NANYANG TECHNOLOGICAL UNIVERSITY
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SC3000 Artificial Intelligence

Introduction To Prolog Assignment

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Exercise 1: The Smart Phone Rivalry

Problem

We are provided with 2 companies, **appy** and **sumsum**. **sumsum** developed a smartphone technology called **galactica-s3**, which was stolen by **stevey**, the boss of **appy**. It's unethical for a boss to steal business from rival companies. A competitor is a rival. Smartphone technology is a business. We are tasked to translate the relationships above from natural language statements to First Order Logic (FOL) and prove that **stevey** is unethical while showing a trace of our proof.

1. Translate the natural language statements into First Order Logic [5 Marks]

The natural language statement to First Order Logic:

1. Competitor Relation
    a. "sumsum is a competitor of appy."
    b. *competitor(sumsum, appy)*

2. Technology and Business Relation
    a. "GalacticaS3 is a smartphone technology, and technology is a type of business."
    b. *technology(galacticaS3)*
    c. business(galacticaS3)

3. Boss Relation
    a. "Stevey is the boss of Appy."
    b. boss(stevey, appy)

4. Stealing Relation
    a. "Stevey stole GalacticaS3 from Sumsum"
    b. steals(stevey, sumsum, galacticaS3)

5. Unethical Behavior
    a. A person X is unethical if they are a boss of company Z, company Z has a competitor Y, and X steals the business (GalacticaS3) from Y (Figure 1).

$$unethical(X) \leftarrow competitor(Y, Z) \wedge boss(X, Z) \wedge steals(X, Y, galacticaS3)$$

Figure 1

2. Write these FOL statements as Prolog clauses
[5 Marks]

The above FOL statements are translated into Prolog as seen in Figure 2.

```
competitor(sumsum, appy).
technology(galacticaS3).
business(galacticaS3).
boss(stevey, appy).
steals(stevey, sumsum, galacticaS3).

unethical(X) :- competitor(Y, Z), boss(X, Z), steals(X, Y, galacticaS3).
```

Figure 2

3. Using Prolog, prove that Stevey is unethical. Show a trace of your proof
[5 Marks]

To prove that Stevey is unethical, we performed the following query in Figure 3.

```
% Query: ?- unethical(stevey).
```

Figure 3

Trace of proof

1. Goal: unethical(stevey)
    - Check if Stevey meets the conditions for unethical behaviour.
2. Evaluate:
    - *competitor(sumsum, appy)*

        True (as defined in knowledge base)

    - *boss(stevey, appy)*

        True (as defined in knowledge base)

    - *steals(stevey, sumsum, galacticaS3)*

        True (as defined in knowledge base)

3. Conclusion: All conditions for unethical(stevey) are met, hence Prolog returns true as seen in Figure 4. Stevey is confirmed to be unethical.

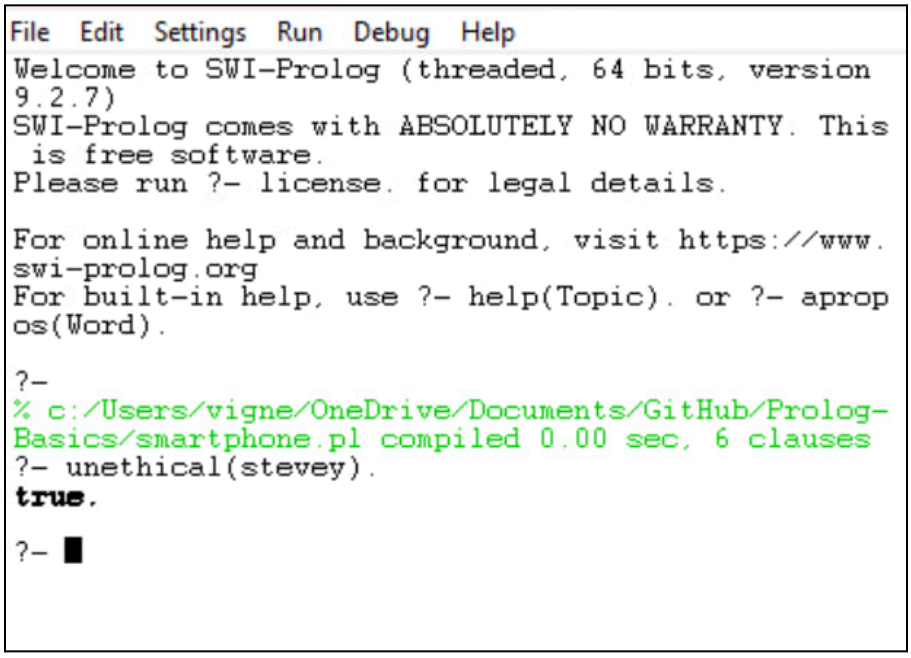

Figure 4

Exercise 2: The Royal Family Succession

Problem Summary

The royal family succession rules determine the order in which members can inherit the throne. Under the old rule, the throne is passed down along the male line according to the order of birth before the consideration along the female line, similarly according to the order of birth. This rule was later changed to allow inheritance solely based on birth order, regardless of gender.

queen elizabeth has four offsprints: namely:- **prince charles**, **princess ann**, **prince andrew** and **prince edward** – listed in the order of birth.

1. Define their relations and rules in a Prolog rule base. Hence, define the old Royal succession rule. Using this old succession rule determine the line of succession based on the information given. Do a trace to show your results.

