
**DUBLIN INSTITUTE OF TECHNOLOGY**

# DT228 BSc. (Honours) Degree in Computer Science

## Year 3

**Winter Examinations**
**2017/2018**

# INTRODUCTION TO ARTIFICIAL INTELLIGENCE

**INTERNAL EXAMINERS**
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**EXTERNAL EXAMINER**
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18TH JANUARY
9.30 – 11.30

2 HOURS

INSTRUCTIONS TO CANDIDATES
ANSWER **FOUR** QUESTIONS OUT OF **FIVE**.
ALL QUESTIONS CARRY EQUAL MARKS.

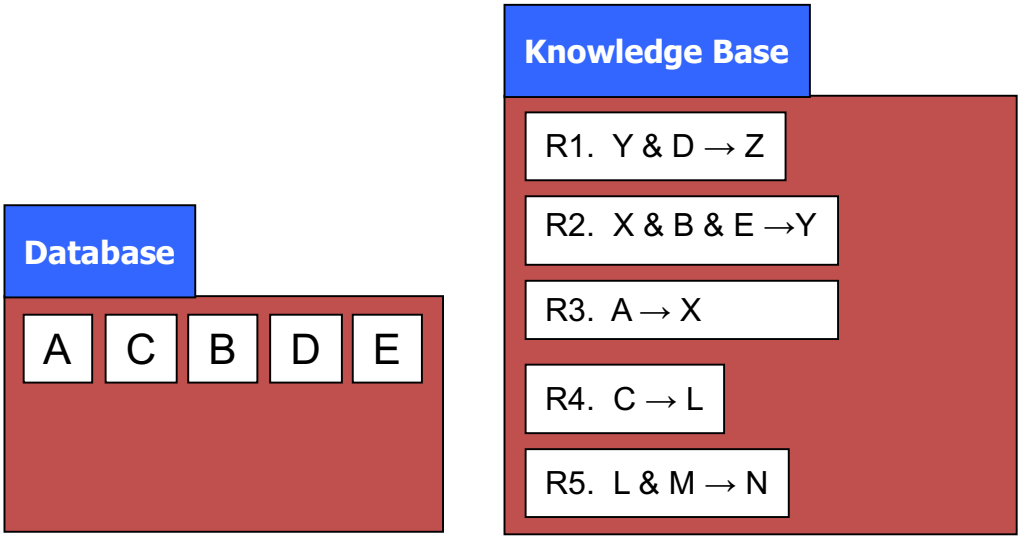
**1 (a)** Describe the architecture of a rule-based expert system.

(8 marks)

**(b)** Given the following facts database and list of rules, show how:

i. the workings of forward-chaining on each rule firing cycle

ii. backward-chaining would proceed if an attempt was made to infer Z.




(6 marks)

**(c)** Explain why the use of an expert system shell can dramatically reduce the development time of an expert system.

(5 marks)

**(d)** In data driven rule based systems when many rules can be fired at the same time, outline three strategies that an inference engine might use in choosing which rule to fire.

(6 marks)

**2 (a)** Outline three sources of uncertain knowledge.

(6 marks)

**(b)** Give three reasons why Bayesian reasoning is difficult to use in an expert system. Also, briefly describe three advantages in using certainty factors as opposed to Bayesian reasoning. Briefly mention two well-known historical expert systems, one of which used Bayesian reasoning and the other certainty factors.

(10 marks)

**(c)** Given the forecasting rules below, show how they would fire to forecast tomorrow's weather when provided with the following information: there is rain today and the rainfall is low with a certainty factor of 0.8, and also it is cold with a certainty factor of 0.9. This formula may be useful:

$$cf(cf_1, cf_2) = cf_1 + cf_2 \times (1 - cf_1)$$

Rule: 1
if today is rain
then tomorrow is rain {cf 0.5}

Rule: 2
if today is dry
then tomorrow is dry {cf 0.5}

Rule: 3
if today is rain
and rainfall is low
then tomorrow is dry {cf 0.6}

Rule: 4
if today is rain
and rainfall is low
and temperature is cold
then tomorrow is dry {cf 0.7}

Rule: 5
if today is dry
and temperature is warm
then tomorrow is rain {cf 0.65}

Rule: 6
if today is dry
and temperature is warm
and sky is overcast
then tomorrow is rain {cf 0.55}

(9 marks)

**3 (a)** Given the following representation of some of a Financial Advisor's knowledge rules, write them in Prolog.

$\forall$ X amount_saved(X) $\wedge$ $\forall$ Y dependents(Y) $\wedge$ greater(X, minsavings(Y))
$\Rightarrow$ savings_account(adequate).

