INFERENCING STRATEGIES

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Introduction

- The discovery of penicillin began with a single observation. Sir Alexander Fleming notice that bacteria had been destroyed on a culture plate which had been lying around for a couple of weeks.
- In fact, a chain of coincidence had led to their destruction. “Chance,” as Pasteur said, “favors the prepared mind.”
- Flemming was prepared. He knew that the bacteria were hardly, and so he reasoned that something must have killed them: Event of this type do not normally happen. An event of this type has happened.
- Therefore, there is some agent that caused the event.
  - Philip N. Johnson-Laird
  - The Computer and Mind (Cambridge, MA:Harvard Univ. Press, 1988), p234

Introduction

- Inferencing means deriving a conclusion based on statements that only imply that conclusion
- Inference engine is an algorithm that controls the reasoning process (called rule interpreter in rule base system)
- It direct the search in knowledge base and decides:
  - which rule to investigate
  - which alternative to eliminate
  - which attribute to match (pattern matching)

Introduction

- Reasoning is the process of applying knowledge to arrive at solutions.
- To reason is to think clearly and logically, to draw reasonable inference or conclusion from known or assumed facts
- It works through interaction of rules and data

Categories of Reasoning

Typically, human reasons by the following ways:

- Deductive Reasoning
- Inductive Reasoning
- Abductive Reasoning
- Analogical Reasoning
- Common-Sense Reasoning

Categories of Reasoning

- **Deductive Reasoning**
- A process in which general premises are used to obtain specific inference.

- Example:

  Major premise: I do not jog when the temperature exceeds 90 degrees

  Minor premise: Today the temperature is 93 degree

  Conclusion: Therefore, I will not jog today

  Major premise: I will come to class if there is an exam

  Minor premise: Today is exam

  Conclusion: I will come to class

Categories of Reasoning

- **Inductive Reasoning**
- Human use to arrive new conclusion from a limited set of facts by the process of generalization.

- Example:

  Premise: Monkeys in the Zoo Negara eats bananas

  Premise: Monkeys in Taiping Zoos eats bananas

  Conclusion: In general, all monkeys eat bananas.

Categories of Reasoning

- **Abductive Reasoning**
- A form of deduction that allows for plausible inference.

- Plausible means, the conclusion might follow from available information, but it might be wrong.

- Example:

  If B is true and if A implies B is true, then A is true?

  Major Premise: Ground is wet if it is raining

  Minor Premise: Ground is wet

  Conclusion: It is raining ?

Categories of Reasoning

- **Analogical Reasoning**
- Human form a mental model of some concept through their experiences and use it to help them understand some situation or objects.

- For example:

  If you are ask, “what are the working hours engineers in the company”

  The computer may reason that engineers are white-collar employees in the company and it knows that white collar employees work from 8-5.

  The computer will infer that engineers work from 8-5.

Categories of Reasoning

- **Common-Sense Reasoning**
- Learns to solve problem through experience and use common-sense to solve problem more efficiently. Called heuristic knowledge.

- Relies more on good judgment than on exact logic. Example:
  - A loose fan usually causes strange noises.

- Valuable for quick solutions.

Reasoning

- Reasoning is performed by using:
  - inference techniques: guides the ES using KB and facts in working memory. (modus ponens, modus tolens)
  - control strategies: establish goals and guide in reasoning. (forward and backward chaining)

Inference Techniques

- Modus Ponens
- Modus Tollens
- Resolution

Inference Techniques

MODUS PONENS (Affirmative mode)

- A common rule for deriving new facts from existing rules and known facts
- A rule of inference used in proof procedures and an intuitive ways of conducting the reasoning process
- If statement a and (a $\rightarrow$ b) are known to be true, then one can infer that b is true

Inference Techniques

MODUS PONENS (Example)

1. It is sunny day
2. If it is sunny, then we will go to the beach
3. We will go to the beach

or (in PL)

1. E1
2. E1 $\rightarrow$ E2
3. E2

if E2 $\rightarrow$ E3 exist, E3 would be add to the list.

