

Components of an Expert System

Decision Support via Expert Systems

6.872/HST950
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- Knowledge
 - In various forms: associations, models, etc.
- Strategy
 - Baconian, exhaustive enumeration, on-line, etc.
- Implementation
 - Programs, pattern matching, rules, etc.

Flowchart

BI/Lincoln Labs
Clinical Protocols
1978

U.T.I./ VAGINITIS PROTOCOL (12/73)

Unit#: _____ Date: _____

Name: _____

Birthdate: _____ Phone: _____

Provider: _____

Chief complaint(s)

yes no SUBJECTIVE

Vaginal discharge, unusual
Days duration _____

Vaginal/vulvar Itch/irritation
Days duration _____

Pain/burning on urination
Inside urethra _____
Outside on a raw area _____
Days duration _____

Unusually frequent urination
Days duration _____

Rx for any of above in past 3 mo
Age245 _____
Pregnant now _____
Diabetic _____
 New pain side/back/belly/pelvis
Severe _____

Any blue boxes checked
Gyn procedure in past 2 mo _____
Medic inserted into vagina
in past few days _____

Any grey boxes checked
Incontinence (prior to UTI Sx) _____
Vomiting/too nauseated to eat _____
Fever by Hx in past 48 hrs _____
Chills, teeth chatter _____
Hx of hospitalization for UT prob. _____
Kidney X-ray (IVP) _____
Bladder/kidney stones _____
Cystoscopy/In-dwelling catheter _____
High blood pressure _____
Had a UTI before age 12 _____
Past UTI's23 _____
Antibiotic taken in past 3 weeks _____

OBJECTIVE

Temperature2100 _____
 Systolic BP2160 or Diastolic295 _____
BP: _____

Any grey boxes checked
CVA tenderness _____

Do urinalysis and culture

Bact _____ WBC _____ RBC _____

25+ protein _____
 Any sugar _____
 Bact22+ or WBC220? **dx UTI** _____
210 RBC _____
 22+ protein _____

Any blue boxes checked
dx UTI _____

Any red boxes checked? **Consult MD** _____
dx UTI _____
dx UTI _____
Abnormalities-not discharge _____
Cervix painful on movement _____
Urethral/cervical discharge? _____
dx UTI _____

Any dx yet? _____
Any greys? **dx urethritis** _____

Any reds? **Consult MD** _____
Will consult MD for other reasons _____
PLAN (also see back of protocol)

Dx of trichomonas? **Rx Flagyl** _____
 Dx of nonitis? **Rx Mycostatin** _____
 Dx of non-specific vaginitis? _____
dx UTI _____
dx UTI _____
dx UTI _____

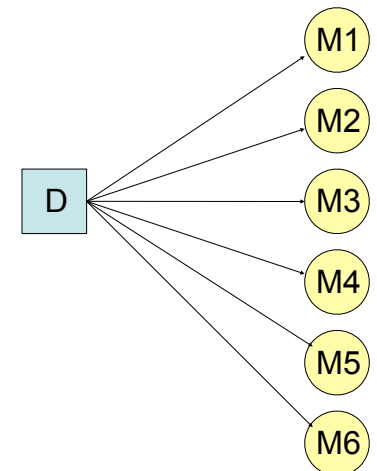
Dx of UTI/urethritis _____
 Dx of urethritis/vaginitis _____
Dysuria so bad pt can hardly urinate
frequency interfering with work
or sleep? **Rx as below but tell pt
to wait for culture result before
beginning med.** _____

Sulfa allergy? **Rx Sulfisoxazole** _____
dx UTI _____
dx UTI _____
dx UTI _____
dx UTI _____

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Institute of Technology, Cambridge, 1974 -- HSW Contract No. HSW 110-73-335.

Naïve Bayes

- Exhaustive and Mutually Exclusive disease hypotheses (1 and only 1)
- Conditionally independent observables (manifestations)
- $P(D_i)$, $P(M_{ij}|D_i)$



Codifying Human Knowledge

- Decomposition into “chunks” of knowledge, chaining of inferences
- Matching of case data to prototypical situations
- Using causal models (pathophysiology) to figure out cases

Mycin—Rule-based Systems

- **Task: Diagnosis and prescription for bacterial infections of the blood (and later meningitis)**

- **Method:**
 - **Collection of modular rules**
 - **Backward chaining**
 - **Certainty factors**

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RULE037
IF the organism
  1) stains grampos
  2) has coccus
  shape
  3) grows in chains

THEN
  There is suggestive
  evidence (.7) that the
  identity of the
  organism is
  streptococcus.
    
