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VO 709.049 Medical Informatics
14.12.2016 11:15-12:45



Lecture 08 Decision Making under Uncertainty: Decision Support Systems

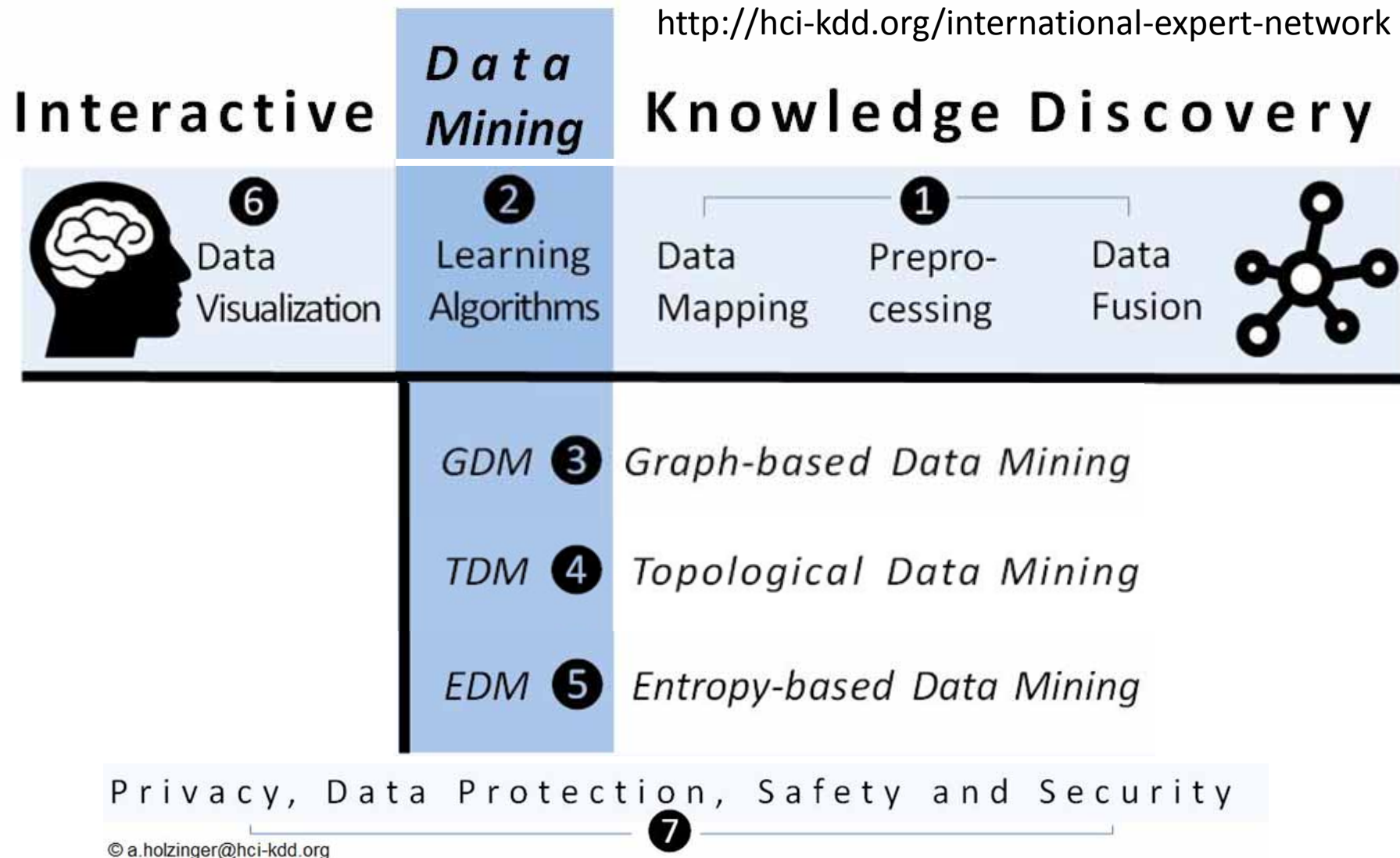
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<http://hci-kdd.org/biomedical-informatics-big-data>



<http://hci-kdd.org/international-expert-network>



Holzinger, A. 2014. Trends in Interactive Knowledge Discovery for Personalized Medicine: **Cognitive Science meets Machine Learning**. IEEE Intelligent Informatics Bulletin, 15, (1), 6-14.

- Artificial intelligence
- Case based reasoning
- Computational methods in cancer detection
- Cybernetic approaches for diagnostics
- Decision support models
- Decision support system (DSS)
- Fuzzy sets
- MYCIN
- Reasoning under uncertainty
- Radiotherapy planning

- **Case-based reasoning (CBR)** = process of solving new problems based on the solutions of similar past problems;
- **Certainty factor model (CF)** = a method for managing uncertainty in rule-based systems;
- **CLARION** = Connectionist Learning with Adaptive Rule Induction ON-line (CLARION) is a cognitive architecture that incorporates the distinction between implicit and explicit processes and focuses on capturing the interaction between these two types of processes. By focusing on this distinction, CLARION has been used to simulate several tasks in cognitive psychology and social psychology. CLARION has also been used to implement intelligent systems in artificial intelligence applications.
- **Clinical decision support (CDS)** = process for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve health delivery;
- **Clinical Decision Support System (CDSS)** = expert system that provides support to certain reasoning tasks, in the context of a clinical decision;
- **Collective Intelligence** = shared group (symbolic) intelligence, emerging from cooperation/competition of many individuals, e.g. for consensus decision making;
- **Crowdsourcing** = a combination of "crowd" and "outsourcing" coined by Jeff Howe (2006), and describes a distributed problem-solving model; example for crowdsourcing is a public software beta-test;

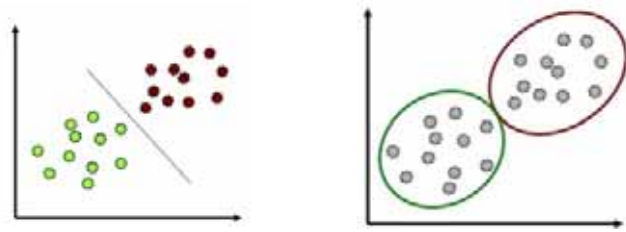
- **Decision Making** = central cognitive process in every medical activity, resulting in the selection of a final choice of action out of several alternatives;
- **Decision Support System (DSS)** = is an IS including knowledge based systems to interactively support decision-making activities, i.e. making data useful;
- **DXplain** = a DSS from the Harvard Medical School, to assist making a diagnosis (clinical consultation), and also as an instructional instrument (education); provides a description of diseases, etiology, pathology, prognosis and up to 10 references for each disease;
- **Expert-System** = emulates the decision making processes of a human expert to solve complex problems;
- **GAMUTS** in Radiology = Computer-Supported list of common/uncommon differential diagnoses;
- **ILIAD** = medical expert system, developed by the University of Utah, used as a teaching and testing tool for medical students in problem solving. Fields include Pediatrics, Internal Medicine, Oncology, Infectious Diseases, Gynecology, Pulmonology etc.
- **MYCIN** = one of the early medical expert systems (Shortliffe (1970), Stanford) to identify bacteria causing severe infections, such as bacteremia and meningitis, and to recommend antibiotics, with the dosage adjusted for patient's body weight;
- **Reasoning** = cognitive (thought) processes involved in making medical decisions (clinical reasoning, medical problem solving, diagnostic reasoning);

- ... can apply your knowledge gained in the previous lectures to example systems of decision support;
- ... have an overview about the core principles and architecture of decision support systems;
- ... are familiar with the certainty factors as e.g. used in MYCIN;
- ... are aware of some design principles of DSS;
- ... have seen similarities between DSS and KDD on the example of computational methods in cancer detection;
- ... have seen basics of CBR systems;

- **00 Reflection – follow-up from last lecture**
- **01 Decision Support Systems (DSS)**
- **02 History of DSS = History of AI**
- **03 Development of DSS**
- **04 Further Practical Examples**
- **05 Towards Precision Medicine (P4)**
- **06 Case Based Reasoning (CBR)**

A golden scroll with a panda face and the text "00 Reflection". The scroll is held by two black hands. The panda face is a simple, stylized drawing with large eyes and a small mouth. The text "00 Reflection" is written in a large, white, sans-serif font across the center of the scroll. The scroll has a decorative border with a repeating geometric pattern.

00 Reflection



1

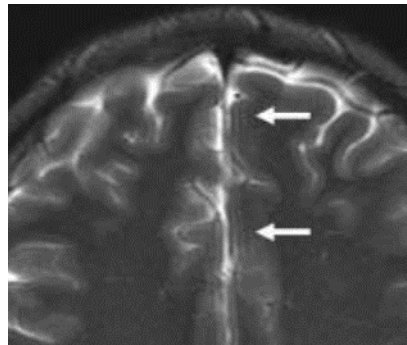
$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_N \end{bmatrix} \rightarrow \begin{bmatrix} x_{i_1} \\ x_{i_2} \\ \vdots \\ x_{i_M} \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_N \end{bmatrix} \rightarrow \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_M \end{bmatrix} = f \left(\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_N \end{bmatrix} \right)$$

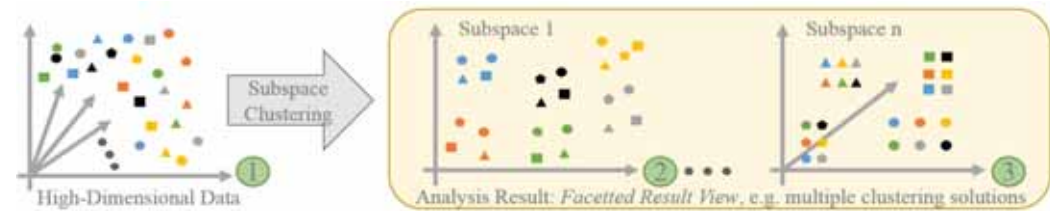
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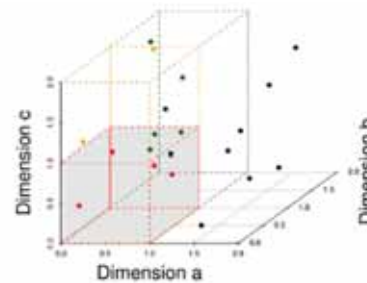
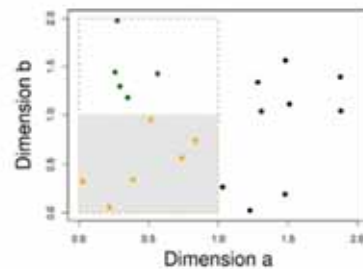
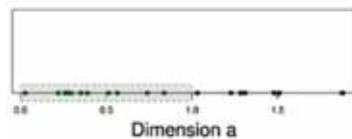
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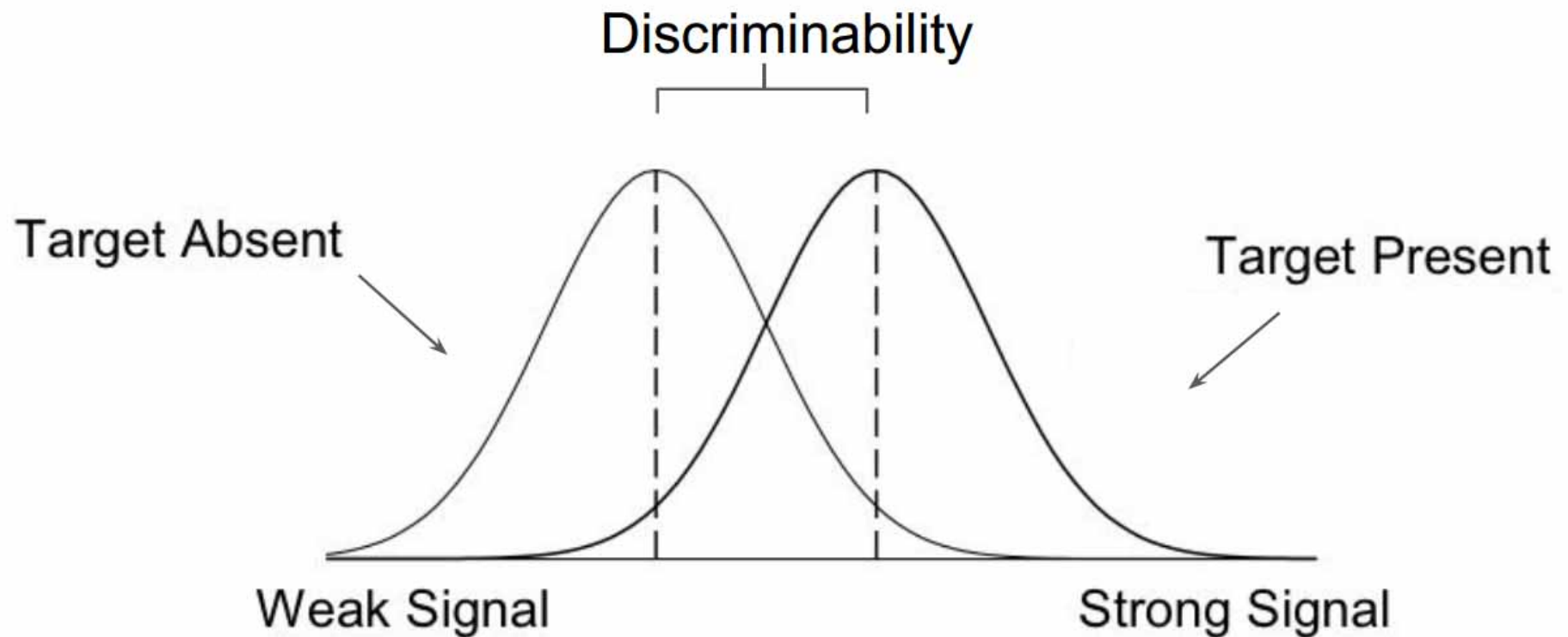
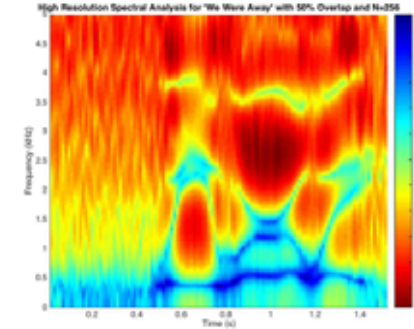
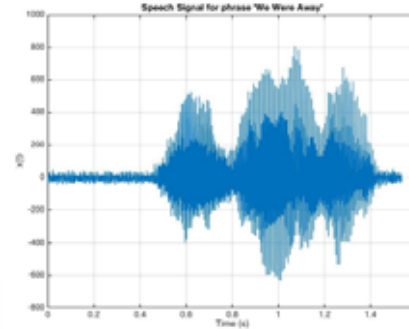
True State

