Expert system

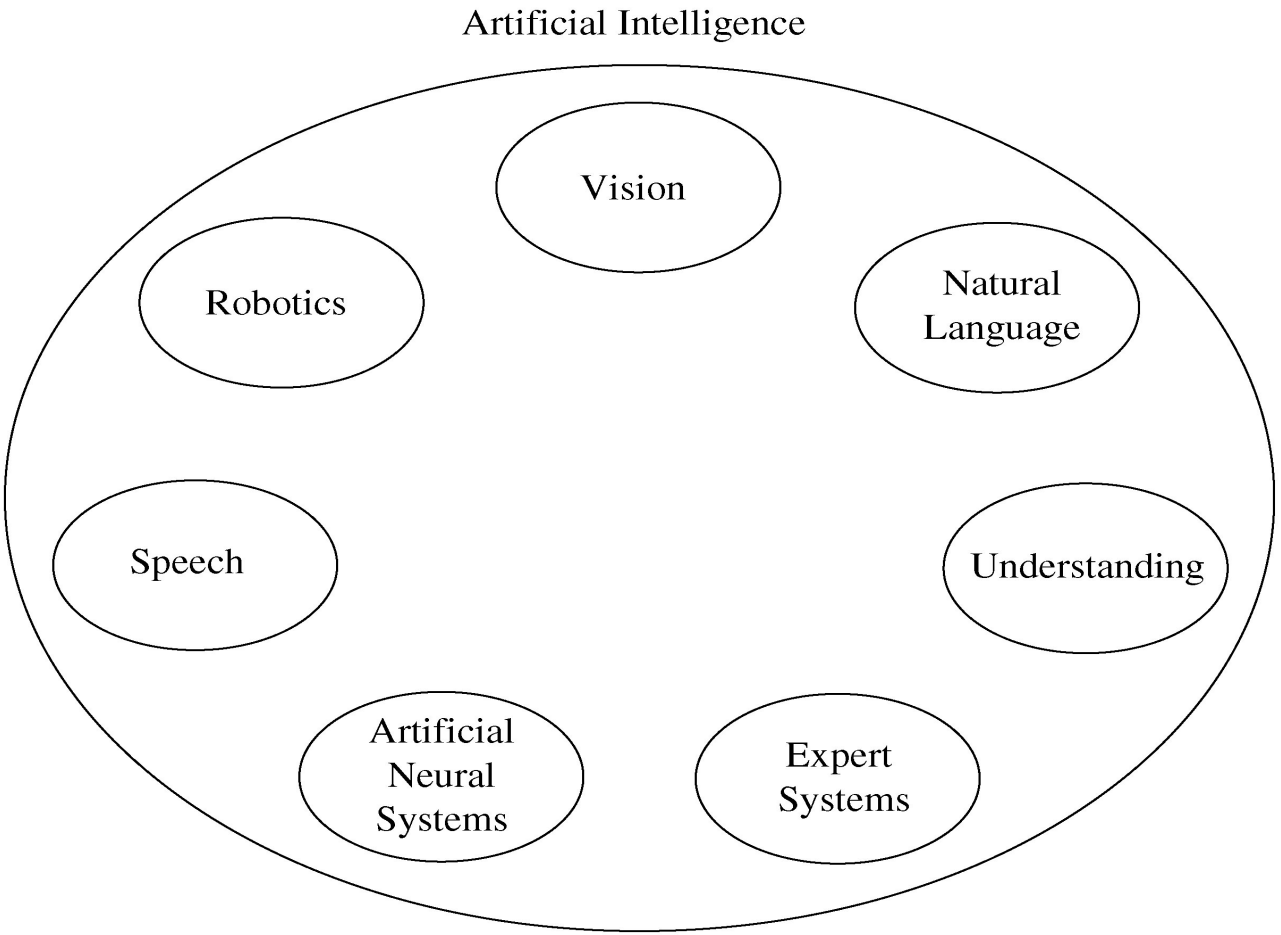
What is an expert system?

"An expert system is a computer system that emulates, or acts in all respects, with the decision-making capabilities of a human expert."

