LECTURER: TAI LE QUY

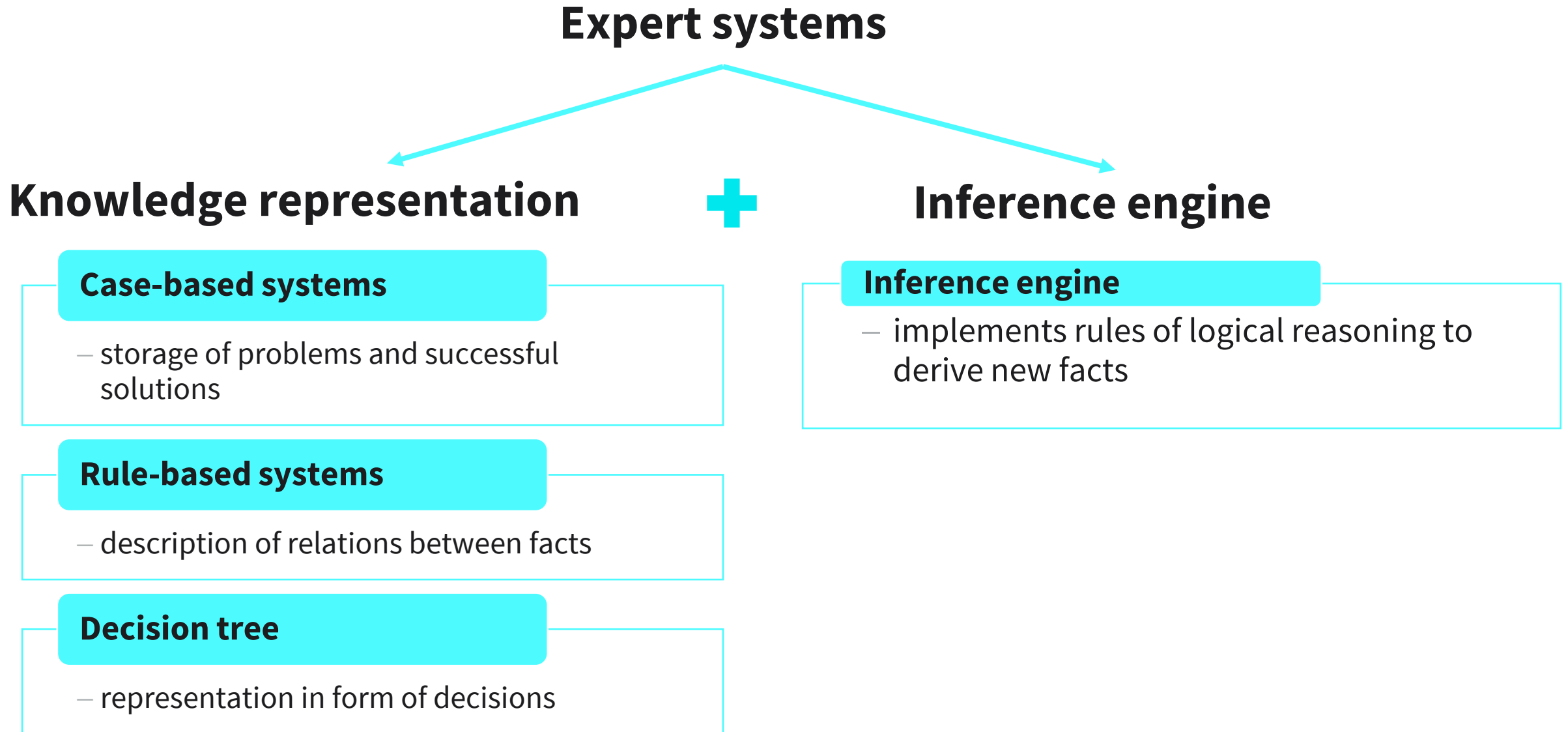# ARTIFICIAL INTELLIGENCE

EARLY SYSTEMS IN ARTIFICIAL INTELLIGENCE

On completion of this unit, you will have learned …

- … about important approaches that have defined the field of artificial intelligence in the past and that continue to influence it today.
- … why expert systems are important and how they have contributed to artificial intelligence and computer science.
- … about advances brought about in the Prolog programming language.
- … the definition of machine learning and how it contributes to artificial intelligence.