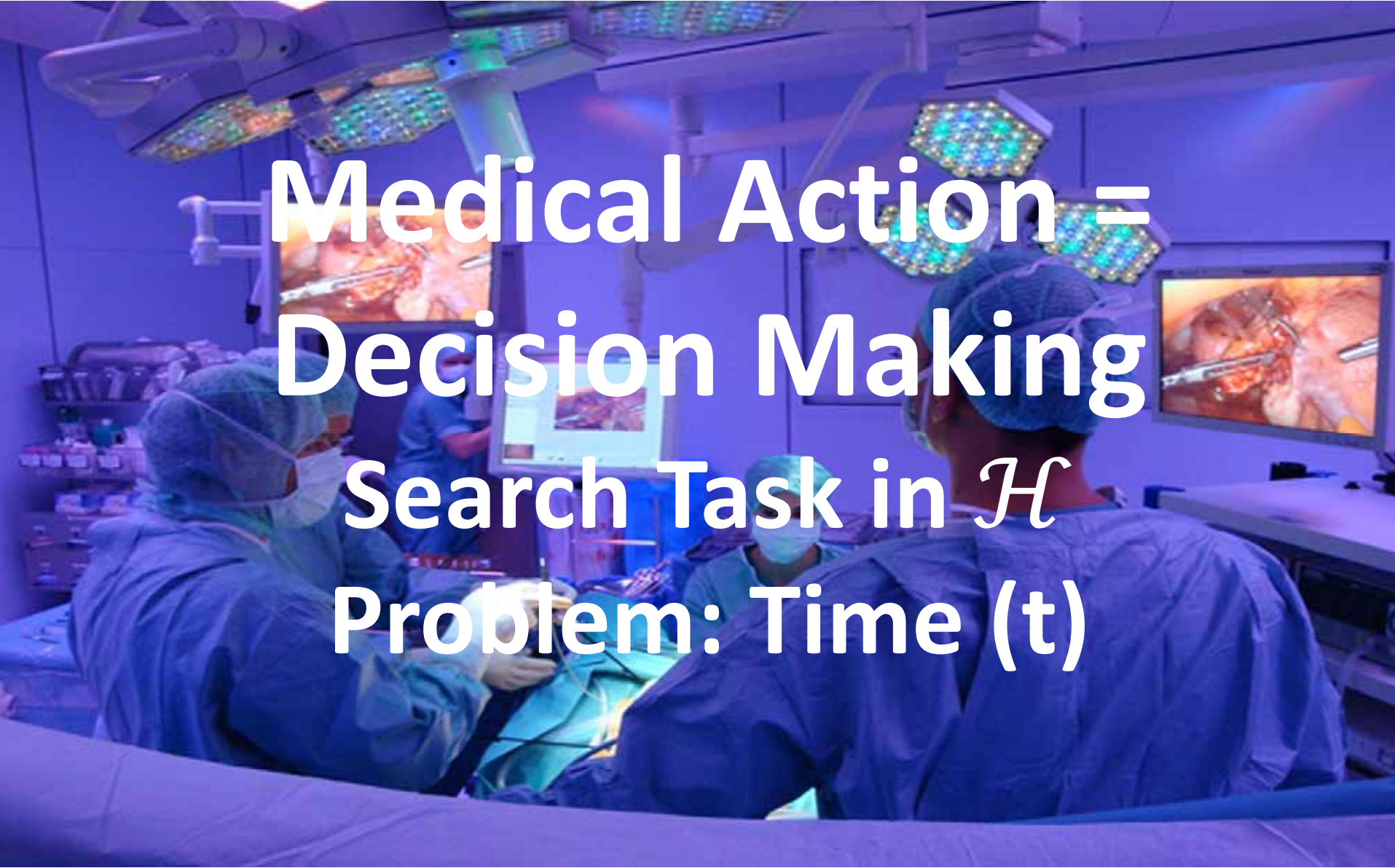
Diagnostic Decision

	Diagnostic Decision	
	Present	Absent
Present	Hit	Miss
Absent	False Alarm	Correct Rejection

7

Swets, J. A. 1961. Detection theory and psychophysics: a review. Psychometrika, 26, (1), 49-63, doi:10.1007/BF02289684.





Medical Action =
Decision Making
Search Task in \mathcal{H}
Problem: Time (t)

01 Decision Support Systems

- 400 BC Hippocrates (460-370 BC), father of western medicine:
 - A medical record should accurately reflect the course of a disease
 - A medical record should indicate the probable cause of a disease
- 1890 William Osler (1849-1919), father of modern western medicine
 - **Medicine is a science of uncertainty and an art of probabilistic decision making**
- Today
 - Prediction models are based on data features, patients are modelled as high-dimensional feature vectors ...

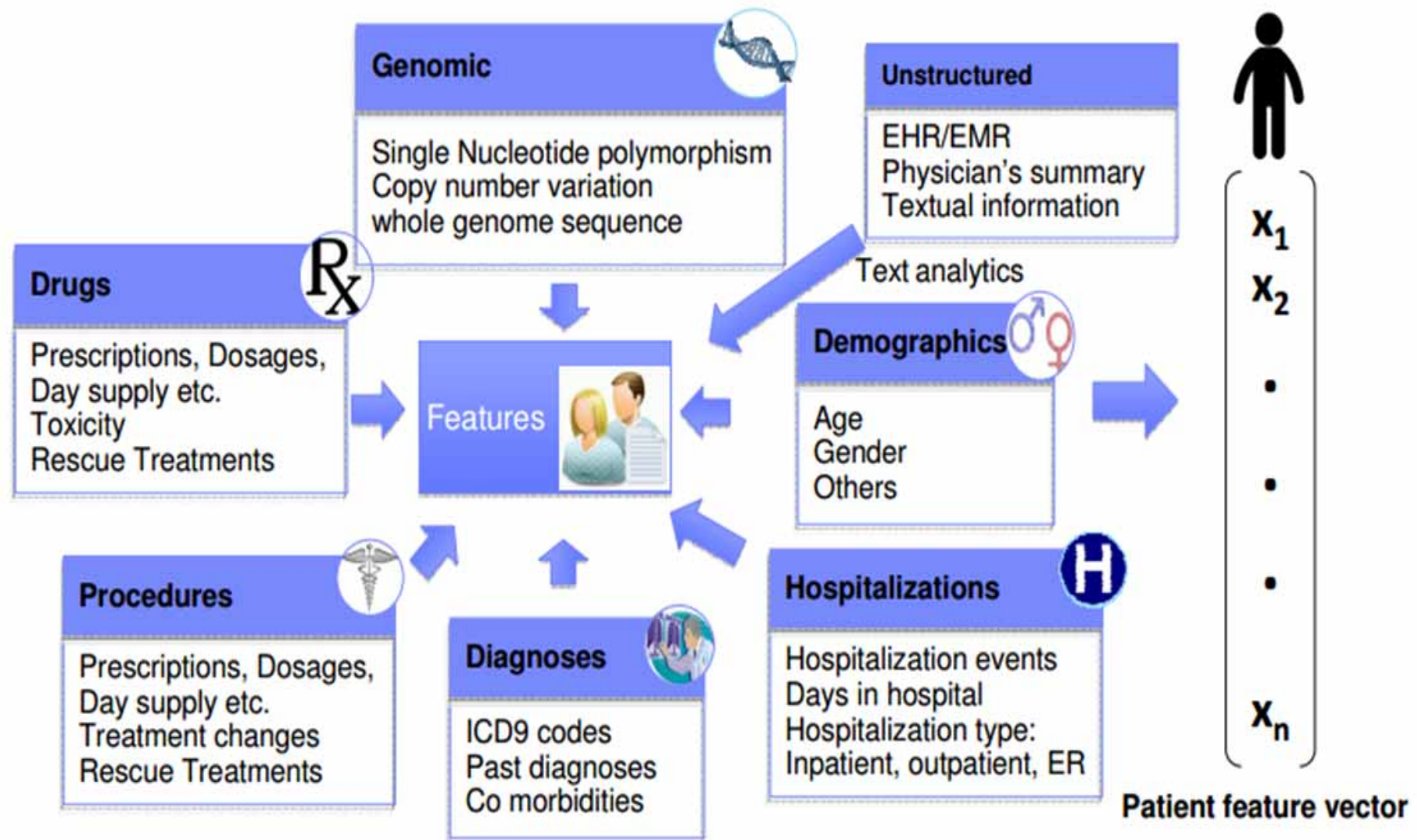


Image credit to Michal Rosen-Zvi

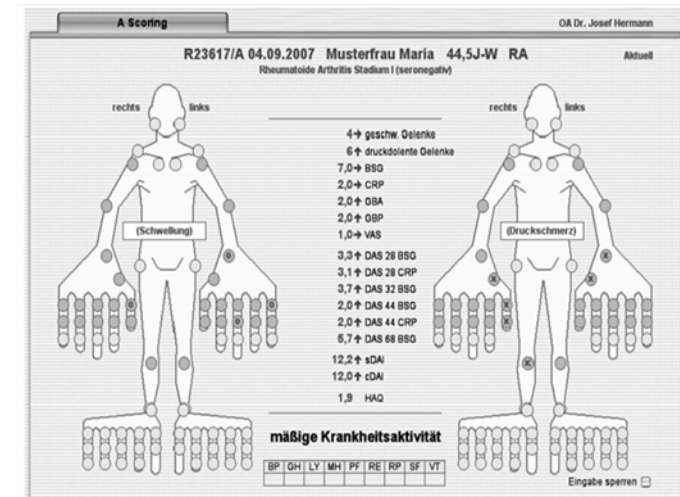
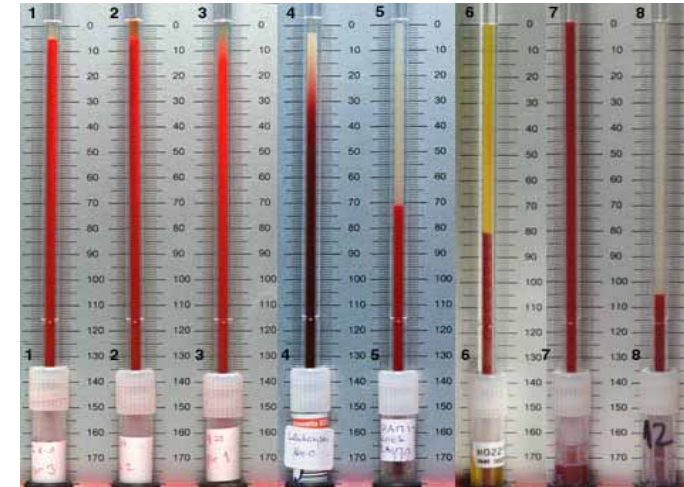


Chao, J., Parker, B. A. & Zvaifler, N. J. (2009) Accelerated Cutaneous Nodulosis Associated with Aromatase Inhibitor Therapy in a Patient with Rheumatoid Arthritis. *The Journal of Rheumatology*, 36, 5, **1087-1088**.



Ikari, K. & Momohara, S. (2005) Bone Changes in Rheumatoid Arthritis.
New England Journal of Medicine, 353, **15**, **e13**.

- 50+ Patients per day ~ 5000 data points per day ...
- Aggregated with specific scores (Disease Activity Score, DAS)
- Current patient status is related to previous data
- = convolution over time
- **⇒ time-series data**



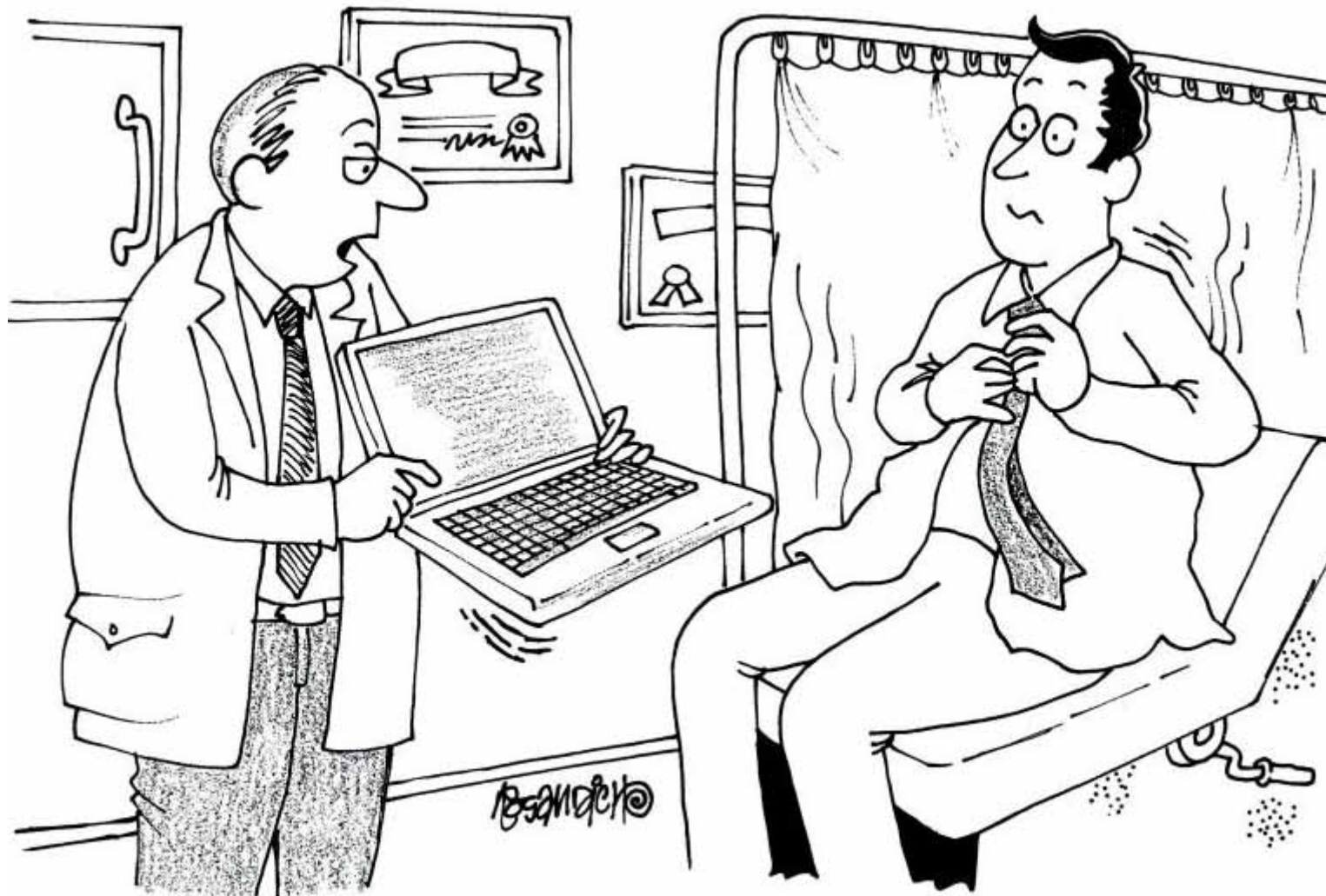
Simonic, K. M., Holzinger, A., Bloice, M. & Hermann, J. (2011). *Optimizing Long-Term Treatment of Rheumatoid Arthritis with Systematic Documentation*. *Pervasive Health - 5th International Conference on Pervasive Computing Technologies for Healthcare, Dublin, IEEE*, 550-554.