The natural language statement to First Order Logic:

1. Parent-Child Relation
    a. "*X* is an offspring of Queen Elizabeth."
    b. *offspring(X,Elizabeth)*
2. Gender Relations
    a. "*X* is male."
    b. male(X)
    c. "*X* is female."
    d. female(X)
3. Birth Order
    a. Define birth order by listing individuals in their birth sequence.
    b. birth_order(charles)
    c. birth_order(ann)
    d. birth_order(andrew)
    e. birth_order(edward)

4. Old Succession Rule
    a. Males are prioritised over females in the line of succession, based on their birth order (Figure 5).

$$Succession\ Rule\ (Male):\ succession(X) \leftarrow male(X) \wedge offspring(X, Elizabeth)$$

$$Succession\ Rule\ (Female):\ succession(X) \leftarrow female(X) \wedge offspring(X, Elizabeth)$$

Figure 5

Write these FOL statements as Prolog clauses:

```
offspring(charles, elizabeth).
offspring(ann, elizabeth).
offspring(andrew, elizabeth).
offspring(edward, elizabeth).

male(charles).
male(andrew).
male(edward).

female(ann).

% Rule: Males come before females in birth order.
succession(X) :- male(X), offspring(X, elizabeth).

% Rule: Females come after all males in birth order.
succession(X) :- female(X), offspring(X, elizabeth).
```

Figure 6

<u>Query for Old Succession Rule</u>

```
% Query: ?- succession(X).
```

Figure 7

Trace for Old Succession Rule

Goal: *succession(X)*

Prolog attempts to satisfy succession(X).

Evaluate Males:

Charles (succeeds first as eldest male)

Andrew (next eldest male)

Edward (youngest male)

Evaluate Females:

Ann (only female offspring)

Conclusion: Succession order: Charles, Andrew, Edward, Ann (Figure 8).

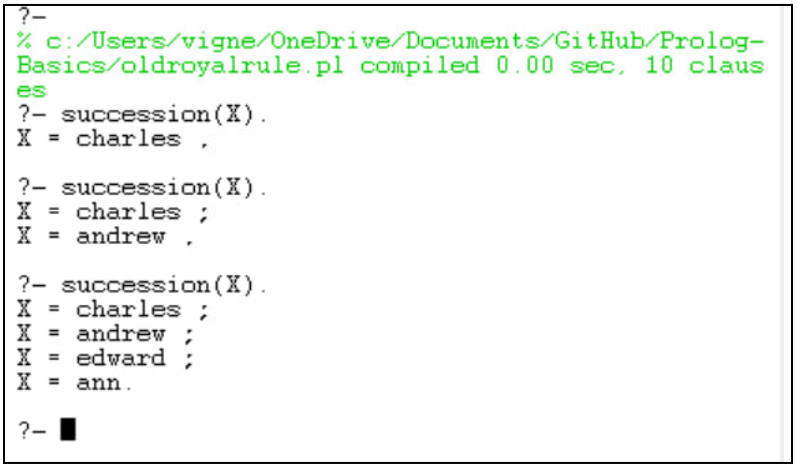

Figure 8

Old Succession Order Result: *Charles → Andrew → Edward → Ann.*

2. Recently, the Royal succession rule has been modified. The throne is now passed down according to the order of birth irrespective of gender. Modify your rules and Prolog knowledge base to handle the new succession rule. Explain the necessary changes to the knowledge needed to represent the new information. Use this new succession rule to determine the new line of succession based on the same knowledge given. Show your results using a trace.

In the new rule, gender is no longer a factor; succession is determined by birth order alone:

The natural language statement to First Order Logic:

New Succession Rule:

$$Succession(X) \leftarrow offspring(X, Elizabeth) \wedge birth\_order(X)$$

Write these FOL statements as Prolog clauses:

```
offspring(charles, elizabeth).
offspring(ann, elizabeth).
offspring(andrew, elizabeth).
offspring(edward, elizabeth).

male(charles).
male(andrew).
male(edward).

female(ann).

birth_order(charles).
birth_order(ann).
birth_order(andrew).
birth_order(edward).

% Rule for direct birth order, regardless of gender
succession(X) :- offspring(X, elizabeth), birth_order(X).
```

Figure 9

Query for New Succession Rule

```
% Query: ?- succession(X).
```

Figure 10

Trace for New Succession Rule

Goal: *succession(X)*

Prolog attempts to satisfy *succession(X)* by birth order.

Evaluate by Birth Order:

Charles (first-born)

Ann (second-born)

Andrew (third-born)

Edward (fourth-born)

Conclusion: Succession order: Charles, Ann, Andrew, Edward.

```
?-
% c:/Users/vigne/OneDrive/Documents/GitHub/Prolog-
Basics/newroyalrule.pl compiled 0.00 sec, 13 claus
es
?- succession(X).
X = charles ;
X = ann ;
X = andrew ;
X = edward.

?-
```

Figure 11

New Succession Order Result: *Charles → Ann → Andrew → Edward.*

Summary

In this report, we modeled two exercises in Prolog. The traces confirmed Stevey's unethical behaviour under Exercise 1 and demonstrated how changing the royal succession rule from gender-based to birth-order-based impacted the succession line in Exercise 2. These exercises showcase Prolog's capabilities in reasoning about logical conditions and relationships.