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?
   ** BLOOD
   =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

Start

Patient Data → Consultation

Dynamic Data → Consultation

Consultation → Rules

Explanation

Rules → Aquisition

Aquisition

Exit
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

PATIENT-1

<table>
<thead>
<tr>
<th>CULTURE-1</th>
<th>CULTURE-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORGANISM-1</td>
<td>ORGANISM-2</td>
</tr>
<tr>
<td></td>
<td>DRUG-3</td>
</tr>
</tbody>
</table>
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: \( CF1 \times CF2 \)
• CF1 in WS, update CF2:
  – Both positive? \( CF1 + CF2 - CF1 \times CF2 \)
  – Both negative? \( CF1 + CF2 + CF1 \times CF2 \)
  – 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?