Can Computers help doctors to make better decisions?





- Medicine is an extremely complex application domain – dealing most of the time with probable information!
- Some challenges include:
- (a) defining general system architectures in terms of generic tasks such as diagnosis, therapy planning and monitoring to be executed for (b) medical reasoning in (a);
- (c) patient management with (d) minimum uncertainty.
- Other challenges include: (e) knowledge acquisition and encoding, (f) human-computer interface and interaction; and (g) system integration into existing clinical environments, e.g. the enterprise hospital information system; to mention only a few.



"If you want a second opinion, I'll ask my computer."

<http://biomedicalcomputationreview.org/content/clinical-decision-support-providing-quality-healthcare-help-computer>

- **Type 1 Decisions:** related to the diagnosis, i.e. computers are used to assist in diagnosing a disease on the basis of the individual patient data. Questions include:
 - What is the probability that this patient has a myocardial infarction on the basis of given data (patient history, ECG, ...)?
 - What is the probability that this patient has acute appendices, given the signs and symptoms concerning abdominal pain?

- **Type 2 Decisions:** related to therapy, i.e. computers are used to select the best therapy on the basis of clinical evidence, e.g.:
 - What is the best therapy for patients of age x and risks y , if an obstruction of more than z % is seen in the left coronary artery?
 - What amount of insulin should be prescribed for a patient during the next 5 days, given the blood sugar levels and the amount of insulin taken during the recent weeks?

Bemmel, J. H. V. & Musen, M. A. 1997. *Handbook of Medical Informatics*, Heidelberg, Springer.



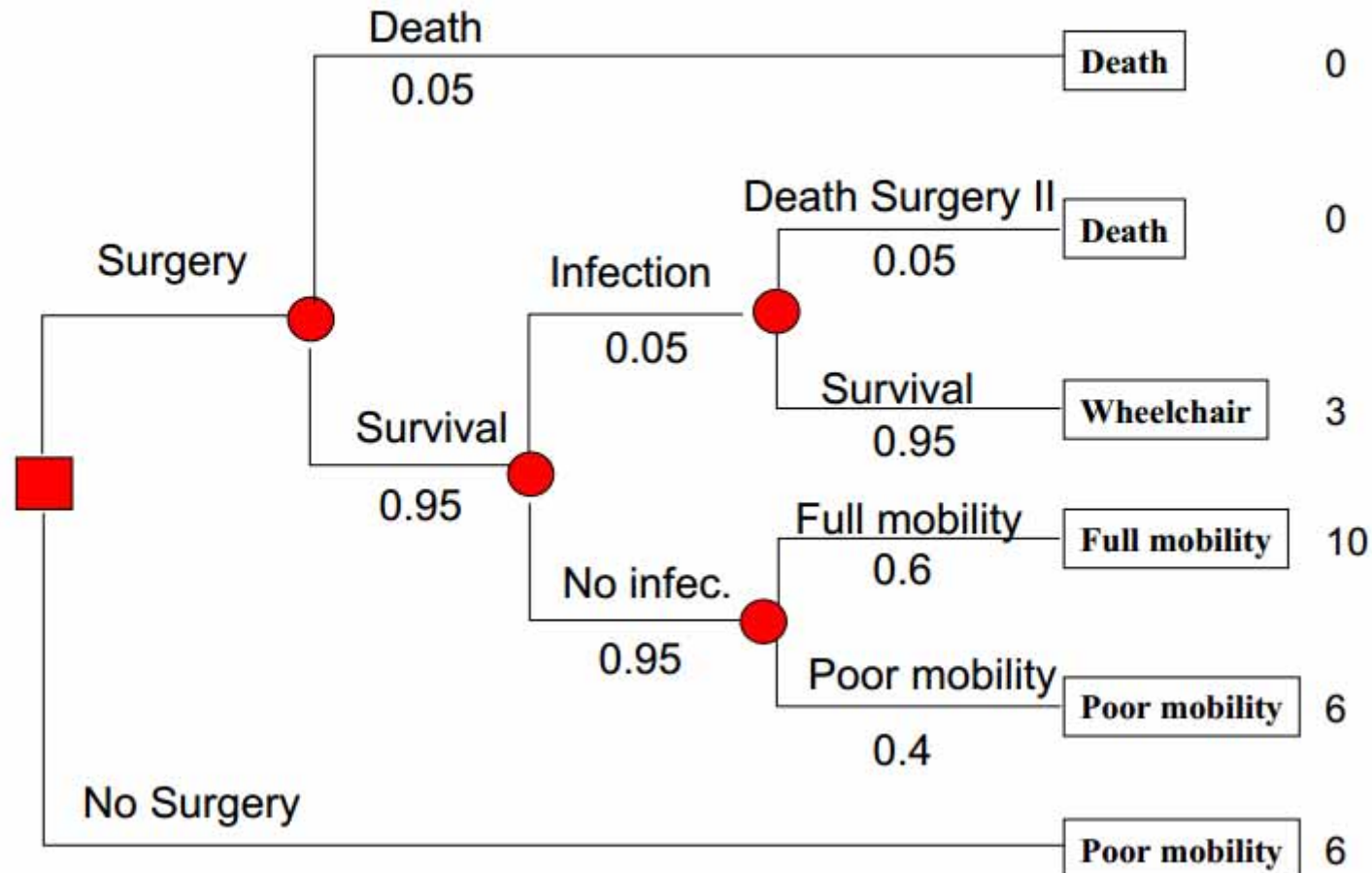
- Example of a Decision Problem
- Soccer player considering knee surgery
- Uncertainties:
- Success: recovering full mobility
- Risks: infection in surgery (if so, needs another surgery and may lose more mobility)
- Survival chances of surgery

Harvard-MIT Division of Health Sciences and Technology

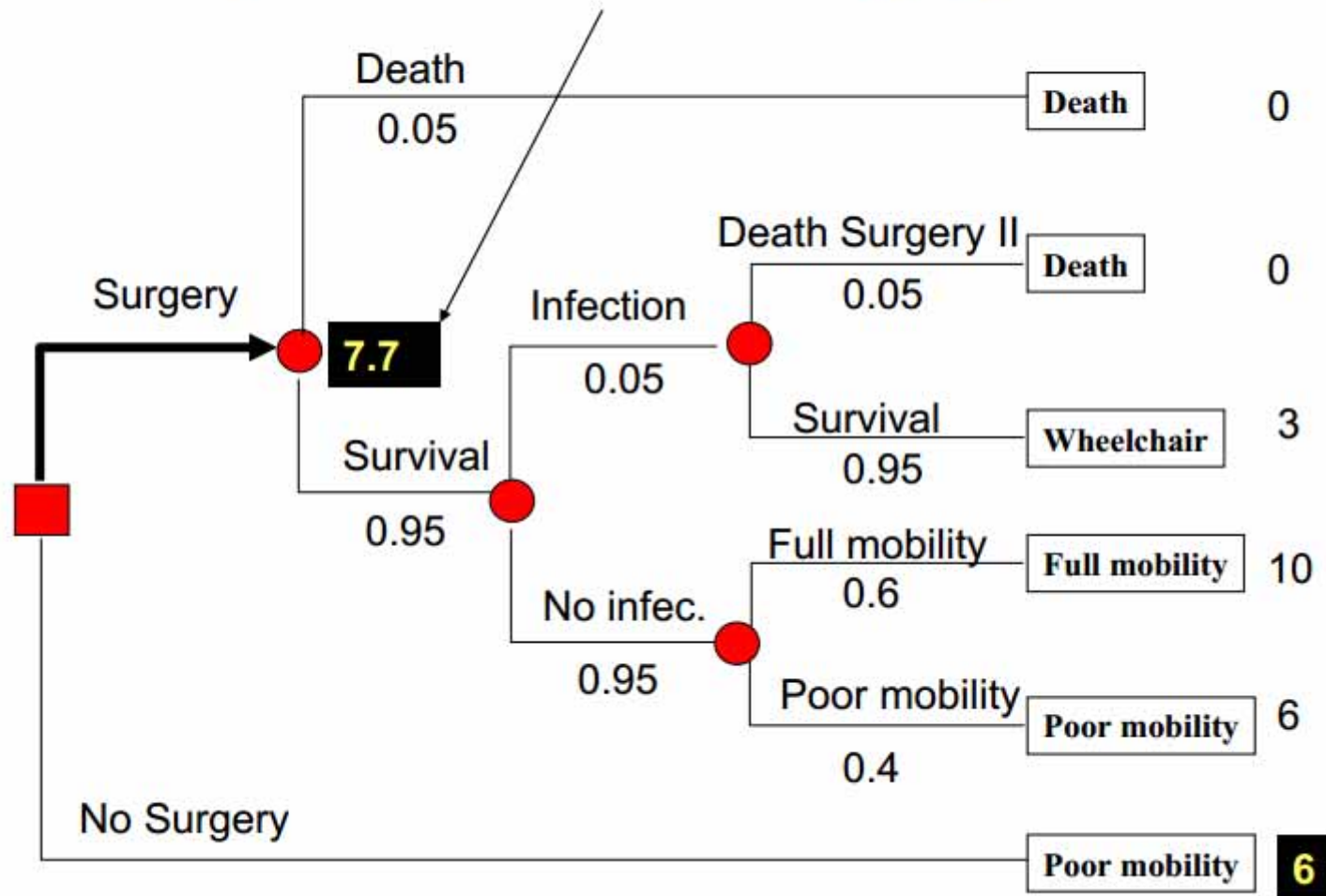
HST.951J: Medical Decision Support, Fall 2005

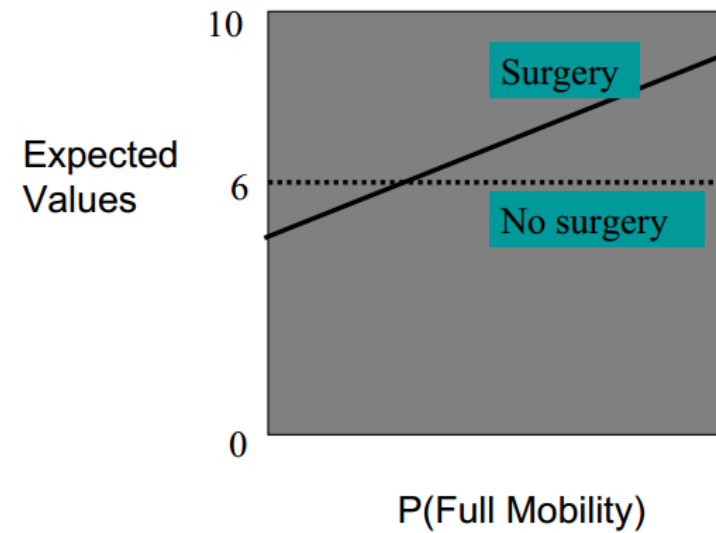
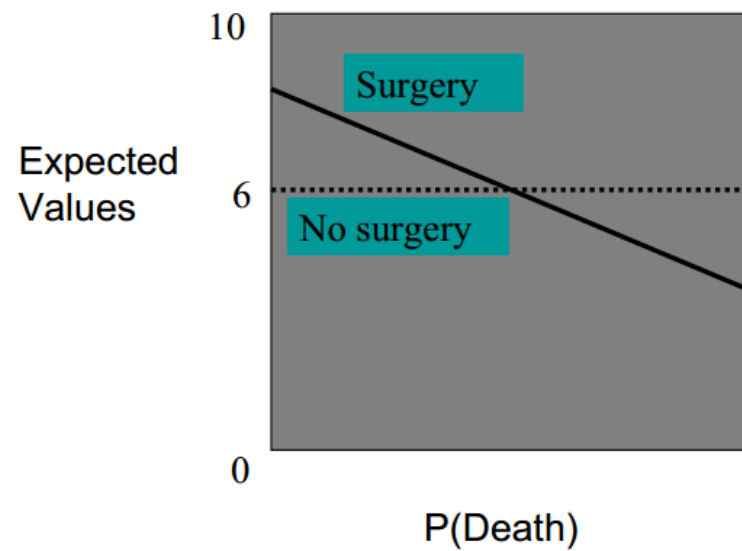
Instructors: Professor Lucila Ohno-Machado and Professor Staal Vinterbo