Professor Edward Feigenbaum

Stanford University

Fig 1.1 Areas of Artificial Intelligence



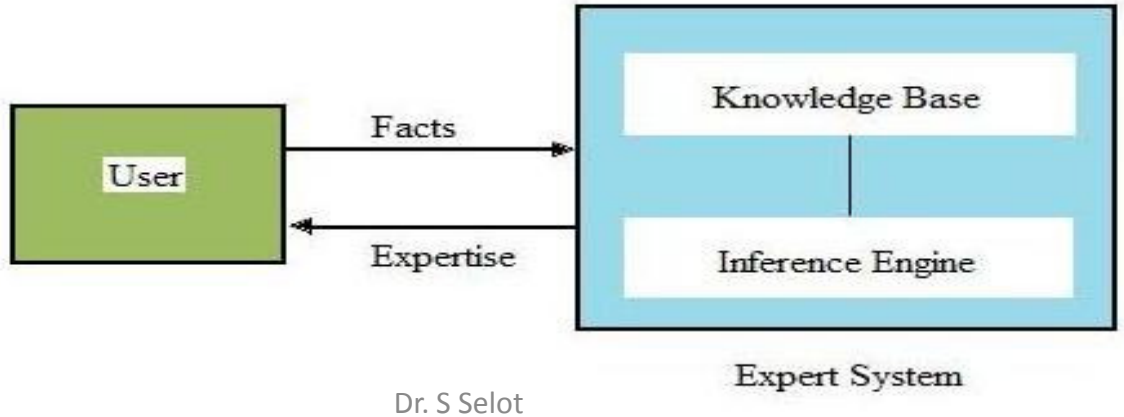
Expert system

- **Definition:** An intelligent computer program that uses knowledge and inference mechanism to solve problem that are difficult enough and require significant human expertise for their solution
- ES are knowledge intensive program that solve problem in a domain that require considerable amount of technical knowledge
- ES is computer system that emulates the decision making ability of human expert

Expert System Main Components

- Knowledge base – obtainable from books, magazines, knowledgeable persons, etc.

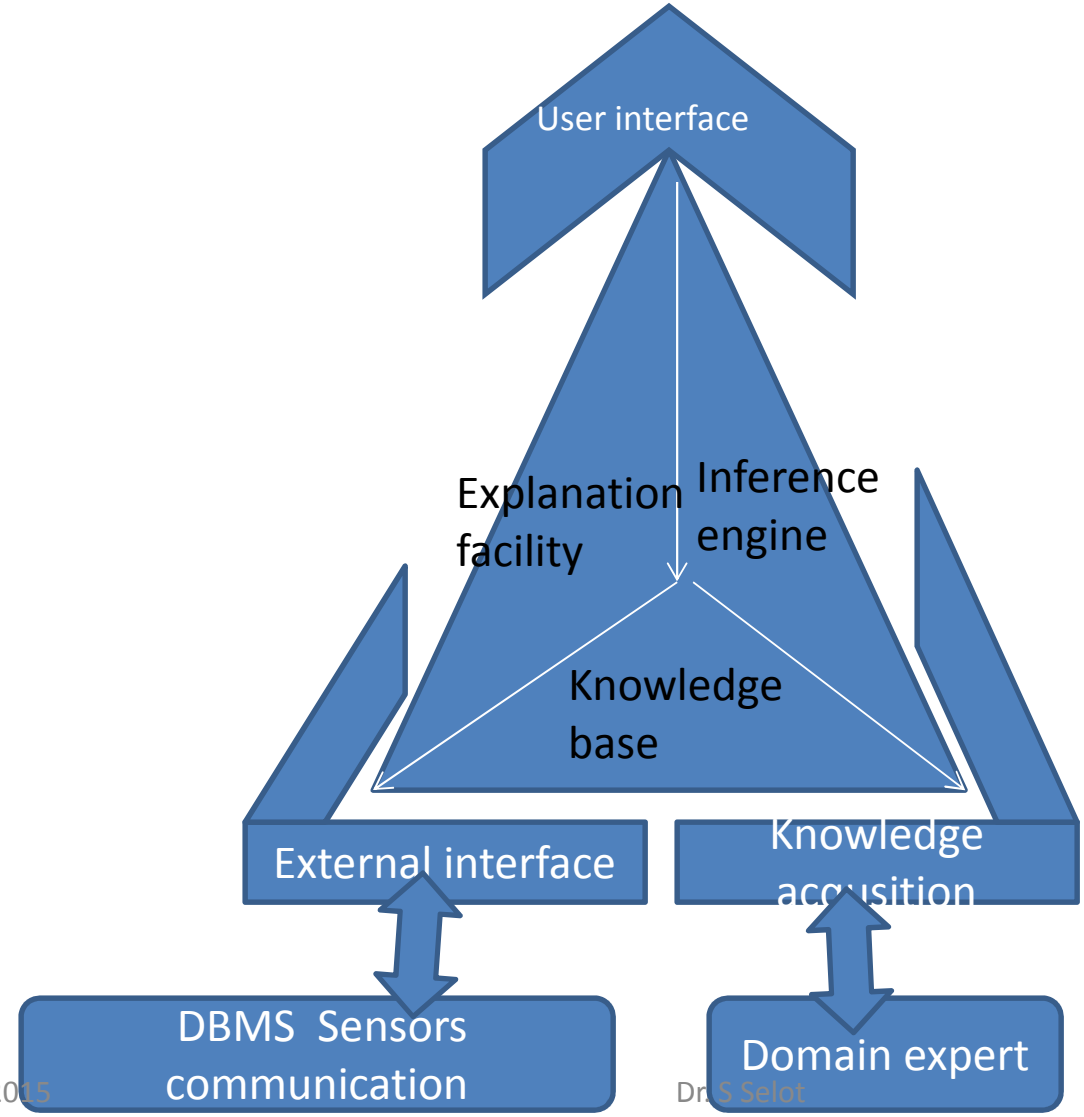
- Inference engine – draws conclusions from the knowledge base