1. List the three types of machine learning and explain them using your own words.
2. What are the main components of expert systems?
3. Explain the declarative programming paradigm.

Expert systems

Knowledge representation ✚ Inference engine

Case-based systems
— storage of problems and successful solutions

Rule-based systems
— description of relations between facts

Decision tree
— representation in form of decisions

Inference engine
— implements rules of logical reasoning to derive new facts

VisiRule – decision-support system

— Assesses severe COVID-19 cases with the help of a decision tree

— Combines complex human respiratory and cardiovascular information in a visual manner

https://visiruleexamples.com/vregs.html

Source of the image: VisiRule, https://www.visirule.co.uk/medical-demos.

New use cases require a larger knowledge base

- Increased computational complexity during inference
- Challenge of consistency without contradictions
- → Lead to development of logical programming to formulate rules and reasoning processes

Declarative programming

- programming style with specified properties of the sought solution but not the algorithm
- → sequence of operations that lead to a solution (= logic)

What's Prolog?

– Prolog is a language that is useful for doing symbolic and logic-based computation.

– It's **declarative**: very different from imperative style programming like Java, C++, Python,…

– A program is partly like a **database** but much more powerful since we can also have general **rules** to infer new facts!

– A **Prolog interpreter** can follow these facts/rules and answer **queries** by sophisticated **search**.

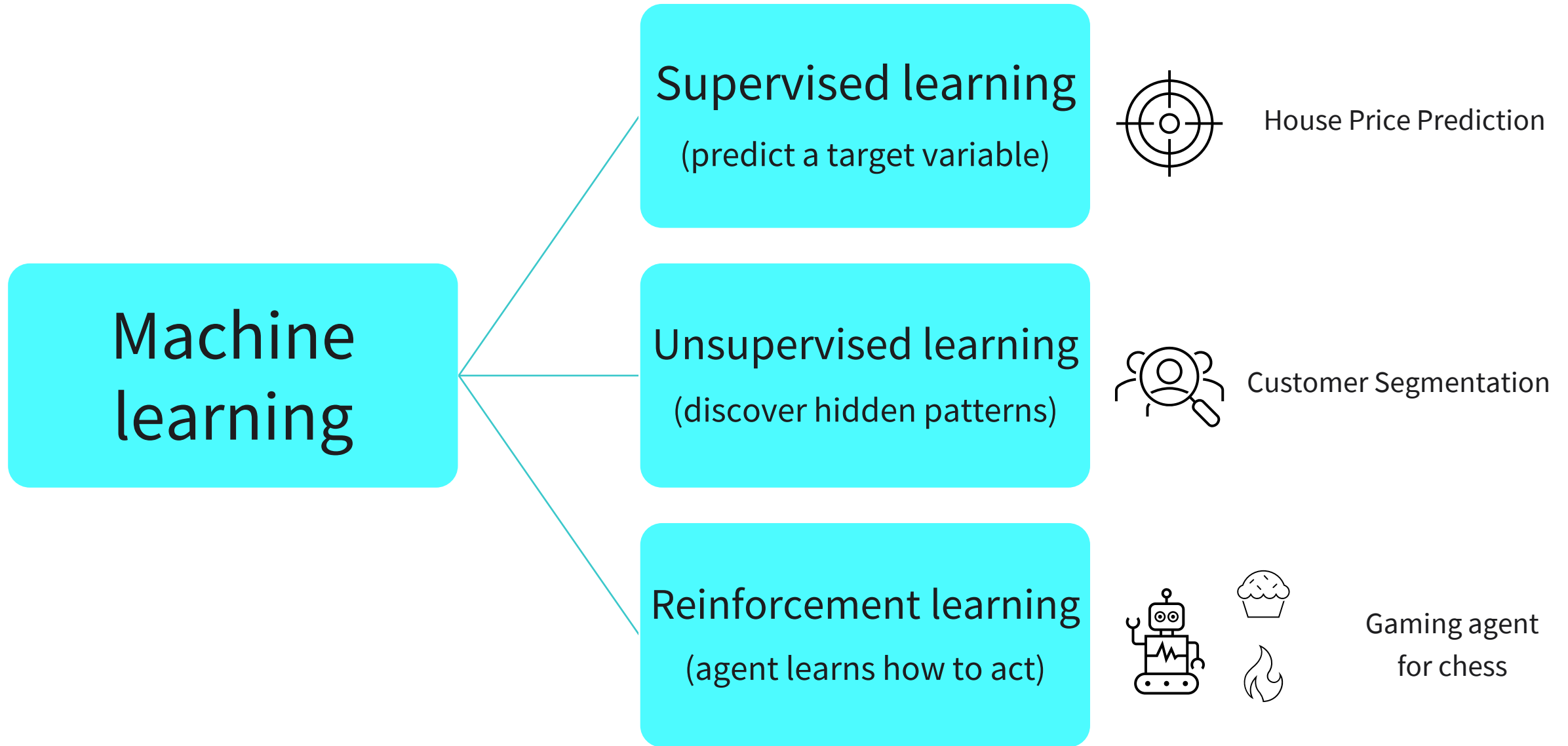# PROgramming in LOGic (Prolog): Consists of predicates and clauses