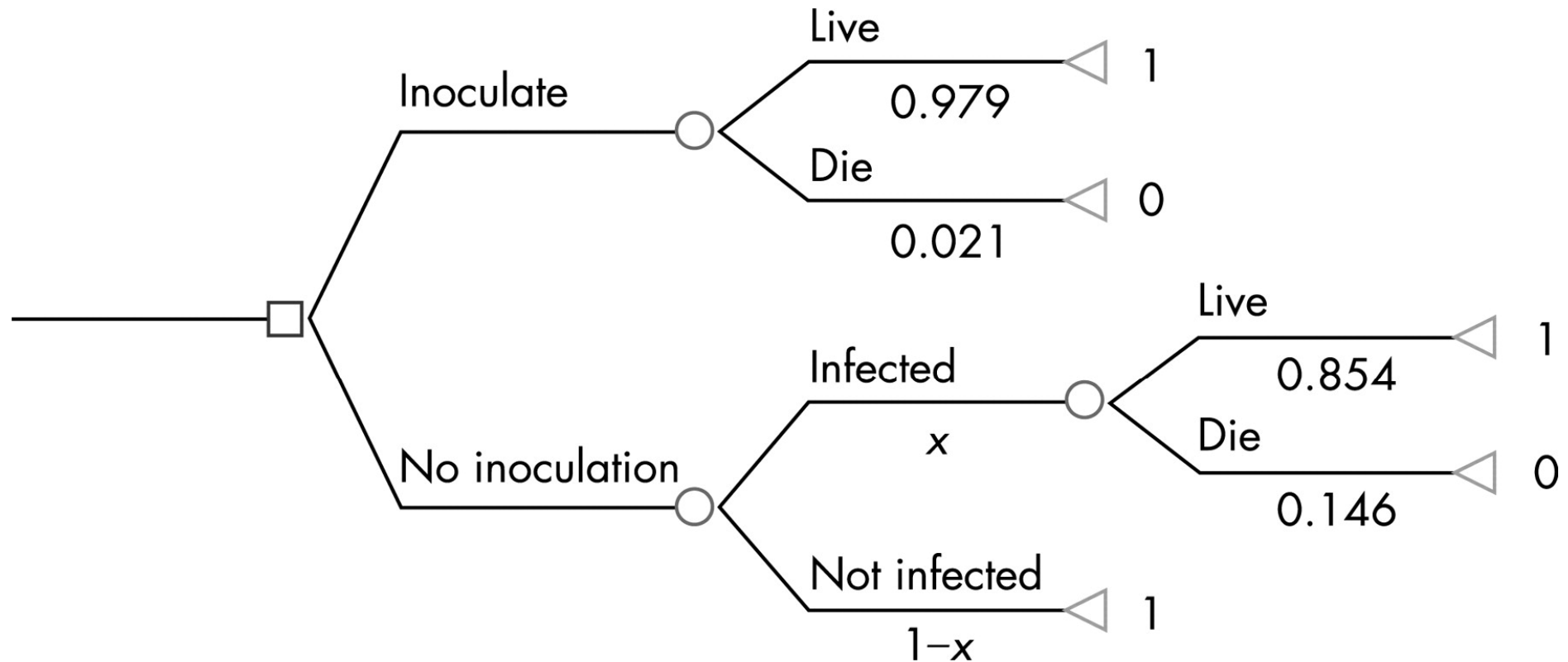
Knee Surgery



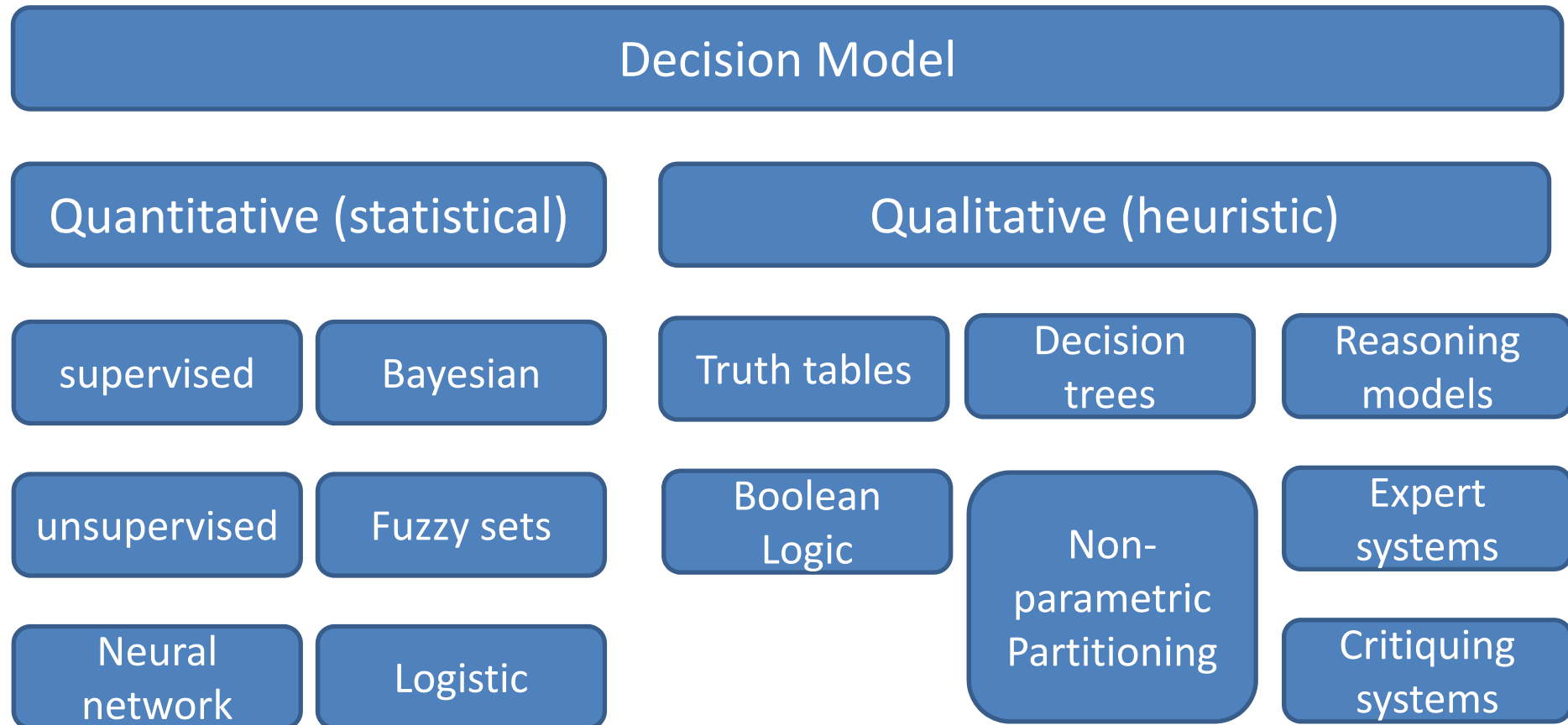
Expected Value of Surgery







Ferrando, A., Pagano, E., Scaglione, L., Petrinco, M., Gregori, D. & Ciccone, G. (2009) A decision-tree model to estimate the impact on cost-effectiveness of a venous thromboembolism prophylaxis guideline. *Quality and Safety in Health Care*, 18, 4, 309-313.



Bemmel, J. H. v. & Musen, M. A. (1997) *Handbook of Medical Informatics*. Heidelberg, Springer.

02 History of DSS = History of AI



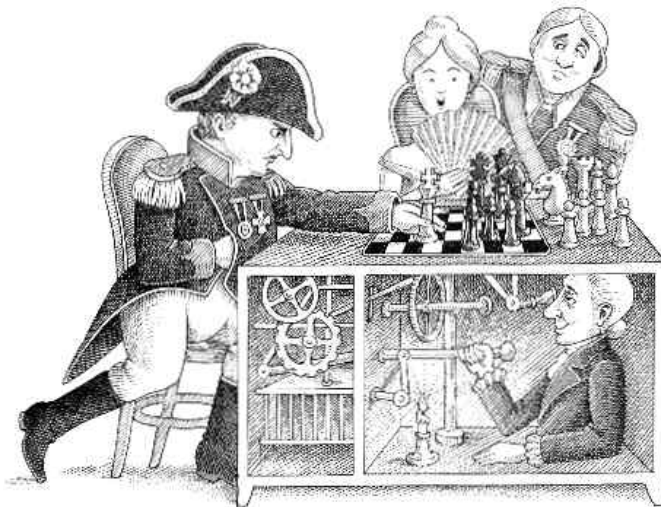
Stanford Heuristic Programming Project
Memo HPP-78-1

February 1978

Computer Science Department
Report No. STAN-CS-78-649

E. Feigenbaum, J. Lederberg, B. Buchanan, E. Shortliffe

Rheingold, H. (1985) *Tools for thought: the history and future of mind-expanding technology*. New York, Simon & Schuster.



DENDRAL AND META-DENDRAL:
THEIR APPLICATIONS DIMENSION

by

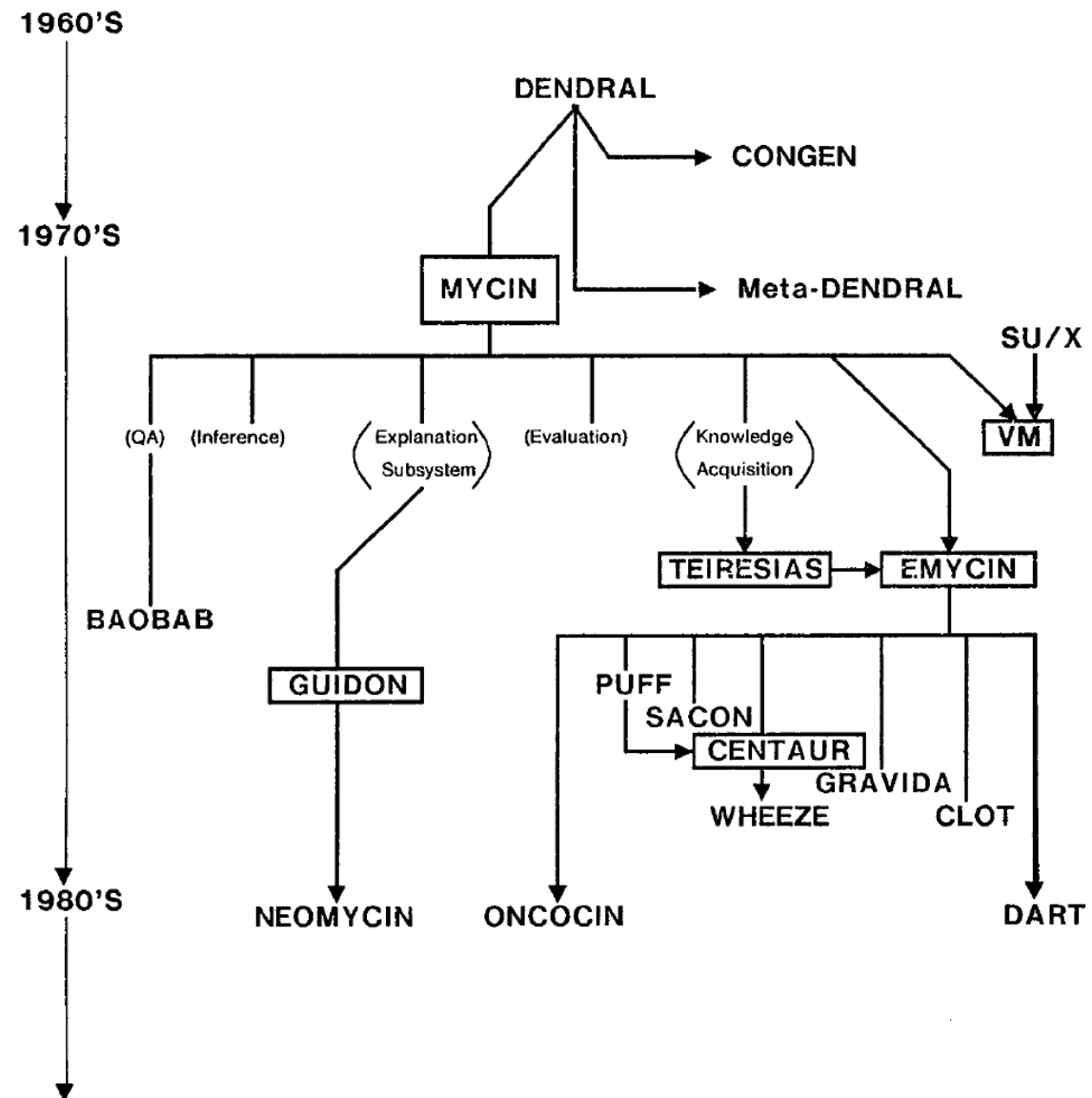
Bruce G. Buchanan and Edward A. Feigenbaum

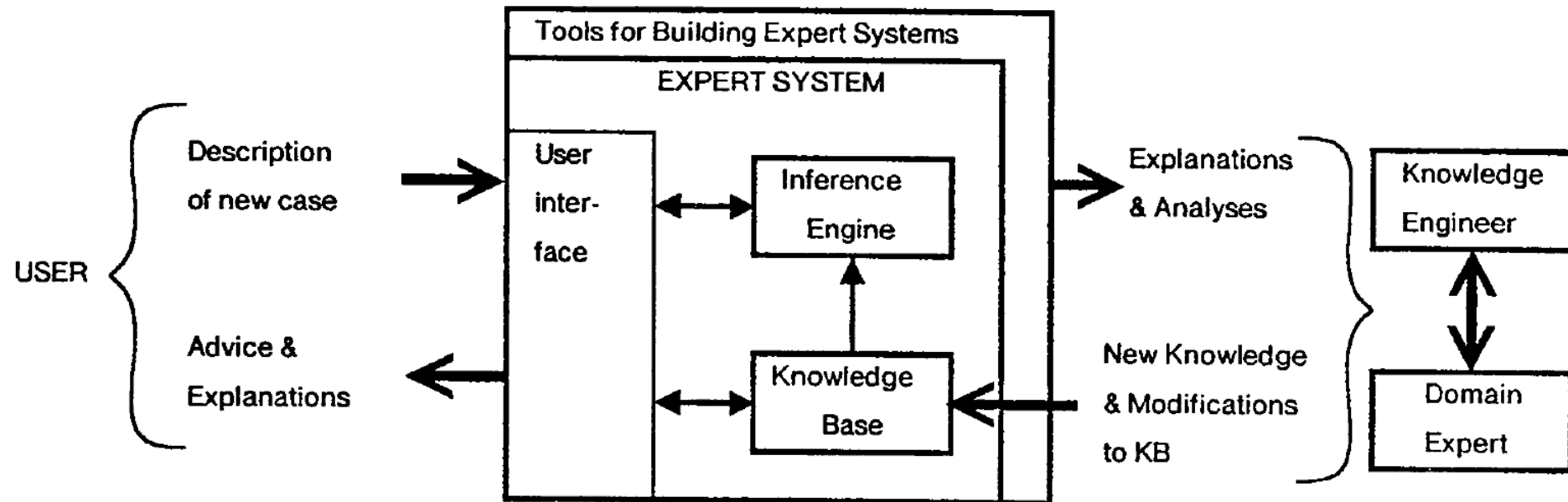
COMPUTER SCIENCE DEPARTMENT
School of Humanities and Sciences
STANFORD UNIVERSITY



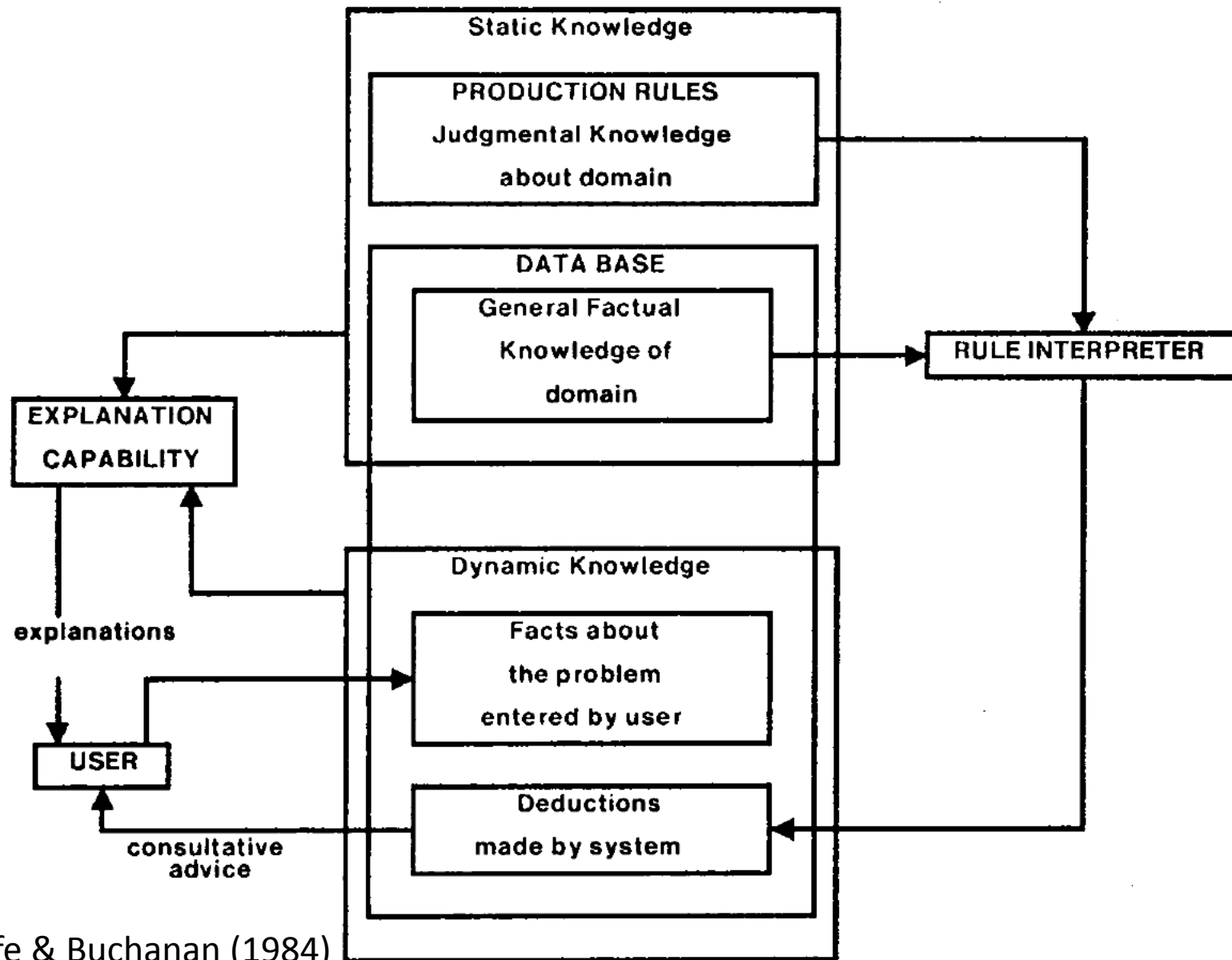
Buchanan, B. G. & Feigenbaum, E. A. (1978) DENDRAL and META-DENDRAL: their applications domain. *Artificial Intelligence*, 11, 1978, 5-24.

