KING'S College LONDON

Assignment: Concurrency & Control

27th June 2024

In this assignment, you are required to produce a report that answers all parts of the following two questions.

1. Three tasks, `taskX`, `taskY` and `taskZ` run concurrently in a real time system. They each require access to the same shared resource.

   a. Describe three forms of concurrent computation that may be found in real time systems.

   [8 marks]

   b. Consider the case that a value `v` computed by `taskZ` is needed for a computation in `taskX` and a computation in `taskY`. Neither `taskX` nor `taskY` modify `v`. Give pseudo-code showing how semaphores can be used to solve this synchronisation problem.

   [10 marks]

   c. Explain how use of a semaphore instead of a lock in Question 1.b improves efficiency.

   [10 marks]

   d. Explain the difference between a *pool* and *channel* in concurrent task communication.

   [8 marks]

   e. Consider the case that `taskZ` reads a sensor periodically and stores the resultant value in a shared memory location. Concurrently, `taskX` reads the values from the shared memory and computes a command for an actuator. Give pseudocode showing how counting semaphores can be used to solve this synchronisation problem.

   [14 marks]

2. The Bailiffast Building Society offers mortgages at a basic rate of 8% interest, charged monthly.

   As a special offer, it offers new customers two-part mortgages, where the first $£25000$ of the loan are charged at 4% interest and the rest is charged at the basic rate. As part of the deal, customers must make monthly payments, half of which must go toward the first part of the loan.

   First-time buyer A wishes to borrow $£75000$ to buy a house using the special offer.

   a. Write a linear difference equation describing how the balance of the two parts of the loan change over time.

   [10 marks]

b. Recall that the solution of a forced linear difference equation for $k > 0$ is given by

$$\mathbf{x}_k = \mathbf{A}^k \mathbf{x}_0 + \sum_{m=0}^{k-1} \mathbf{A}^{k-1-m} \mathbf{b} u_m.$$

Buyer A is able to make fixed monthly repayments of $£1000$ per month. If the initial balances of the two parts of the loan is $\mathbf{x}_0 = (25000, 50000)^\top$, what will be the total balance of the mortgage after 6 months?

[12 marks]

c. Explain what is meant by the *observability* of a dynamic system.

[8 marks]

d. First time buyer B wishes to take out the same loan amount, $£75000$, taking advantage of the special offer. Instead of paying a fixed monthly amount, Buyer B chooses to pay the loan proportionately to its balance using a closed-loop controller of the form

$$u_k = \mathbf{k}^\top \mathbf{x}_k \quad \text{and} \quad \mathbf{k} = \begin{pmatrix} -0.3 & 0 \end{pmatrix}^\top.$$

Test the stability of the system under this payment policy.

[14 marks]

e. Comment on the affordability of buyer B's payment policy.

[6 marks]

Completed assignments should be submitted to KEATS by 4pm, 25th July 2024.

Your report must be submitted as a single PDF file, with a maximum of 4 pages A4, single-spaced, single column format, margins of at least 2cm, minimum 11pt font size and use a sans-serif font. It must contain your worked answers to the questions, and any extracts of code, images or any plots you generate. The page limit includes all figures but excludes references.