Inference Techniques

MODUS PONENS (Affirmative mode)

Some implications express as rules:

1. E1 $\rightarrow$ E2

   If temperature > 102 THEN Patient has high temperature

2. E2 $\rightarrow$ E3

   If Patient has high temperature THEN take panadol

Known fact: Patient has temperature > 102 (E1)

Inference Techniques

MODUS TOLLEN

- It state that if $(a \rightarrow b)$ is known to be true, and b is false, then a is false

Inference Techniques

RESOLUTION

- Inference strategy used in logical system to determine the truth of an assertion.

- Example:
  - Doctor attempting to prove that a patient has strep throat would run lab test to obtain supporting evidence.

- Attempt to prove that some theorem or goal expressed as proposition P is **TRUE**, given a set of axioms about the problem.

Inference Techniques

RESOLUTION

- **How To Proof Proposition P Is True Using Resolution?**
  - By using proof by refutation, an attempt to proof that a statement is TRUE by initially assuming that it is FALSE. ($\neg$P cannot be true)
  - Involves producing new expressions called resolvents from the union of existing axioms and the negated theorem.

Inference Techniques

RESOLUTION

The resolution rules states:

IF (A $\vee$ B) is TRUE

AND ($\neg$B $\vee$ C) is TRUE

THEN (A V C) is TRUE

Inference Techniques

RESOLUTION (Example from previous case**)**

$A \rightarrow B = \neg A \vee B$ (proof using truth table)

Therefore,

1. $\neg E1 \vee E2$ $(E1 \rightarrow E2)$
   IF temperature > 102 THEN Patient has high temperature

2. $\neg E2 \vee E3$ $(E2 \rightarrow E3)$
   IF patient have high temperature THEN take panadol

3. E1 - temperature > 102

Want to prove take panadol (E3) is **TRUE**.

Inference Techniques Exercise

1. Given the following axioms:

$$A \wedge B \rightarrow C$$

$$D \rightarrow E$$

$$F \wedge E \rightarrow B$$

Prove that C is true given that D,F and A are true using:

a) modus ponen.

b) using resolution.

Inference Techniques Exercise

2. Given the following axioms:

$E1 \wedge E2 \rightarrow E3$

$E4 \rightarrow E1$

$E5 \wedge E6 \wedge E7 \rightarrow E2$

Prove that E3 is true given that E4, E5, E6 and E7 are true using:

a) modus ponen.

b) using resolution.