Shortliffe, E. H. &
Buchanan, B. G. (1984)
*Rule-based expert
systems: the MYCIN
experiments of the
Stanford Heuristic
Programming Project.*
Addison-Wesley.





Shortliffe, T. & Davis, R. (1975) Some considerations for the implementation of knowledge-based expert systems *ACM SIGART Bulletin*, 55, 9-12.



Shortliffe & Buchanan (1984)

- The information available to humans is often imperfect – imprecise - uncertain.
- This is especially in the medical domain the case.
- An **human agent** can cope with deficiencies.
- Classical logic permits only **exact reasoning**:
- IF A is true THEN A is non-false and
IF B is false THEN B is non-true
- Most real-world problems do not provide this exact information, mostly it is inexact, incomplete, uncertain and/or **un-measurable!**

Harcourt Fenton Mudd: Now listen, Spock, you may be a wonderful science officer but, believe me, you couldn't sell fake patents to your mother!

Spock: I fail to understand why I should care to induce my mother to purchase falsified patents.



- MYCIN is a rule-based Expert System, which is used for therapy planning for patients with bacterial infections
- Goal oriented strategy (“Rückwärtsverkettung”)
- To every rule and every entry a certainty factor (CF) is assigned, which is between 0 und 1
- Two measures are derived:
 - MB: measure of belief
 - MD: measure of disbelief
- Certainty factor – CF of an element is calculated by:
$$CF[h] = MB[h] - MD[h]$$
- CF is positive, if more evidence is given for a hypothesis, otherwise CF is negative
- $CF[h] = +1 \rightarrow h$ is 100 % true
- $CF[h] = -1 \rightarrow h$ is 100% false

h_1 = The identity of ORGANISM-1 is streptococcus

h_2 = PATIENT-1 is febrile

h_3 = The name of PATIENT-1 is John Jones

$CF[h_1, E] = .8$: There is strongly suggestive evidence (.8) that the identity of ORGANISM-1 is streptococcus

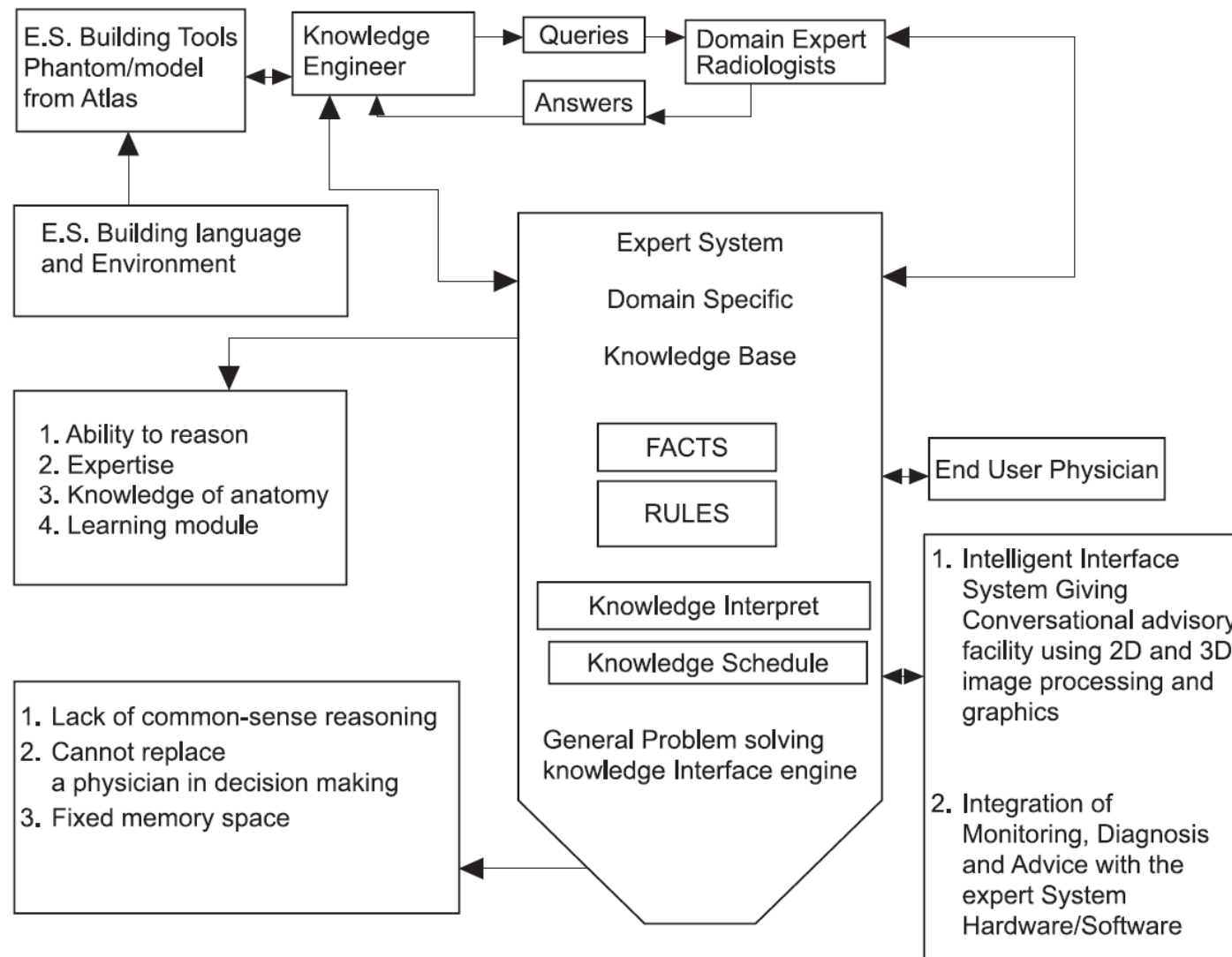
$CF[h_2, E] = -.3$: There is weakly suggestive evidence (.3) that PATIENT-1 is not febrile

$CF[h_3, E] = +1$: It is definite (1) that the name of PATIENT-1 is John Jones

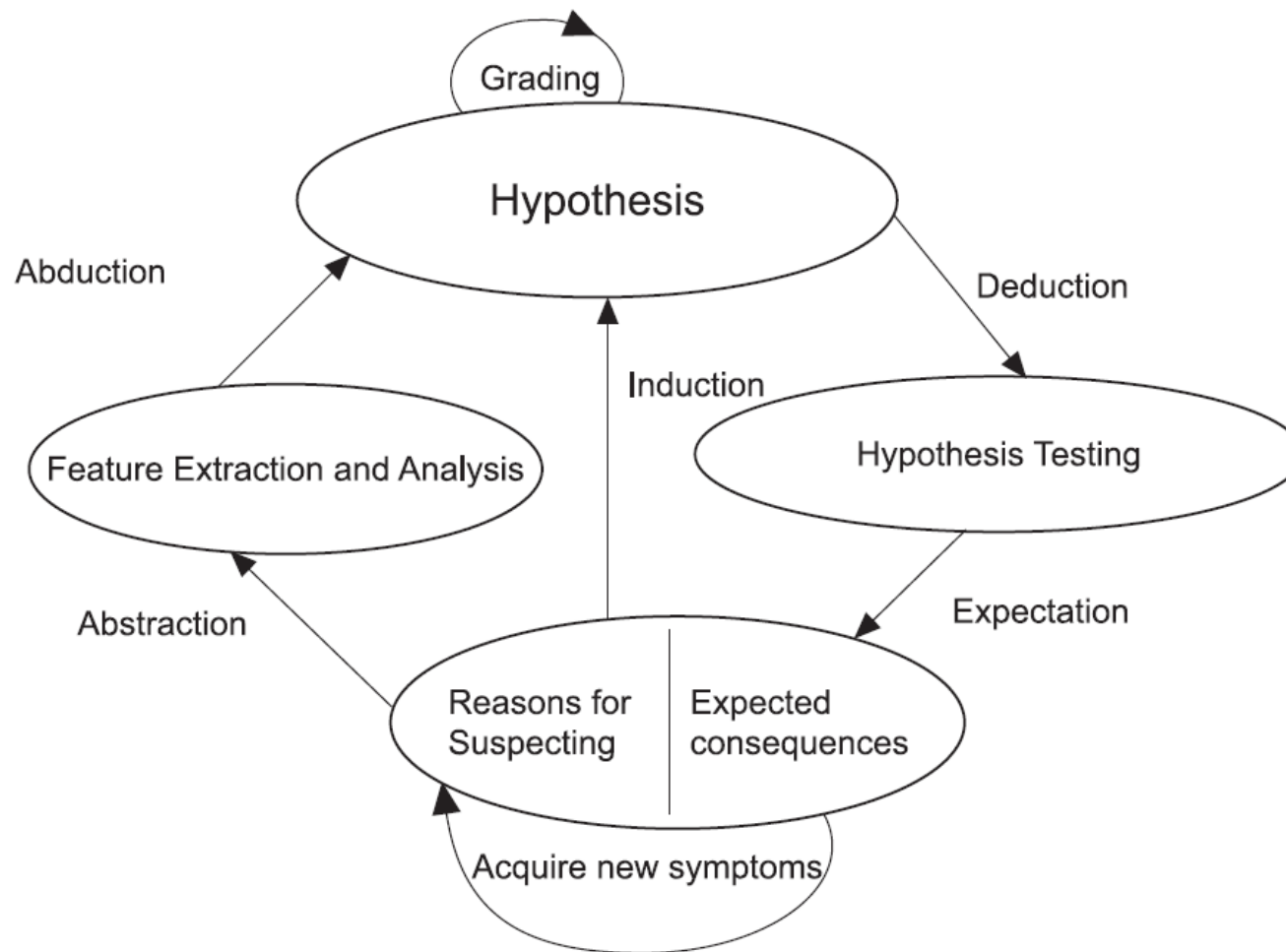
Shortliffe, E. H. & Buchanan, B. G. (1984) *Rule-based expert systems: the MYCIN experiments of the Stanford Heuristic Programming Project*. Addison-Wesley.



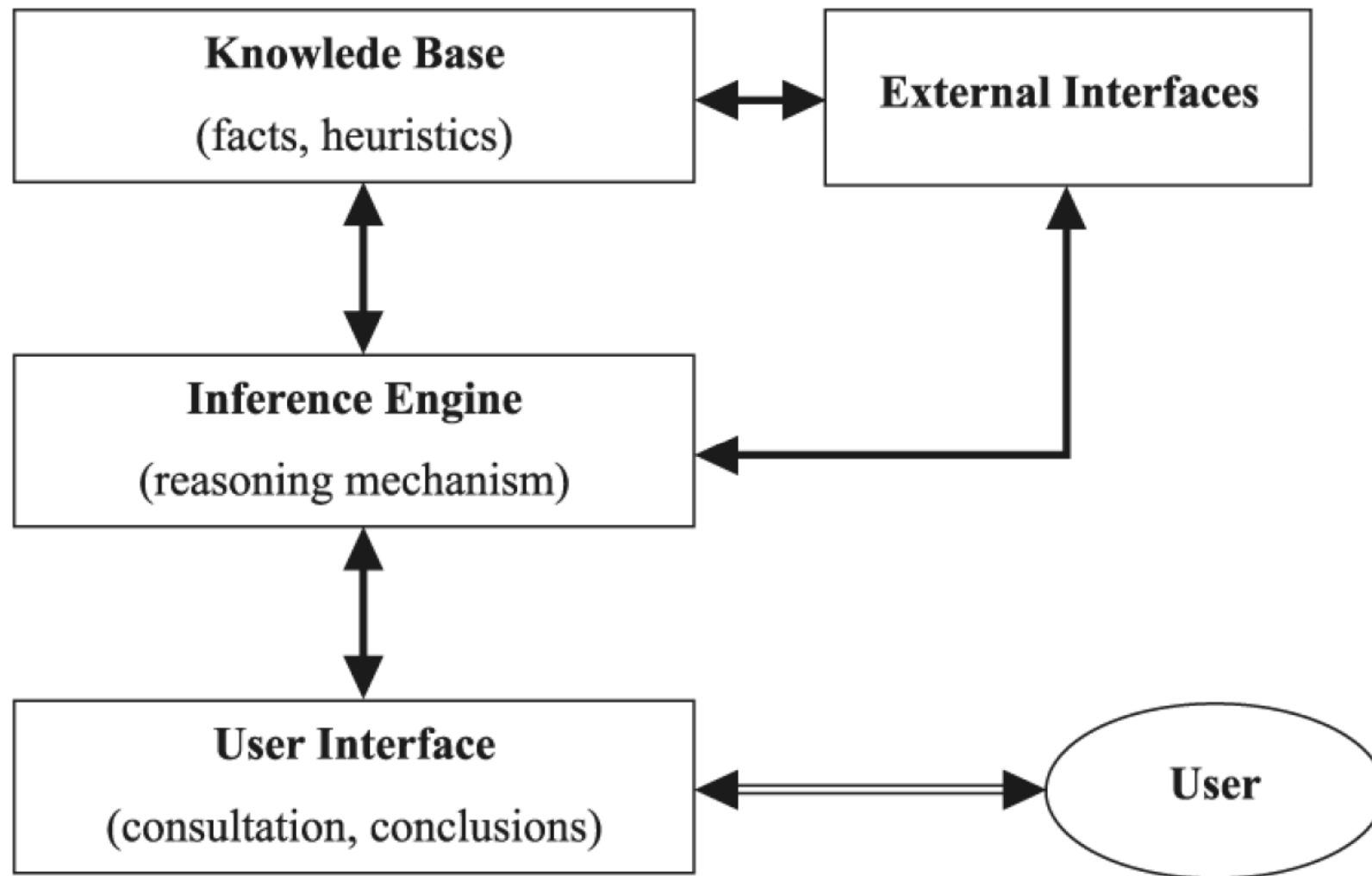
03 Development of Decision Support Systems



Majumder, D. D. & Bhattacharya, M. (2000) Cybernetic approach to medical technology: application to cancer screening and other diagnostics. *Kybernetes*, 29, 7/8, 871-895.