characteristic

- Solve difficult problem
- Process vast quantities of domain specific knowledge
- Permits heuristic search process
- They justify the conclusion
- They accept advice , modify and update
- Deal with uncertain and irrelevant data
- Communicate with user in natural language
- Multiple roles: as tutor, expert and information generator
- Process symbolic information rather numeric info

Architecture of ES



Components of ES

- User interface
- Knowledge base
- Inference engine
- Explanation Facility
- External Interfaces
- Knowledge acquisition

Knowledge base

- Warehouse of domain specific knowledge captured from human expert via knowledge acquisition module
- Expressed in if-then-else form
- If part is condition or antecedent
- Then part is action or consequent

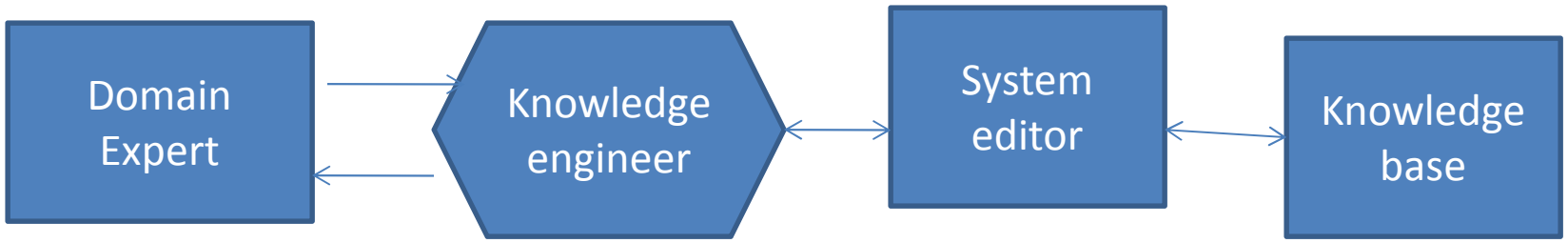
Inference engine

- Rule interpreter
- Performs the task of matching antecedents from responses given by user
- One rule triggers many rules
- Thus network of rules are triggered
- Work if IE is to traverse network rules ro find a path
  - Forward chaining
  - Backward chaining

User Interface

- Provides the facility for user to communicate with system
- It can be for
  - End user who wants
    - answer from ES
    - Explanation to answer(tutor)
    - Heuristic of system
  - Expert who
    - Identifies the problem area
    - Add new knowledge

Knowledge acquisition



Process of collecting knowledge from expert and storing it in organized form

Main bottleneck in developing ES as it require expert in form human or journal research article

Require number of years to capture knowledge

External interfaces

- Provides communication between ES and user external environment
- EI with sensor can capture minute information about situation
- Communication system help ES to connect to global DB
- DBMS: maintains all consultation records. Identifies what exact points need more attention

Advantages

- Increased availability-available at more than one place
- Reduced cost: expert cost per user is high, as number of expert increases cot reduces
- Reduced danger : can be applied at locations where it is dangerous for human to go
- Permanent: unlike human expert they do not leave or retire

Adv contd….

- Availability of multiple experts: Knowledge of multiple experts can be made to work simultaneously
- Increased reliability: No computational error, if knowledge base is maintained correctly, accurate answers are available
- Explanation: maintains reasoning for a decision or answer
- Fast response and steady behavior.

Expert system Shell

- Initially each expert system was built from scratch
- After making of several system, it became clear that that these system had often lot in common
- Systems were made of declarative representation with (rules) along with interpreter for those representation
- It was possible to separate the interpreter with domain specific knowledge
- Thus, create a system that could be used to build a new expert system by adding new knowledge corresponding to new problem domain
- Resulting interpreters are called shells
- Example EMYCIN (empty MYCIN) which was derived from MYCIN
- There are many commercially available shells which provide a basis for expert system

Expert system Shell

- They provide great flexibility in representing knowledge and reasoning with it
- They support rules, frames, truth maintenance and variety of reasoning mechanisms
- Later on tools for knowledge acquisition was also added to shells
- Shells must make it easy to integrate expert system with other programming environment

AI in Medicine (USA 1970)

- Stanford

  MYCIN - blood infections

- Rutgers

  CASNET - casual reasoning

- MIT

  PIP - renal disease

- Stanford

- Pittsburgh

  Internist – internal medicine

- "the primary goal of this field is to develop computer programs that perform efficiently and are able to explain their reasoning and conclusions to their users"