Control Strategies

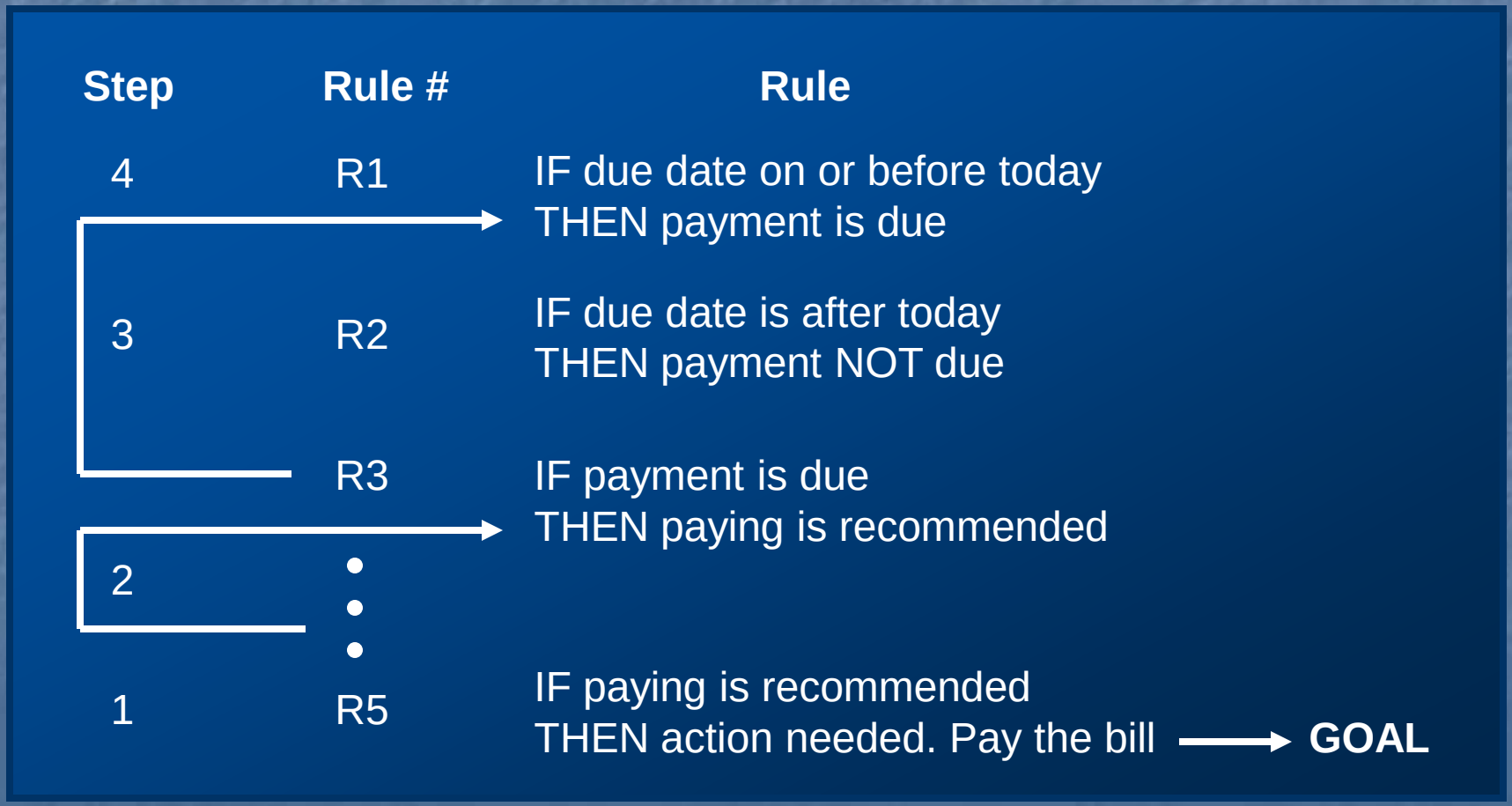
- Most commercial expert system have an inferencing component that uses the modus ponens procedure via rule interpreter.
- The principle of chaining is governed by modus ponens.
- Typically, inference engine utilized 2 control strategies:
  - Backward Chaining (goal driven)
    - determine fact in the conclusion to prove the conclusion is true.
  - Forward Chaining (data driven)
    - premise clause match situation then assert conclusion.
- Chaining signifies linking of a set of pertinent rules.

Control Strategies

- Backward Chaining (Goal Driven)
  - An Inference strategy that attempts to prove a hypothesis by gathering supporting information
  - The system works from the goal by chaining rules together to reach a conclusion or achieve a goal
  - In other words, it start with the goal, and then looks for all relevant, supporting processes that lead to achieving the goal.

Control Strategies

- Backward Chaining in Partial Knowledge Base



Control Strategies

Steps Backward Chaining

1. Check in working memory if goal have previously added
2. If not proven, search the rules looking for one that contain the goal (conclusion part) called **GOAL RULE**
3. If found, check if GOAL RULE premise contain in the working memory.
4. Premise not in working memory become a new goal to prove (sub-goal). Process 1-4 continue in recursive manner until find a **PRIMITIVE,** premise of a rule that is not conclude by any rule.
5. When primitive if found, ES ask the user and use this information to prove sub-goal and original goal.

Control Strategies

Backward Chaining Example

A patient visit a doctor and after listening, the doctor believe patient has strep throat, thus, doctor have to prove his assumption.

R1: IF there are signs of throat infection (E1)
AND there is evidence that organism is streptococcus (E2)
THEN patient has strep throat (E3)

R2: IF patient throat is red (E4)
THEN there are signs of throat infections (E1)

R3: IF stain of organism is grampos (E5)
AND morphology of the organism is coccus (E6)
AND growth of the organism is chains (E7)
THEN there is evidence that the organism is streptococcus (E2)

Objective: PROVE 'patient have strep throat'

Advantages of Backward Chaining

- Works well when the problem naturally begins by forming a hypothesis.
- Remains focus on a given goals
- Search only on relevant knowledge.
- Excellent for diagnostics, prescription and debugging types of problems