Majumder, D. D. & Bhattacharya, M. (2000) Cybernetic approach to medical technology: application to cancer screening and other diagnostics. *Kybernetes*, 29, 7/8, 871-895.



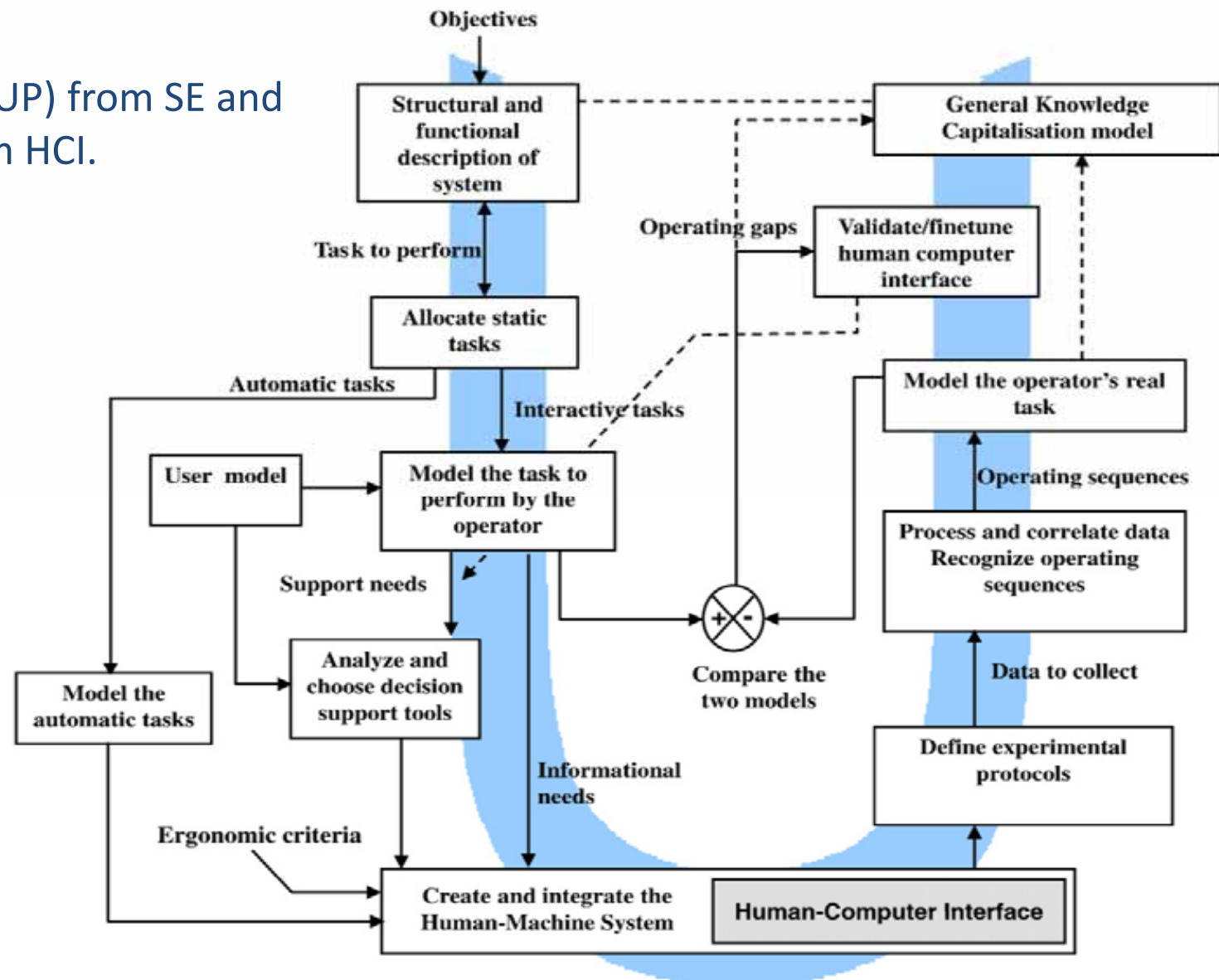
Metaxiotis, K. & Psarras, J. (2003) Expert systems in business: applications and future directions for the operations researcher. *Industrial Management & Data Systems*, 103, 5, 361-368.

- Human–Computer cooperation (integration!) is essential to the decision support process.
- Consequently, the field of Human–Computer Interaction (HCI) is a fundamental aspect for building
- **intelligent, interactive DSS,**
- because the design of such systems heavily relies on a user-centered approach (usability of machine learning!).
- It is necessary to combine and integrate methods from Software Engineering (SE) and HCI.
- Traditional methods and models are limited because the system is highly interactive and
- usually these methods do not integrate the end-user explicitly and systematically.

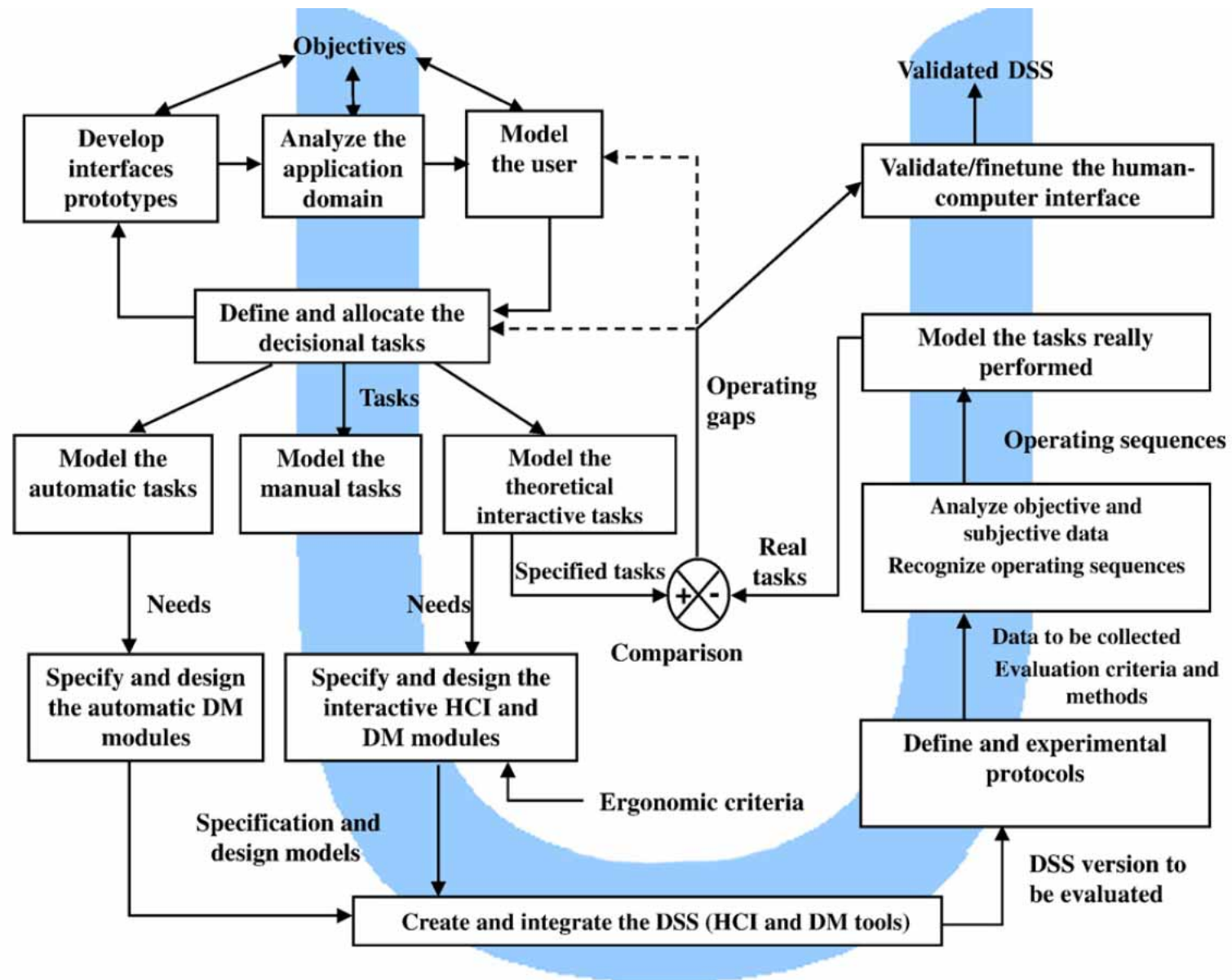
How to combine SE and HCI for effective development of DSS?

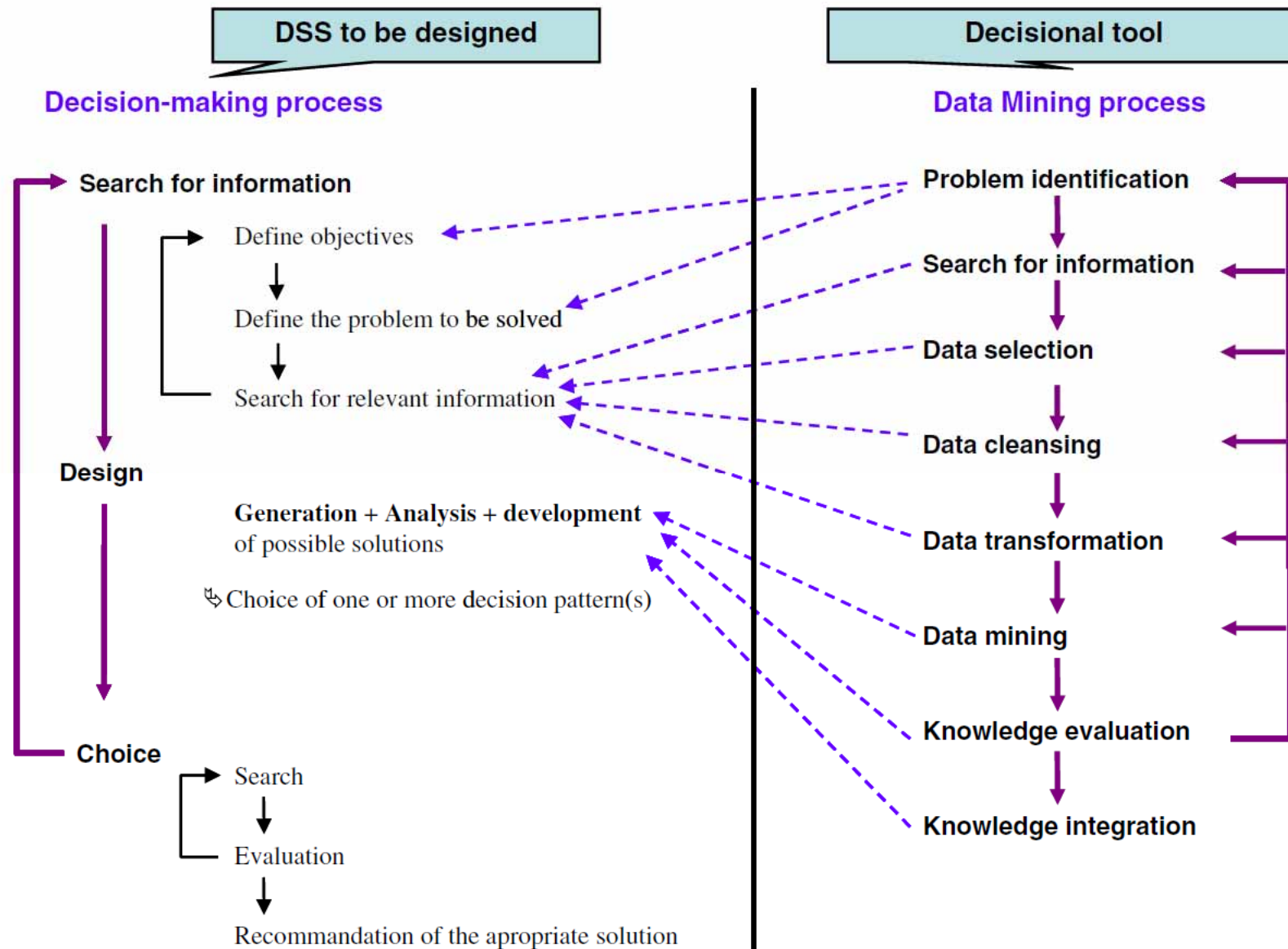
Unified Process (UP) from SE and
the U-model from HCI.

Abed, M.,
Bernard, J. &
Angué, J. (1991).
*Task analysis
and
modelization by
using SADT and
Petri Networks.*
*Tenth European
Annual
Conference on
Human Decision
Making and
Manual Control,*
Liege, 11-13.