Example of the Prolog Language		
Prolog language construct	**Prolog syntax**	**Meaning and output**
Fact	lectures (Smith, DLMAIAI01)	Establishes the fact that Dr. Smith teaches the course DLMAIAI01. It is an exmple of a Prolog clause.
Predicate	professor/1 professor(Smith). professor(Jones). professor(Meyer).	Defines the one argument predicate professor by three facts. Dr. Smith, Jones, and Meyer are professors.
Rule	technicalCourse(X) :- engineeringCourse(X)	All engineering courses are technical courses. Note the use of variable X!
Query	? – lectures(Smith, DLMAIAI01)	Does Dr. Smith teach DLMAIAI01?
Goal	? – lectures(Smith, X)	What courses does Dr. Smith teach? Note the use of the variable X!

Source of the table: Course Book DLMAIAI01, 33-34

Here is a simple Prolog program

```
male(albert).                              %a fact stating albert is a male
male(edward).
female(alice).                             %a fact stating alice is a female
female(victoria).
parent(albert,edward).                     %a fact: albert is parent of edward
parent(victoria,edward).
father(X,Y) :-                             %a rule: X is father of Y if X if a male parent of Y
        parent(X,Y), male(X). %body of above rule, can be on same line.
mother(X,Y) :- parent(X,Y), female(X).  %a similar rule for X being mother of Y
```

– A fact/rule (statement) ends with ".**.**" and white space ignored read **:-** after rule head as "**if**". Read comma "**,**" in body as "**and**" Comment a line with **%** or use **/* */** for multi-line comments

TYPES OF MACHINE LEARNING

Machine learning

Supervised learning
(predict a target variable)

House Price Prediction

Unsupervised learning
(discover hidden patterns)

Customer Segmentation

Reinforcement learning
(agent learns how to act)

Gaming agent
for chess

— Healthcare: wearables

— Automobile: autonomous driving

— Banking: fraud detection

— Retail: personalized product recommendations

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TRANSFER TASK

Use Prolog to develop rules for the following family relations:

