CS4050

UNIVERSITY OF WARWICK

Fourth Year Examinations: Summer 2007

Introduction to Empirical Modelling

Time allowed: 3 hours

Answer **Question 1** and **TWO** other questions.

Read carefully the instructions on the answer book and make sure that the particulars required are entered on each answer book.

Calculators are not required and not permitted.

Credit will be given for evidence of familiarity with a variety of standard illustrative models.

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1. The three fundamental concepts in Empirical Modelling (EM) are observables, dependencies and agents.

   (a) Informally describe what is meant by an *observable*, a *dependency* and an *agent* with specific reference to:

   (i) the relationship between observables and direct sensory experience;
   (ii) the distinction between a dependency and an equational constraint;
   (iii) the manner in which the status of a family of observables as an agent can evolve as the model-building progresses. [20]

   (b) Contrast EM with a traditional conception of computing, with particular reference to:

   (i) the roles that observables, dependency and agents play in EM;
   (ii) the difficulty of giving formal definitions for these three fundamental concepts;
   (iii) the distinction between an EM *construal* and a program. [20]

   Illustrate your answers to (a) and (b) with suitable examples drawn from well-known EM models. (20% of the total credit for the question will be allocated for illustrative examples.)

Continued

2. Describe the categories into which observables are classified in giving an LSD account of a situation. [6]

Explain in general terms how you would go about devising an LSD account and associated interactive EM artefact for your present situation as a student taking the CS405 examination with particular reference to the observables, dependencies and agents relevant to the following scenarios:

(a) you require an additional answer book;

(b) you mistakenly sit at the desk of another CS405 student who is absent from the examination;

(c) you are running out of time during the examination. [24]

3. Empirical Modelling (EM) is concerned with the use of computers for the construction of models. The making of models has often been an important stage, especially in the sciences, in the process of improving our understanding of a domain.

(a) Describe very briefly, with an example for each, the following major kinds of models:

(i) mathematical models
(ii) physical models
(iii) theoretical models (in the sense used by Max Black) [10]

(b) Consider the following two kinds of computer model:

(i) a spreadsheet model of a small business that has worksheets for such things as payroll and shift allocations, stock control and ordering, customer behaviour;
(ii) an educational package, or a 'microworld', built with conventional tools.

To what extent can we 'improve our understanding' by means of such models?
Could you classify each of these models in terms of the three kinds in part (a)? If so, how, and if not, what new classification(s) would you make? [10]

(c) How would you describe EM models in relation to those mentioned in parts (a) and (b)? Draw attention to the distinctive features of EM models and pay regard to the role of the human in the construction and use of the models, and the role of metaphor in the interpretation of the models. Illustrate your answers with reference to models such as those for railway animation, or for heapsort, or other relevant models with which you are familiar (including your coursework model). [10]

Continued

4. Briefly explain the notion of *constructionism* as introduced by Seymour Papert. [4]

Discuss the merits of EM as a means to support constructionism with reference to:

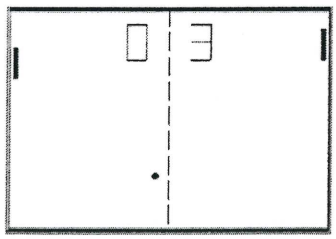
(a) integrating the roles of pupil, teacher and developer;
(b) connecting private and public learning activities. [18]

Illustrate your answer by comparing and contrasting the role that practical construction of geometric figures using

(i) definitive notations for interactive graphics, and
(ii) a traditional procedural language for line drawing

might play in introducing elementary theorems of Euclidean geometry, such as "the angle in a semicircle is a right angle". [8]

5. The figure below is a screenshot from one of the earliest electronic games, a two player game known as Pong based on the principles of table-tennis. The screenshot shows the playing area for Pong. The short lines to the left and right of the screen represent paddles to be moved vertically by two players. The black dot represents a ball that when in motion bounces off the edges of the playing area and off the paddles until such time as one of the players misses the ball and it escapes to the left or right hand side of the screen. The current score is also displayed on the screen.



Outline a practical introduction to basic EM principles and tools such as you might give to an undergraduate computer science student proposing to develop a Pong simulation using the EDEN interpreter in her final year project. Your outline should refer briefly to:

(a) general characteristics of the notations to be used; [9]

(b) pragmatic considerations in managing the modelling activity; [9]

(c) guidance on how different variants of the game (such as manual and semi-automated, slider vs rotating knob controlled etc) might be implemented within a single environment. [7]

What is said to be the world's smallest Pong game can be found on a website measuring only 18 pixels by 18 pixels. How might an EM model of Pong be adapted to work on such a small grid? [5]

End