MYCIN

The embodiment of
"all the clichés of what expert systems are."
(Newell)

What is MYCIN?

- A medical diagnosis assistant
- A wild success
  - Better than the experts
  - Prototype for many other systems
- A disappointing failure
  - Never put into use

Where did it come from?

- Created at Stanford mid 70's
- DENDRAL: domain data & rules
- MYCIN adds: heuristic control, interaction, uncertainty, explanation…
- Collaboration between medical school/CS
- Edward H. Shortliffe

What does MYCIN do?

- Provides consultative advice
- Diagnoses bacterial blood infections & meningitis
- Recommends drugs
- Explains itself

UI is a textual interface

- Keyword based parsing
- Spelling correction
- Prompts can give expected answers
- Very directed questions – no open ended questions

What can the user do?

- User interacts by providing answers
- MYCIN is in charge
- But user can:
  - Ask how: How did you decide X?
  - Ask why: Why are you asking Y?
  - Ask about objects and values
  - Change answers
  - Specify (un) certainty

Example interaction

1) Patient's name: (first-last)
** FRED BRAUN
2) Sex:
** M

…
5) From what site was the specimen for CULTURE-1 taken?
** BLOD
=BLOOD

…
7) Enter the laboratory-reported identity of ORGANISM-1:
** UNKNOWN
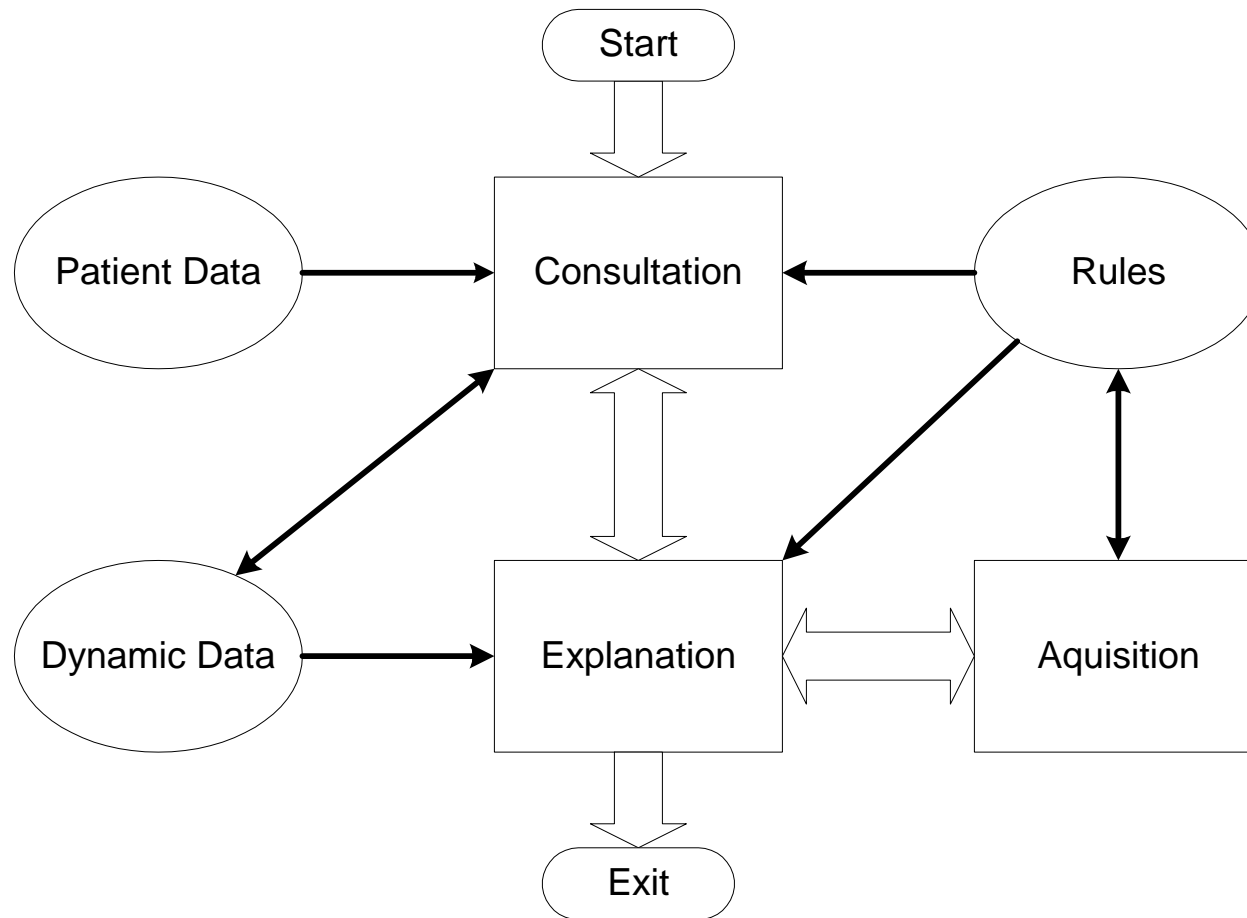
…
23) What is the suspected portal of entry of the gramneg rod from the blood culture of 20-JUN-77 (ORGANISM-1) into this sterile site?
** GI (6)