Paul — Emily

William — Alice   Jerry — Theresa
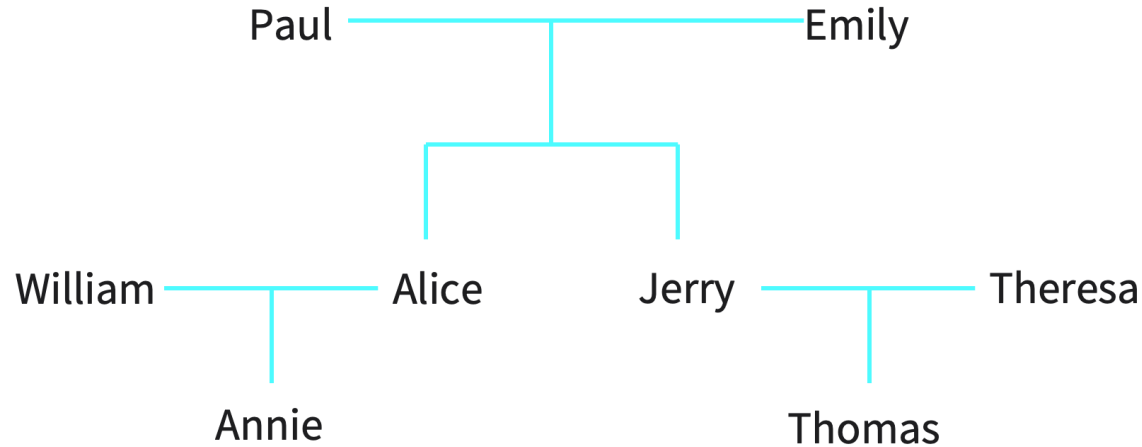
Annie

Thomas

Write the following queries:

— *Does Annie have an uncle? Who?*

— *Who are the grandparents of Thomas?*

→ Use this virtual environment: SWI Prolog

Tutorial: http://www.macs.hw.ac.uk/~rpp6/teaching/F29AI/prolog/

Please present your results.

The results will be discussed in plenary.

TRANSFER TASK SAMPLE SOLUTION

female(annie).
female(theresa).
female(alice).
female(emily).

male(thomas).
male(jerry).
male(william).
male(paul).

parent_of(paul,alice).
parent_of(emily,alice).
parent_of(paul,jerry).
parent_of(emily,jerry).
parent_of(alice,annie).
parent_of(william,annie).
parent_of(jerry,thomas).
parent_of(theresa,thomas).

father_of(X,Y) :- male(X),
              parent_of(X,Y).
mother_of(X,Y) :- female(X),
              parent_of(X,Y).

grandfather_of(X,Y) :- father_of(X,Z),
                 parent_of(Z,Y).
grandmother_of(X,Y) :- mother_of(X,Z),
                 parent_of(Z,Y).

sister_of(X,Y) :- female(X),
            parent_of(Z,X),
            parent_of(Z,Y).
brother_of(X,Y) :- male(X),
             parent_of(Z,X),
             parent_of(Z,Y).

aunt_of(X,Y) :- sister_of(X,Z),
           parent_of(Z,Y).
uncle_of(X,Y) :- brother_of(X,Z),
            parent_of(Z,Y).

Does Annie have an uncle?

➤ *uncle_of*(_,annie).

Who?

➤ *uncle_of*(X,annie).

Who are the grandparents of Thomas?

➤ *grandmother_of*(X,thomas).

➤ *grandfather_of*(X,thomas).

1. In Prolog, the sequence of concrete steps to arrive at a desired program outcome is:

   a) specified by the program user.
   b) generated by the Prolog system.
   c) specified by the programmer.
   d) not determined at all

2. Supervised learning, unsupervised learning, and reinforcement learning

   a) define the full range of the field of artificial intelligence.

   b) are concepts still being tested in laboratories. They are not yet being applied.

   c) have no relation to machine learning or artificial intelligence.

   d) are subfields of machine learning.

3. The main lasting contribution of expert systems to artificial intelligence and/or computer science were

   a) explicit formal representation of knowledge, declarative programming style, and rapid prototyping.
   b) the popularization of imperative programming and probabilistic reasoning.
   c) list processing and procedural programming.
   d) object-oriented programming and the implementation of systems without prototyping.