MYCIN'S knowledge base

- Developed in Standford university in 1970 , using LISP
- Diagnose recommend treatment for certain blood infections
- Knowledge is represented as set of i-then rules---About 400 diagnostic rules ans 5 therapy rules
- Rule based system where each rule was assigned a certainity factor
- Used backward chaining to infer or to answer the query
- Used heuristics for applying rules
    - A rule was chosen if all its premises were satisfied
    - If not then another rule was searched
    - In case of uncertainity , CF's of each evidence was caldulated to check the overall CF of rule

MYCIN

User conversation was divided into three stages

- Stage 1: initial data gathering was done to enable the system to make broad diagnosis

- Stage 2: Questions that were asked to test the specific hypothesis were more direct in nature

- Stage 3: A diagnosis was proposed

- At any stage user can put up a query
  - why a particular question was asked
  - why the particular treatment was give.
  - Is there an alternate treatment

Why Mycin?

- Diagnose likely infecting organisms in blood and meningitis infections
- Use test results and information about patient supplied by doctor
- Prescribe an effective antibiotic treatment
- Do this early in the course of the disease, before all possible information is available
- To counteract:
  - overuse of antibiotics
  - irrational use of antibiotics
  - maldistribution of expertise

Mycin system for diagnosis og meningitis and bacteremia (bacterial infections)

```
IF
   the site of the culture is blood, and
   the identity of the organism is
          not known with certainty, and
   the stain of the organism is gramneg, and
   the morphology of the organism is rod, and
   the patient has been seriously burned
THEN
   there is weakly suggestive evidence (0.4) that
        the identity of the   organism is pseudomonas
```

MYCIN diagnosis rule (2)

IF

the site of the culture is blood, and

the identity of the organism is gramneg, and

the morphology of the organism is rod, and

the patient is a compromised host

THEN

there is suggestive evidence (0.6) that

the identity of the organism is pseudomonas-Aeruginosa

MYCIN diagnosis rule (3)

```
Rule 3
IF (1) stain of organism is gram-positive and
   (2) morphology of organism is coccus and
   (3) growth-conformation of the organism is clumps
THEN there is suggestive evidence (0.7) that
     identity of organism is staphylococcus.
```

MYCIN diagnosis rule (3)
(CEFAX notation)

```
rule 3
if  stain of organism is gram_positive and
    morphology of organism is coccus and
    growth_conformation of organism is clumps
then 0.7 certainty
    identity of organism is staphylococcus.
```

MYCIN: Therapy Selection Rule

IF You are considering giving chloramphenicol, and

the patient is less than 1 week old

THEN it is definite (1.0) that chlorampericol is contraindicated for this patient

[Justification: Newborn infants may develop vasomuscular collapse due to an immaturity of the liver and kidney functions resulting in decreased metabolism of chloramphenicol]

How does MYCIN create confidence in the user

Answering ”Why?” (Why did you ask that?)

Answering ”How” (How did you arraive at that conclusion?)

Answering ”Why not X?” (Why did you not consider X?)

Mycin’s simple rule format and friendly explanations in ”English” are the key.

MYCIN Explanation

User: Why didn't you consider Streptococcus as a possiblity

for Organism- 1

MYCIN: The following rule could have been used to determine that the identoty of Organism-1 was streptococcus:

Rule 33

But Clause 2 ("`the morphology of the organism is Coccus`") was already known to be false for Organism-1, so the rule was never tried.

How MYCIN looks to the user: Therapy recommendation

[REC-1] My preferred therapy recommendation is as follows:

In order to cover for items <1 2 3 4 5Z:

Give the following in combination

1: Kanamycin

Dose 750 mg (7.5 mg(kg)q12h IM (or IV)

for 28 days

Comments: Modify dose in renal failure

2: Penicillin

Dose: 2,500,000 units (2500 units/kg) q4h IV

for 28 days

Emycin and expert system shell

MYCIN has later been developed, and separated into to parts:

An expert system shell EMYCIN (empty MYCIN)

A knowledg base

The expert system shell EMYCIN is ”the mother of all expert system shells”.

One simplified version is called CEFAX is implemented at NTNU in Prolog

EMYCIN

- A new ES called PUFF was developed using EMYCIN in the new domain of hear diseases
- Another ES called NEOMYCIN was also developed using EMYCIN to train the doctors, which takes them through different cases and checks their diagnosis and detects whether their conclusions are right and explains where they went wrong

Other ES

- PROSPECTOR :
  - Developed at Stanford university in 1974
  - To aid exploration geologists in their search for ores (mineral exploration)
  - used Bayes theorem to deal with uncertainty
- DENDRYL:
  - Developed at Stanford university in 1960
  - Was developed to infer compound's molecular structure from mass spectral and nuclear response