…

Main Components

Phases of consultation

- Existence of significant infection
- Likely organisms
- Potentially useful drugs
- Best drugs

How does diagnosis work?

- Production rules
- Backward chaining
- Certainty factors

Production rules

- If <premise> Then <action>
- If 1)… and 2)… and 3)…
- If (operation object attribute value)…
- Stored in Lisp, translate to/from English
- Indirectly executed

A sample rule

English:

```
 IF:    1) THE STAIN OF THE ORGANISM IS GRAMPOS, AND
        2) THE MORPHOLOGY OF THE ORGANISM IS COCCUS, AND
        3) THE GROWTH CONFORMATION OF THE ORGANISM IS
        CLUMPS,
 THEN: THERE IS SUGGESTIVE EVIDENCE (.7) THAT THE
        IDENTITY OF THE ORGANISM IS STAPHYLOCOCCUS
```

Lisp:

```
 PREMISE: ($AND (SAME CNTXT STAIN GRAMPOS)
                (SAME CNTXT MORPH COCCUS)
                (SAME CNTXT CONFORM CLUMPS))
 ACTION:  (CONCLUDE CNTXT IDENT STAPHYLOCOCCUS
            TALLY .7)
```

What are contexts?

- Contexts are types
  - Patient, Cultures, Organisms, Drugs…
  - Have attributes
  - So there are Object-attribute-value triples
    - (ORGANISM-1, STAIN, GRAMPOS)
- Contexts structure the data
- There is a context tree…