```

Mycin consult

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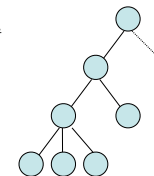
-----PATIENT-1-----
1) Patient's name: FRED SMITH
2) Sex: MALE
3) Age: 55
4) Have you been able to obtain positive cultures from a site at which Fred
   Smith has an infection? YES
-----INFECTION-1-----
5) What is the infection? PRIMARY-BACTEREMIA
6) Please give the date when signs of INFECTION-1 appeared. 5/5/75
   The most recent positive culture associated with the primary-
   bacteremia will be referred to as:
-----CULTURE-1-----
7) From what site was the specimen for CULTURE-1 taken? BLOOD
8) Please give the date when this culture was obtained. 5/9/75
   The first significant organism from this blood culture will be called:
-----ORGANISM-1-----
9) Enter the identity of ORGANISM-1. UNKNOWN
10) Is ORGANISM-1 a rod or coccus (etc.)? ROD
11) The gram stain of ORGANISM-1: GRAMNEG
...
    
```

Davis, et al., *Artificial Intelligence* 8: 15-45 (1977)

How Mycin Works

- To find out a fact
 - If there are rules that can conclude it, try them
 - Ask the user
- To “run” a rule
 - Try to find out if the facts in the premises are true
 - If they all are, then assert the conclusion(s), with a suitable certainty
- Backward chaining from goal to given facts

- ▲ *Dynamically traces out behavior of (what might be) a flowchart*
 - ▲ *Information used everywhere appropriate*
 - ▲ *Single expression of any piece of knowledge*



Explore Mycin's Use of Knowledge

**** Did you use RULE 163 to find out anything about ORGANISM-1?**

RULE163 was tried in the context of ORGANISM-1, but it failed because it is not true that the patient has had a genito-urinary tract manipulative procedure (clause 3).

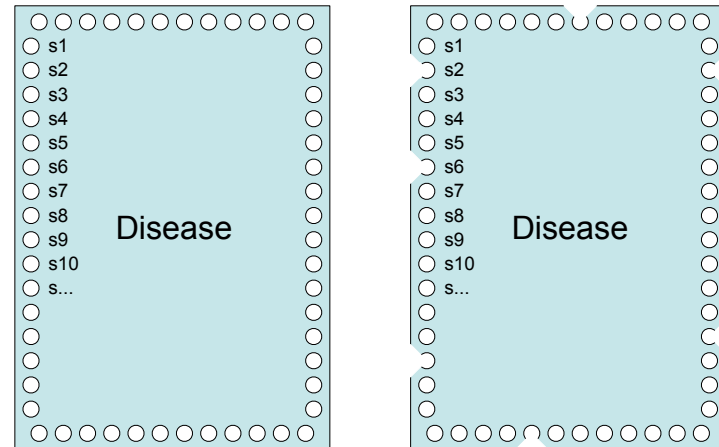
**** Why didn't you consider streptococcus as a possibility?**

The following rule could have been used to determine that the identity of ORGANISM-1 was streptococcus: RULE033

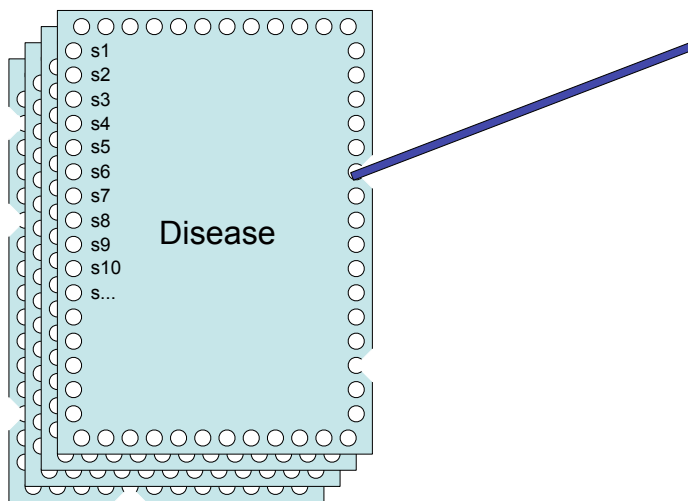
But clause 2 ("the morphology of the organism is coccus") was already known to be false for ORGANISM-1, so the rule was never tried.

Davis, *et al.*, *Artificial Intelligence* 8: 15-45 (1977)

Even Simpler Representation



Diagnosis by Card Selection



Diagnosis by Edge-Punched Cards

- Dx is intersection of sets of diseases that *may cause* all the observed symptoms
- Difficulties:
 - Uncertainty
 - Multiple diseases
- ~ "Problem-Knowledge Coupler" of Weed