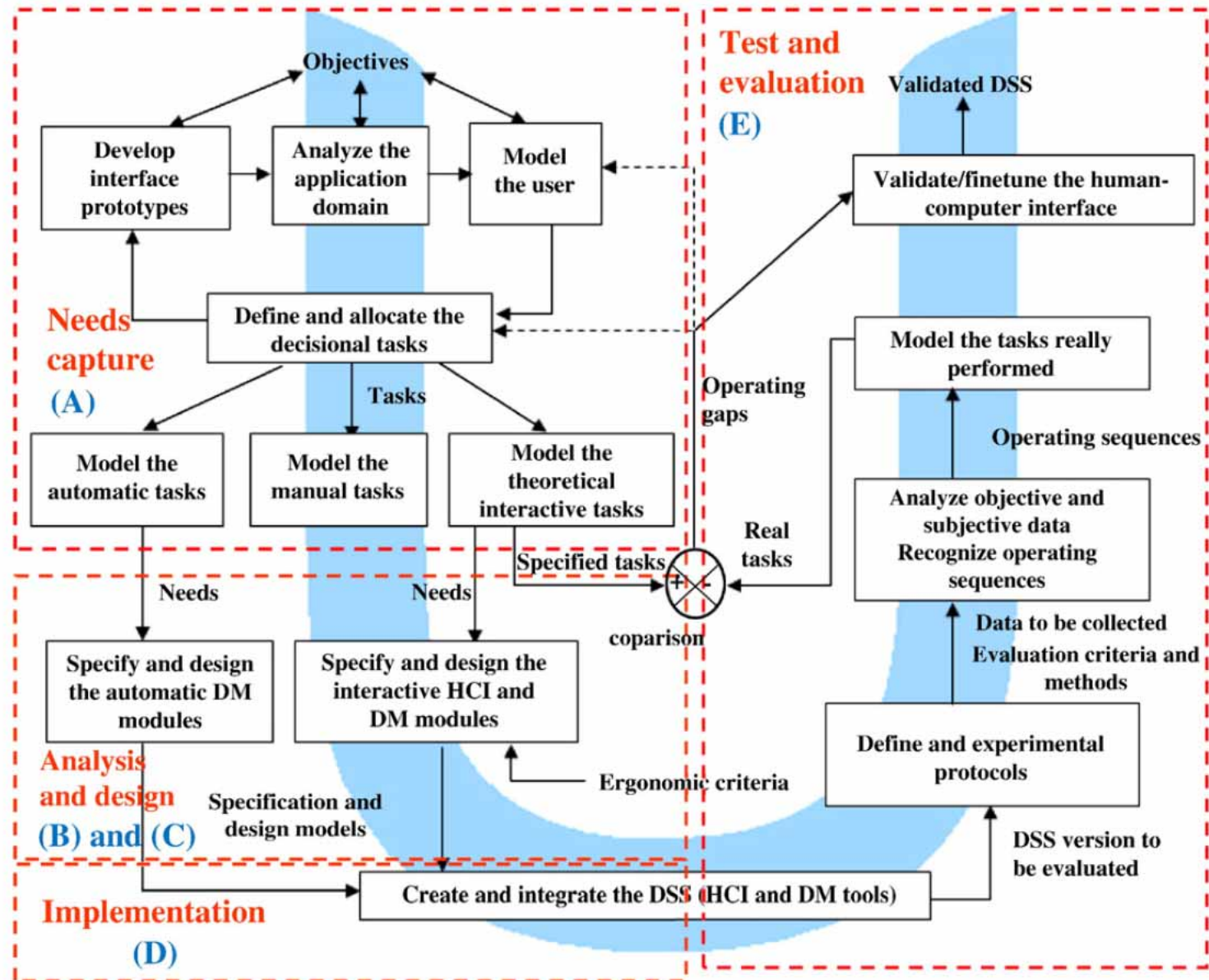


Ayed, B. M.,
Ltifi, H., Kolski,
C. & Alimi, A.
(2010) A user-
centered
approach for
the design &
implementation
of KDD-based
DSS: A case
study in the
healthcare
domain.
*Decision
Support
Systems*, 50, 64
78.





Ayed et al. (2010)



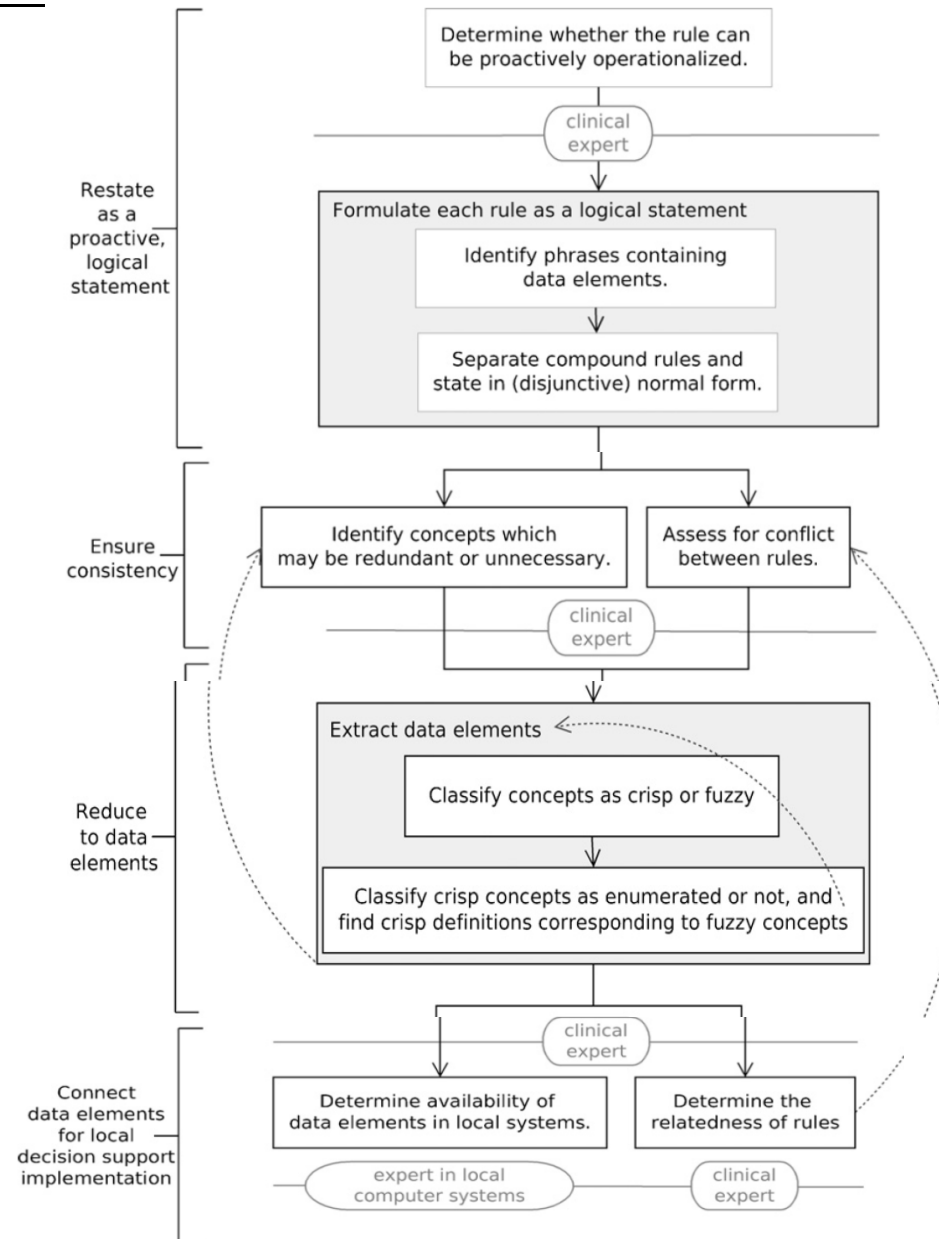
Ayed et al. (2010)

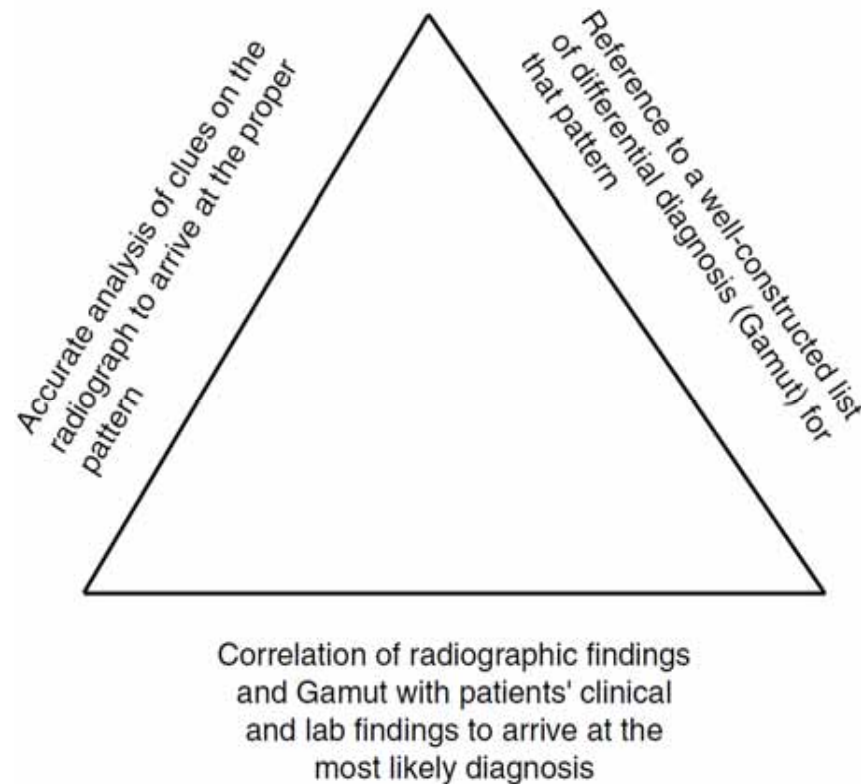
04 Further Practical Examples

What is the simplest possibility of clinical decision support?

- Clinical guidelines are **systematically** developed documents to assist doctors and patient decisions about appropriate care;
- In order to build DS, based on a guideline, it is **formalized** (transformed from natural language to a logical algorithm), and
- **implemented** (using the algorithm to program a DSS);
- To increase the quality of care, they must be linked to a process of care, for example:
 - “80% of diabetic patients should have an HbA1c below 7.0” could be linked to processes such as:
 - “All diabetic patients should have an annual HbA1c test” and
 - “Patients with values over 7.0 should be rechecked within 2 months.”
- **Condition-action rules** specify one or a few conditions which are linked to a specific action, in contrast to narrative guidelines which describe a series of branching or iterative decisions unfolding over time.
- Narrative guidelines and clinical rules are two ends of a continuum of clinical care standards.

Medlock, S., Opondo, D., Eslami, S., Askari, M., Wierenga, P., de Rooij, S. E. & Abu-Hanna, A. (2011) LERM (Logical Elements Rule Method): A method for assessing and formalizing clinical rules for decision support. *International Journal of Medical Informatics*, 80, 4, 286-295.





Reeder, M. M. & Felson, B. 2003.
Reeder and Felson's gamuts in radiology: comprehensive lists of roentgen differential diagnosis, New York, Springer Verlag.

Gamut F-137

PHRENIC NERVE PARALYSIS OR DYSFUNCTION

COMMON

1. Iatrogenic (eg, surgical injury; chest tube; therapeutic avulsion or injection; subclavian vein puncture)
2. Infection (eg, tuberculosis; fungus disease; abscess)
3. Neoplastic invasion or compression (esp. carcinoma of lung)

UNCOMMON

1. Aneurysm_g, aortic or other
2. Birth trauma (Erb's palsy)
3. Herpes zoster
4. Neuritis, peripheral (eg, diabetic neuropathy)
5. Neurologic disease_g (eg, hemiplegia; encephalitis; polio; Guillain-Barré S.)
6. Pneumonia
7. Trauma

Reference

1. Prasad S, Athreya BH: Transient paralysis of the phrenic nerve associated with head injury. JAMA 1976;236:2532-2533

REEDER AND FELSON'S

GAMUTS IN RADIOLOGY

GAMUT G-25EROSIVE GASTRITIS*

COMMON

1. Acute gastritis (eg, alcohol abuse)
2. Crohn's disease **I** **I**
3. Drugs (eg, aspirin **I** **I**; NSAID **I**; steroids)
4. *Helicobacter pylori* infection **I**
5. Idiopathic
6. [Normal areae gastricae **I**]
7. Peptic ulcer; hyperacidity

UNCOMMON

1. Corrosive gastritis **I**
2. *Cryptosporidium* antritis
3. [Lymphoma]
4. Opportunistic infection (eg, candidiasis {moniliasis} **I**; herpes simplex; cytomegalovirus)
5. Postoperative gastritis
6. Radiation therapy
7. Zollinger-Ellison S. **I**; multiple endocrine neoplasia (MEN) S.

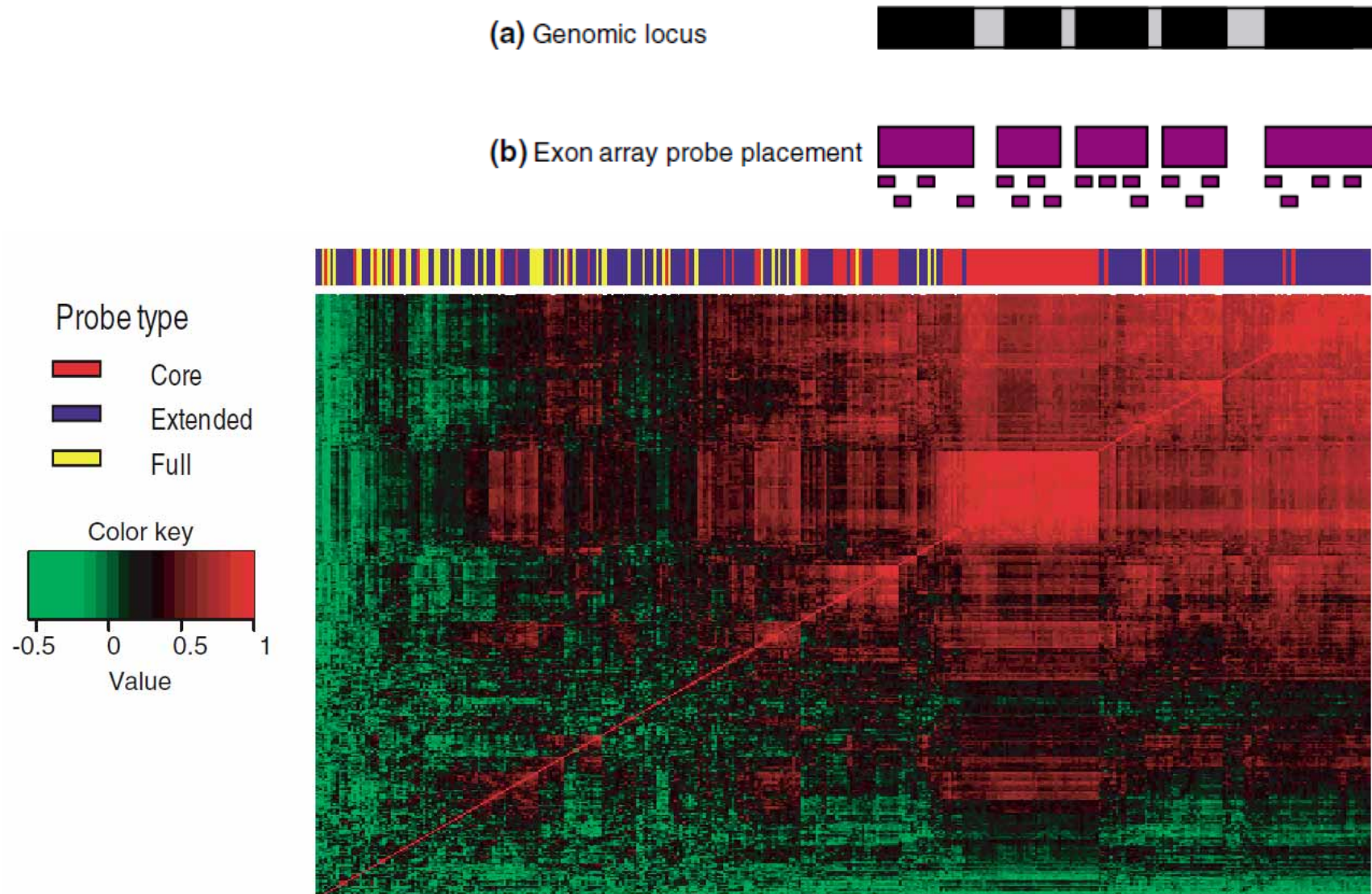
* Superficial erosions or aphthoid ulcerations seen especially with double contrast technique.

[] This condition does not actually cause the gamuted imaging finding, but can produce imaging changes that simulate it.