Context Tree
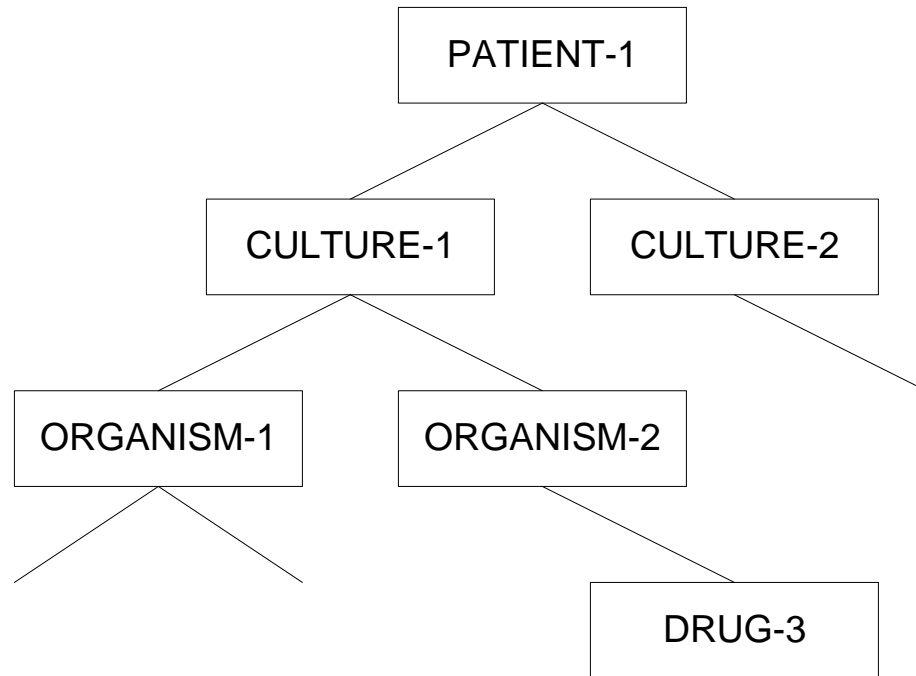
Clinical Parameters

- Attributes have types
- Example: STAIN, MORPH, IDENT …
- PROMPT1, …
- ASKABLE
- INFERRABLE
  - AGE is not inferrable
- LABDATA
  - ask first, infer if UNKNOWN

How does diagnosis work?

- Production rules
- **Backward chaining**
- Certainty factors

Backward chaining

- Start from the result:
  - Find a rule that produces that result, and attempt to prove
- Find an unknown, ask the user
- Use depth first to keep the questions on the same subject

Backward chain, depth-first …

- LOOKAHEAD
- Generalization
- Combination & CFs
- CF cutoff
- MAINPROPS
- Antecedent

- Self-reference
- Mapping
- Meta-rules
- Prefer certainty
- Cast out false

More on rules

- Common-sense rules
  - If Male, pregnancy (-1)

How does diagnosis work?

- Production rules
- Backward chaining
- **Certainty factors**

What are CFs?

- Nominally, "degree of belief in a hypothesis"
- The user's certainty of a fact
  - "The morphology is rod (8)"
    - 8 out of 10
    - In this case, it is more a fuzzy measure than a probability
    - "How rod-like is it?" vs. "How likely is it to be a rod?"
- The expert's certainty of the right hand side
  - "Then the organism is E. coli (.6)"
    - Range is −1 (No way) to +1 (definitely)

How are CF's used?

- A fuzzy measure or likelihood of inputs
- A likelihood of results
- During rule inference
- A measure of output validity

CF Math

- CF1 and CF2: min(CF1, CF2)
- CF1 or CF2: max(CF1, CF2)
- If …CF1 then…CF2: CF1* CF2
- CF1 in WS, update CF2:
  - Both positive? CF1+CF2 – CF1*CF2
  - Both negative? CF1+CF2 + CF1*CF2
  - Mixed? (CF1+CF2) / (1-min(|CF1|, |CF2|))

Are CF's a good idea?

- CF's are intuitive and efficient
- CF's are not mathematically sound
  - CF's are not probabilities
  - CF's can give inconsistent results
  - So some cases are counter-intuitive
- In practice, they work OK
  - Short chains of reasoning and careful rule creation
  - User's evaluations are not probabilities either!

The MYCIN gang's evaluations

- First 2 studies
  - Experts evaluated MYCIN transcripts
  - 75% approval
  - MYCIN gang disappointed
- Third study
  - Blind, clinical summary and outputs only
  - MYCIN better than experts
  - Experts only 50% agreement!!!

What followed?

- EMYCIN
  - PUFF, SACON, …
- TEIRESAS
- GUIDON

Some lessons learned

- Production rule systems can reason expertly (with tweaks)
- Backward chaining and asking questions works
- CFs work

Why did MYCIN fail?

- It succeeded wildly in research terms
- It failed main objective! Help real world.
  - Narrow – needed broader scope
  - Before its time
    - Required DEC-10 & LISP
    - Data access (networking)
  - Liability – who do you sue?
  - Usability
    - Too much time – too many questions
    - Can't direct it

Strengths

- Performed as well as experts.
- Led to a whole generation of expert systems.
- Dealt with uncertainty in a useful way.
- Explicitly dealt with usability issues, according them great importance from design on.
- Provided visibility into its reasoning.
- Structured data in a useful way.
- Attempted to really solve an important problem.

Weaknesses

- Ad hoc mechanism for uncertainty is inconsistent.

- Data structures and rule control too specific.

- Explanation mechanism not always helpful.

- Didn't give user enough control.

- Inability to update over time.

MYCIN

Questions?