Real-Time Control Systems

Exam 2009-01-12

14:00 – 18:00: Halls at "Väg och Vatten"

Course code: SSY190

Teacher: Knut Åkesson, phone 0701-749525

The teacher will visit examination halls twice to answer questions. This will be done approximately one hour after the examination started and one hour before it ends.

The exam comprises 30 credits. For the grades 3, 4, and 5, is respectively required 15, 20 and 25 credits.

Solutions and answers should be complete, written in English and be unambiguously and well motivated. In the case of ambiguously formulated exam questions, the suggested solution with possible assumptions must be motivated. The examiner retains the right to accept or decline the rationality of assumptions and motivations.

Solutions will be announced on the course web-page on the first week-day after the exam date. *Exam results* will be announced on the department notice board on the latest 2009-01-26 at 12:30. *The results* are open for review 2008-01-26, 12:30-13:30 at the department.

Allowed aids:

- An A4 sheet with handwritten notes on both pages. The name of the student must be on the sheet. You should hand-in your notes together with your solutions.
- A pocket calculator with erased memory.
- Dictionary (paper and electronic) between English and the students native language.

1

a) What is priority inversion? Explain by giving a simple example.
(1p)

b) Explain shortly how the priority inheritance protocol works.
(1p)

c) How is the concept known as PWM used in the implementation of control systems?
(1p)

d) Explain what an interrupt how it is used by real-time operating systems.
(1p)

e) Describe problems that might occur when switching between manual and automatic mode for a PID-controller.
(1p)

f) Describe the main parts of the CAN-bus protocol.
(2p)

2

We have three task that we want to execute on a single processor. Assign priorities to the tasks by using the rate monotonic and the deadline monotonic principle. T is the period of the task and D is the deadline of the task.

Task	T	D
A	10	2
B	5	4
C	20	10

a) Assign priorities to the tasks according to the rate monotonic principle.

(2p)

b) Assign priorities to the tasks according to the deadline monotonic principle.

(3p)

3

We have three task that we want to execute on a single processor. Assign priorities to the tasks by using the rate monotonic and the deadline monotonic principle. T is the period of the task, D is the deadline of the task and C is the worst-case computation time.

Task	T	D	C
A	3	3	0.6
B	4	4	1.2
C	5	5	1.5

a) Will the task meet their deadlines according to the approximate analysis in Rate Monotonic Scheduling Theory?

(2p)

b) Will the task meet their deadlines according to the exact analysis in Rate Monotonic Scheduling Theory?

(3p)

4

Write pseudo code for implementing a process model, using a C/Java like language, given by the following state-space equation. The process should be discretized using the forward difference approximation.

$$\begin{cases} \dot{x}_1(t) &= -1368x_1(t) - 17.5x_2(t) + 175u(t) \\ \dot{x}_2(t) &= 5000x_1(t) - 0.5x_2(t) \\ y(t) &= x_2(t) \end{cases}$$

(5p)

5

A continuous PD-controller may be written as

$$F(s) = K(1 + \frac{sT_d}{1 + sT_d/N})$$

Discretize the controller $F(s)$ using the sampling time h and the backward difference approximation. Show how the control signal $u(k)$ at sample k can be calculated from the control errors $(r(k) - y(k), r(k-1) - y(k-1), \ldots)$ and previous values of the control signal and controller states. Determine which part of the control signal $u(k)$ that can be precomputed at sample $k - 1$.

(3p)

6

Solve the following optimization problems.

a) Find the optimal solution.

(4p)

$$\begin{array}{ll} \max & 2x_1 - 3x_2 + 4x_3 \\ \text{s.t.} & 4x_1 - 3x_2 + x_3 \leq 3 \\ & x_1 + x_2 + x_3 \leq 10 \\ & 2x_1 + x_2 - x_3 \leq 10 \\ & x_1, x_2, x_3 \geq 0 \end{array}$$

b) Find the optimal solution, note that the variables can only take integer values.

(1p)

$$\begin{array}{ll} \max & x_1 + 5x_2 \\ \text{s.t.} & x_1 + 10x_2 \leq 20 \\ & x_1 \leq 2 \\ & x_1, x_2 \geq 0 \text{ and integer} \end{array}$$

Good Luck!