

## 2005 Paper 9 Question 8

### Artificial Intelligence II

We wish to model the unobservable state of an environment using a sequence  $S_0 \rightarrow S_1 \rightarrow S_2 \rightarrow \dots$  of sets of random variables (RVs) where at time  $i$  we are in state  $S_i$  and observe a set of RVs  $E_i$ . The distributions of the RVs do not change over time, and observations depend only on the current state.

- (a) Define a *Markov process*, the *transition model* and the *sensor model* within this context. [3 marks]
- (b) Assuming that evidence  $E_{1:t} = e_{1:t} = (e_1, e_2, \dots, e_t)$  has been observed define the tasks of *filtering*, *prediction* and *smoothing*. [3 marks]
- (c) Derive a recursive estimation algorithm for performing filtering by combining the evidence  $e_t$  obtained at time  $t$  with the result of filtering at time  $t - 1$ . [8 marks]
- (d) How does a *hidden Markov model* differ from the setup described? [1 mark]
- (e) Show how for the case of a hidden Markov model your filtering algorithm can be expressed in terms only of matrix operations. [5 marks]