Disadvantages of Backward Chaining

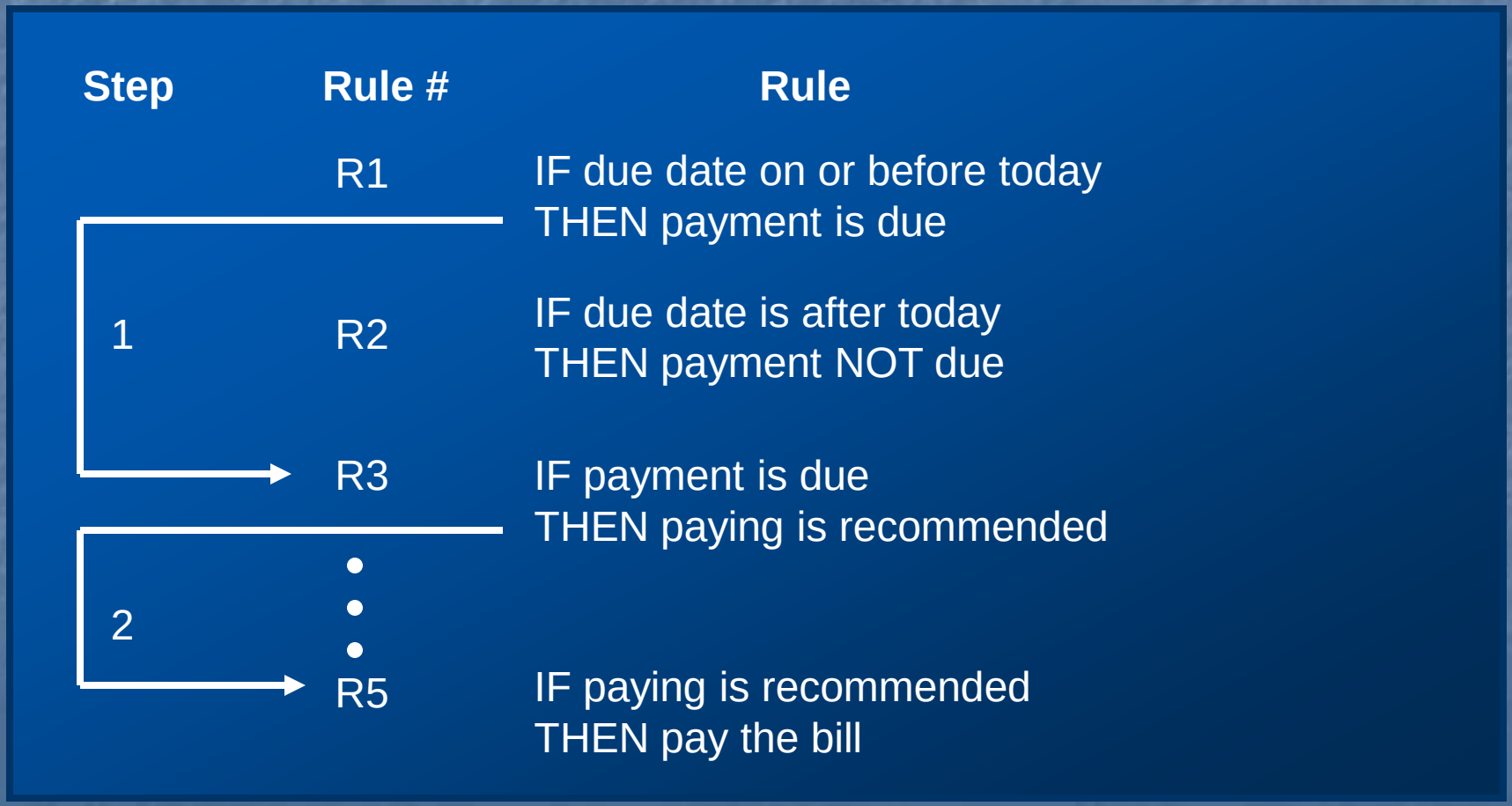
- Principal disadvantage, it will continue to follow a given line of reasoning even if it should drop it and switch to a different one.