$\forall$ X earnings(X, steady) $\wedge$ $\forall$ Y dependents(Y) $\wedge$ greater(X, minincome(Y)
$\Rightarrow$ income(adequate).

$\forall$ X earnings(X, unsteady) $\Rightarrow$ income(inadequate).

savings_account(adequate) $\wedge$ income(adequate) $\Rightarrow$ investment(stocks).

Functions
minsavings(Y) = 5000 * Y
minincome(Y) = 15000 + 4000 * Y

(10 marks)

**(b)** What is the meaning and difference if any in the following two Prolog clauses?

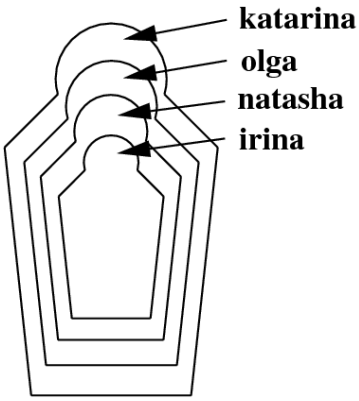
```
a :- not( city(dublin)).
a :- city(X), X \== dublin.
```

(5 marks)

**(c)** Write a Prolog predicate **fac(N, X)** to compute the factorial of N.

(5 marks)

**(d)** Given the information expressed in the Russian doll diagram, write a knowledge base using the predicate **directlyIn/2** which encodes which doll is directly contained in which other doll. Then, define a recursive predicate **in/2** , that tells us which doll is (directly or indirectly) contained in which other dolls.




(5 marks)

**4 (a)** What is a perceptron? Draw a diagram for a single two-input perceptron. Explain what is meant by linear separability. How many categories can it classify inputs into? Mention any issues involved in using a perceptron to compute logical AND, OR and XOR.

(7 marks)

**(b)** Illustrate the single perceptron training algorithm for an OR gate by computing the weight adjustments for the first three epochs in the table below.

(5 marks)

**(c)** Draw a multilayer perceptron diagram that would be appropriate for an XOR gate. Name and draw the activation function which is suitable for a multilayer perceptron.

Comment briefly on its learning algorithm.

(8 marks)

**(d)** Explain the problem of overtraining an artificial neural network and how it could be alleviated.

(5 marks)

**Perceptron Training for logical OR**

Threshold $\theta = 0.2$ , learning rate $\alpha = 0.1$.

| Epoch | Inputs | | Desired output | Weights | | Weighted Sum | Actual Output | Error | Weight adjustments | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $x_1$ | $x_2$ | $Y_d$ | $w_1$ | $w_2$ | X | Y | e | $\Delta w_1$ | $\Delta w_2$ |
| 1 | 0 | 0 | 0 | 0.3 | -0.1 | | | | | |
| | 0 | 1 | 1 | | | | | | | |
| | 1 | 0 | 1 | | | | | | | |
| | 1 | 1 | 1 | | | | | | | |
| 2 | 0 | 0 | 0 | | | | | | | |
| | 0 | 1 | 1 | | | | | | | |
| | 1 | 0 | 1 | | | | | | | |
| | 1 | 1 | 1 | | | | | | | |
| 3 | 0 | 0 | 0 | | | | | | | |
| | | | | | | | | | | |

**5 (a)** In early AI research general problem solving methods were investigated which made the assumption that many problem domains could be characterised as a finite "*state space"* in which the problem solver could "operate" by moving from one state to another, making an allowed move.

Discuss this from the perspective of the *monkey-banana* problem.

(5 marks)

**(b)** Show how a *monkey-banana* state could be represented in Prolog and write some code for generating allowed moves or state operations.

(5 marks)

**(c)** Write a generic Prolog predicate solve/3 which could be used to find a depth first search solution path from a starting state to a goal state in a problem amenable to state space search.

(5 marks)

**(d)** Explain how an 8-puzzle state could be represented in Prolog and use your scheme to represent the following state.

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 8 | | 5 |
| 7 | 4 | 6 |

(5 marks)

**(e)** Outline the relative advantages and disadvantages of using depth first search versus breadth first search. It there a way to combine the benefits of both approaches?

(5 marks)