereo vision system, consisting of two cameras mounted in a suitable location (above the conveyor belt). Suppose that the recognition process is carried out by integrating the two-dimensional features of the top view of the objects with the height information extracted by the pixel disparity on the two images. As a consequence, the computational activities of the application can be organized by defining the following tasks:

- Two tasks (one for each camera) dedicated to image acquisition, whose objective is to transfer the image from the camera to the processor memory (they are identified by *acq1* and *acq2*);
- Two tasks (one for each camera) dedicated to low-level image processing (typical operations performed at this level include digital filtering for noise reduction and edge detection; we identify these tasks as *edge1* and *edge2*);
- A task for extracting two-dimensional features from the object contours (it is referred as *shape*);
- A task for computing the pixel disparities from the two images (it is referred as *disp*);
- A task for determining the object height from the results achieved by the *disp* task (it is referred as *H*) ;
- A task performing the final recognition (this task integrates the geometrical features of the object contour with the height information and tries to match these data with those stored in the data base; it is referred as *rec*).

Question B (10 points):

The problem is to design a defense system that is capable of simultaneously handling up to 10000 "tracks" of possible "threats" (targets), up to 1000 known threats (tracks that have previously been identified as targets), and up to 100 engagements where an engagement means that a defensive weapon system is being employed against a known target. Tracks may include many things other than threats, like civilian aircraft in the area, friendly aircraft, decoys, birds, etc., as well as real threats. When a track is classified as a target, it then has to be "monitored" once a second each time the radar "illuminates" the target. All targets get illuminated approximately once a second, but since the targets are moving with respect to the radar the time interval between successive illuminations may not be constant and therefore need not be strictly periodic for an individual target. During this monitoring of the track, additional tests are run to determine the lethality of the target which influences the significance of the target. Finally, once a target is identified, it must be engaged within 2 seconds provided there is a weapon system available to engage it, with priority being given to engaging the most important threats first. For targets that are currently engaged, guidance update information has to be relayed to the defensive weapon every second while it is homing in on the target. Answer the following:

1. Identify all the possible tasks in the system. Indicate the nature of the tasks: periodic/aperiodic, hard/firm/soft deadline. Also identify the resource requirements and the precedence relationship among the tasks.

2. Which or which combination of scheduling paradigm(s) is suitable for this problem. Justify your answer.

3. What is the most suitable computing system (uniprocessor, multiprocessor, distributed system) for the problem. Justify your answer.

Question C (10 points):

Use the schedulability test and use the exact analysis of RMS, if required, to check if each of the following periodic task set is RM-schedulable. Construct the schedule for at least ONE of the schedulable task sets. For each task, (c_i, p_i) values are given below.

1. $\{T_1, T_2, T_3\}$ = {(1,8), (2,6), (2,24)}.
2. $\{T_1, T_2, T_3\}$ = {(1,3), (4,12), (2,6)}.
3. $\{T_1, T_2, T_3\}$ = {(2,8), (3,12), (4,16)}.

Question D (10 points):

Determine whether the above task sets (stated in Question F) are schedulable using EDF algorithm. Construct the schedule for at least ONE of the schedulable task sets.

Question E (10 points):

1. Find the maximum value of x for which the periodic task set {(x,5), (4,7)} is schedulable under (a) RMS and (b) EDF algorithms. The variable x can assume a fractional value.
2. If the deadline is not equal to the task period (i.e., deadline is less than the period), RMS is not an optimal static priority algorithm. Show this by means of an example. That is, construct a task set which is not RM-schedulable, but is schedulable by some other allocation of static priorities.

   Answer: Choose a task set that is schedulable by Deadline Monotonic Scheduling (DMS) algorithm, but not by RMS algorithm.

Question F - Reading or Attempting Assignment (NO need to submit answers):

1. What is a real-time system? What is predictability in real-time systems?
2. List some popular real-time operating systems (proprietary, open source, and research kernels) and the areas/applications in which they are being used or likely to be used.
3. There are several `misconceptions` about real-time systems. Read the four most popular misconceptions stated in the book and understand why they are not true. Further, read the paper "Misconceptions in Real-Time Computing," by Stankovic) and state which two are, in your view, the most interesting misconceptions.
4. Construct pre-run and post-run schedules that illustrate the following. (Hint: It is a hard question. Don't waste too much time in trying to get an answer).

   (a) Weakening the precedence relation leads to run-time anomaly.

   (b) Increasing the number of processors leads to run-time anomaly.