Control Strategies

- Forward Chaining (Data Driven)
  - An Inference strategy that begins with a set of known facts, derives new facts using rules whose premises match the known facts, continues until goal reached or no more rules matches.
  - Begins with known data and works forward to see if any conclusions (new information) can be drawn.
  - It can also provide explanation for any conclusions in terms of the rule that was used to deduce it
  - The spot light is on the premise. The action part is only the means to the next premise in the process

Control Strategies

- Forward Chaining in Partial knowledge base



Control Strategies

The steps in forward chaining:

1. ES obtain information from user and place in working memory.
2. Inference engine scans the rules and perform pattern matching
3. If rules found, add conclusion to the working memory
4. Repeat steps 2 and 3 Until no more matches or goal achieved

Control Strategies

Example of forward chaining

- Patient visit the doctor to complaint about certain ailments.
- Assume the following rules:

Rule 1:
IF patient has sore throat
AND suspect bacterial infection
THEN believe patient has strep throat

Rule 2:
IF patient temperature > 100
THEN patient has fever

Rule 3:
IF patient sick over a month
AND patient has a fever
THEN suspect a bacterial infections

Control Strategies

Example of forward chaining

Assert the following facts (from user)

1. Patient temperature > 102
2. Patient has been sick for 12 months
3. Patient has sore throat

Advantages of Forward Chaining

- Works well when the problem naturally begins by gathering information.
- Provide considerable amount of information from only a small amount of data.
- Excellent for planning, monitoring, control and interpretation types of problems

Disadvantages of Forward Chaining

- No means of recognizing that some evidence might be more important than the others. Ask all possible questions.
- May ask unrelated questions

Comparative Summary of Backward and Forward Chaining

Attribute	Backward Chaining	Forward Chaining
Also known as	Goal-driven	Data-driven
Starts from	Possible conclusion	New data
Processing	Efficient	Somewhat wasteful
Aims for	Necessary data	Any conclusion (s)
Approach	Conservative/cautious	Opportunistic
Practical if	Number of possible final answers is reasonable or a set of known alternatives is available	Combinatorial explosion creates an infinite number of possible right answers
Appropriate for	Diagnostic, prescription and debugging application	Planning, monitoring, control and interpretation application
Example of application	Selecting a specific type of investment	Making changes to corporate pension fund

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Conflict Resolution

- Refers to a situation in which the expert system needs to select a rule from several rules that apply.
- Can be a source of uncertainty.

Conflict Resolution

Example 1

R1: IF a person is old
THEN better bertaubat
R2: IF a person is over 65
THEN better berubat

Which rule to fire?

Conflict Resolution

Example 2

R1: IF there is a fire on the assembly line
THEN throw water on it

R2: IF there is a fire on the assembly line
THEN don't throw water on it

Contradict conclusion.

Conflict Resolution

Example 3

R1: IF today is hot
AND my lecturer looks very dull
THEN there will be a quiz

R2: IF today is sunny
AND many students did not attend class
THEN class will be cancelled

Assume all the premises are true, which rule to fire?

Conflict Resolution

- Thus, inference engine needs to resolve conflicts between rules.

- Inference engine used 3 steps ***recognise-resolve-act*** process when cycling through the rules.
  1. recognise - do pattern matching and identify rules that can fire
  2. resolve - if > 1 rule can fire, choose I rule using some strategy.
  3. act. Fire the rule and add its conclusion in W.M.

Conflict Resolution

- The *Recognise* step insert all the rules that can fire in a *conflict set,* then use the following strategy to choose a rule from the set*:*

  a. First rule that matches contents of working memory.
  b. Highest priority rule
  c. Most specific rule
  d. Rule that refers to the element most recently added in W.M.
  e. Don't fire a rule that has already fired

Goal Agenda

- Is a series of goals to pursue in a prescribed sequence.
- A goal agenda can be simple ordered list of goals such as:

1. Goal1
2. Goal2
3. Goal3

- The system will pursue the goals in the order they appear

  on the agenda.

Goal Agenda

- Consider the following goals:

  1. Recommend you purchase a television
  2. Recommend you purchase a radio
  3. Recommend you purchase a computer.

- The system will determine a purchase for the user. Can stop after a goal is proven or list everything that should be purchase.

Goal Agenda

- Can also use more complex agenda, such as identifying animal.
- 1. The animal is a bird
  - 1.1 The bird is a robin
  - 1.2 The bird is a finch
    - 1.2.1 It is a golden finch
    - 1.2.2 It is a brown finch
- 2. The animal is a mammal
  - 2.1 The mammal is a horse
  - 2.2 The mammal is a cow
- 3. The animal is a reptile