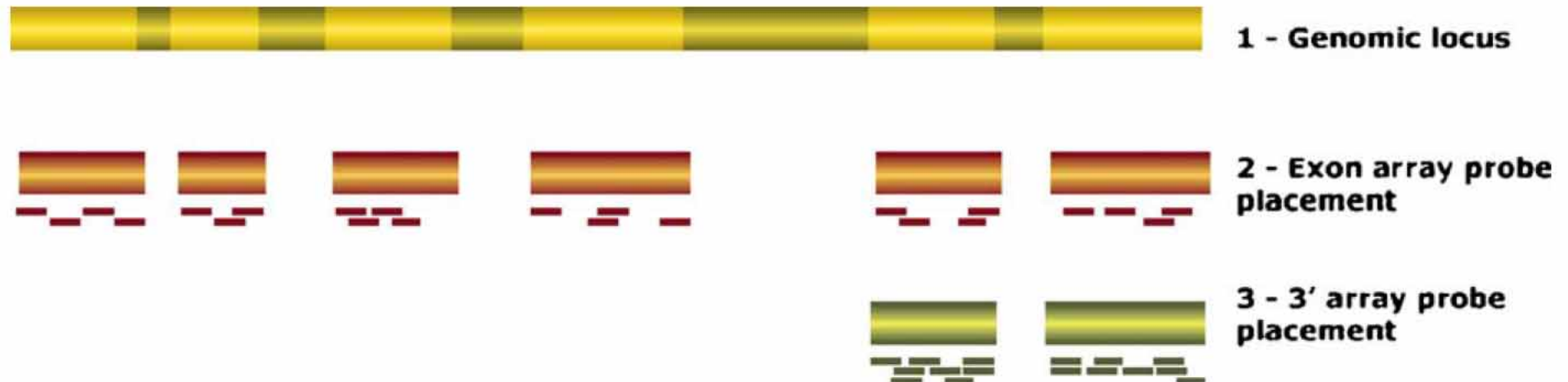
Reeder, M. M. & Felson, B. (2003) *Reeder and Felson's gamuts in radiology: comprehensive lists of roentgen differential diagnosis*. New York, Springer Verlag.

<http://rfs.acr.org/gamuts/data/G-25.htm>

05 Towards P4-Medicine

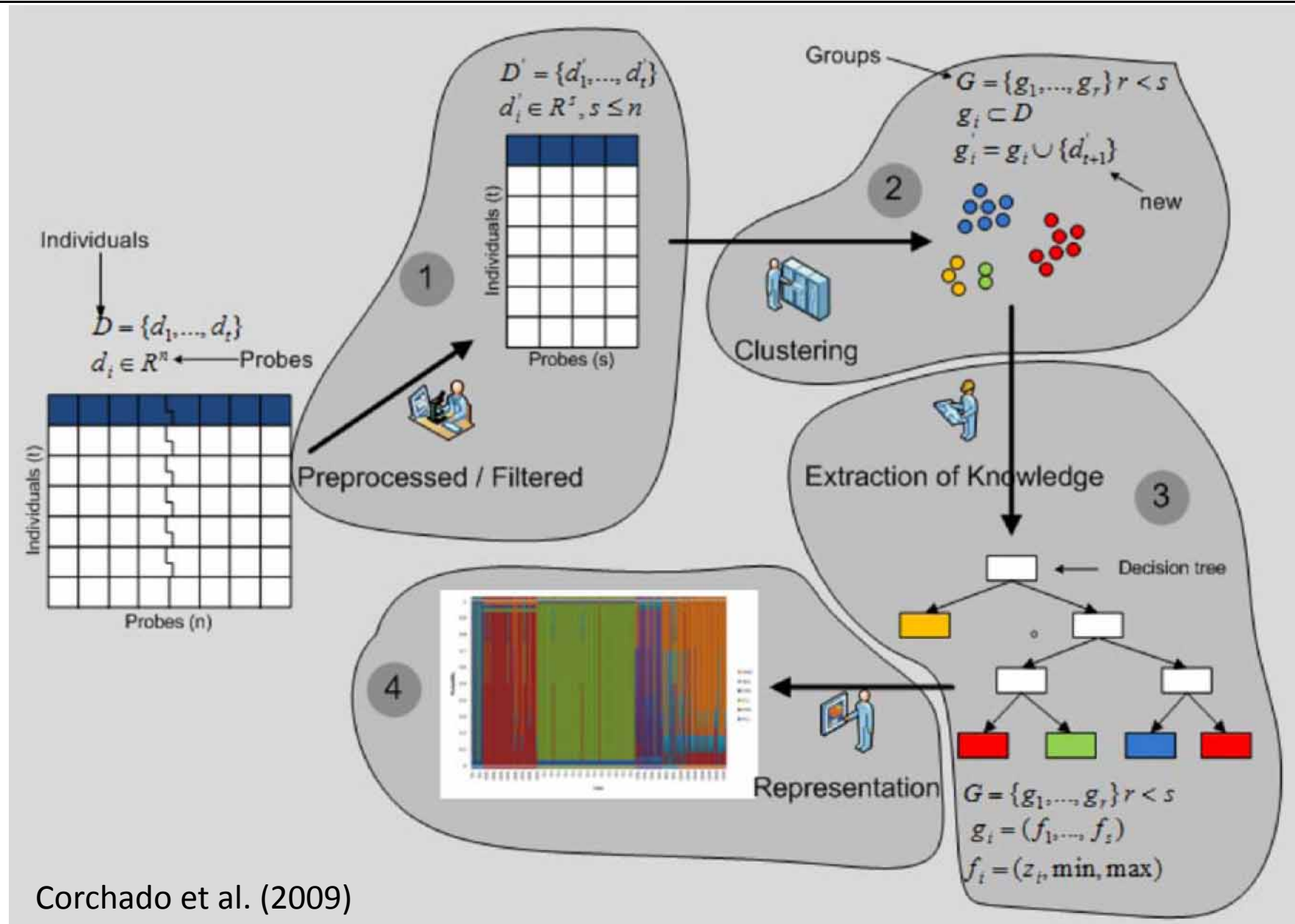


Kapur, K., Xing, Y., Ouyang, Z. & Wong, W. (2007) Exon arrays provide accurate assessments of gene expression. *Genome Biology*, 8, 5, R82.



Exon array structure. Probe design of exon arrays. (1) Exon—intron structure of a gene. Gray boxes represent introns, rest represent exons. Introns are not drawn to scale. (2) Probe design of exon arrays. Four probes target each putative exon. (3) Probe design of 30expression arrays. Probe target the 30end of mRNA sequence.

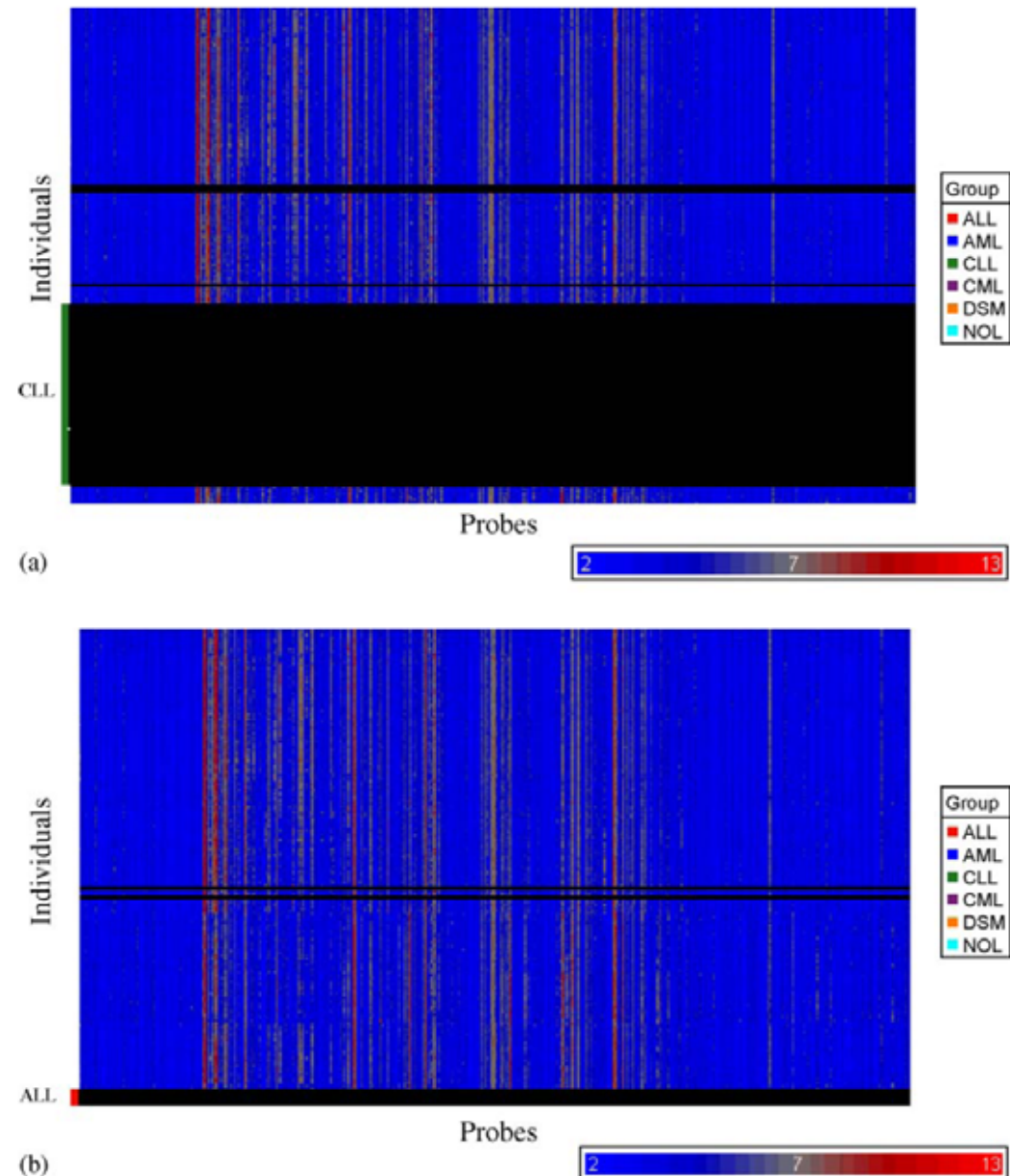
Corchado, J. M., De Paz, J. F., Rodriguez, S. & Bajo, J. (2009) Model of experts for decision support in the diagnosis of leukemia patients. *Artificial Intelligence in Medicine*, 46, 3, 179-200.

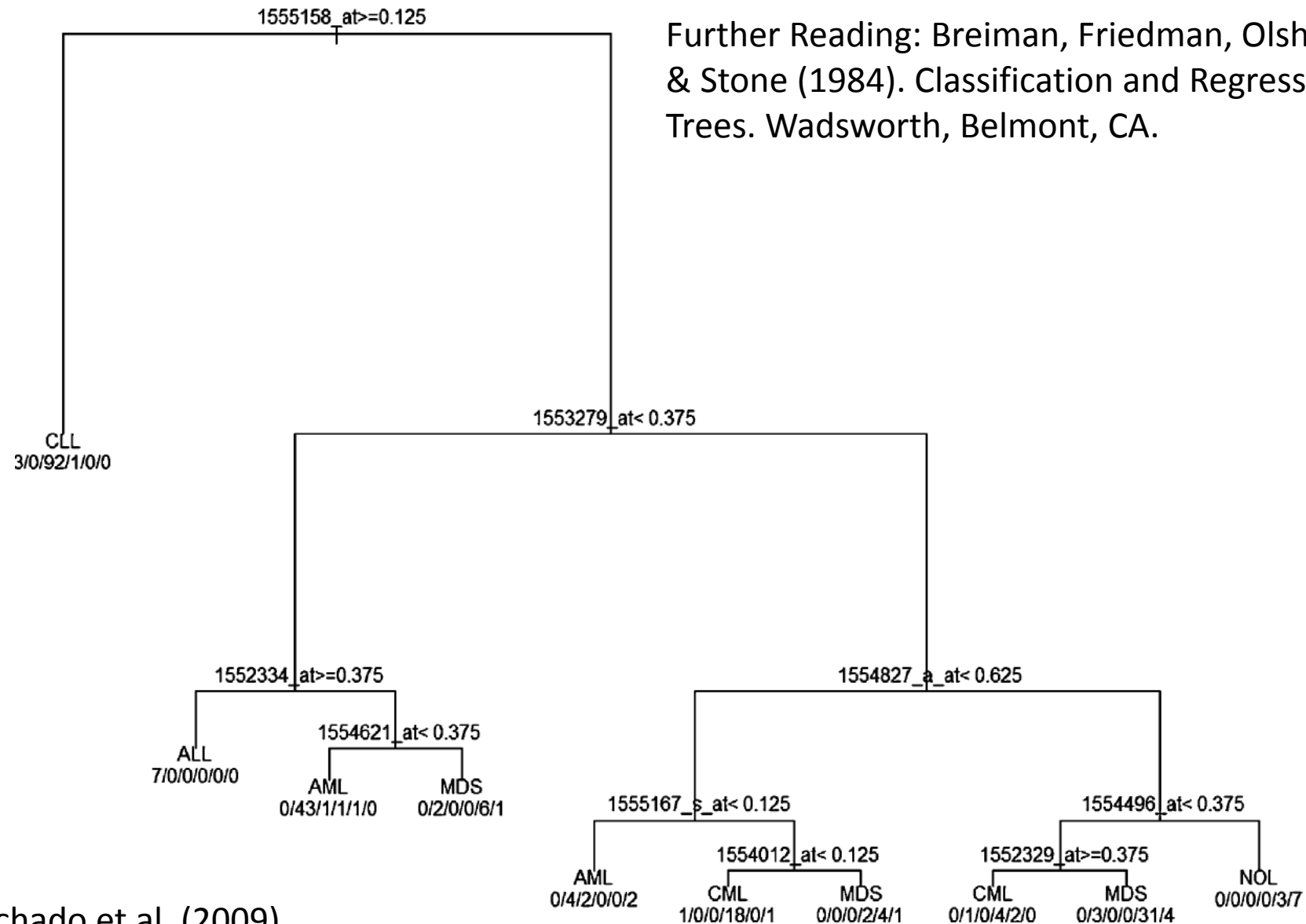


A = acute, C = chronic,
L = lymphocytic, M = myeloid

- **ALL** = cancer of the blood AND bone marrow caused by an abnormal proliferation of lymphocytes.
- **AML** = cancer in the bone marrow characterized by the proliferation of myeloblasts, red blood cells or abnormal platelets.
- **CLL** = cancer characterized by a proliferation of lymphocytes in the bone marrow.
- **CML** = caused by a proliferation of white blood cells in the bone marrow.
- **MDS** (Myelodysplastic Syndromes) = a group of diseases of the blood and bone marrow in which the bone marrow does not produce a sufficient amount of healthy cells.
- **NOL** (Normal) = No leukemias

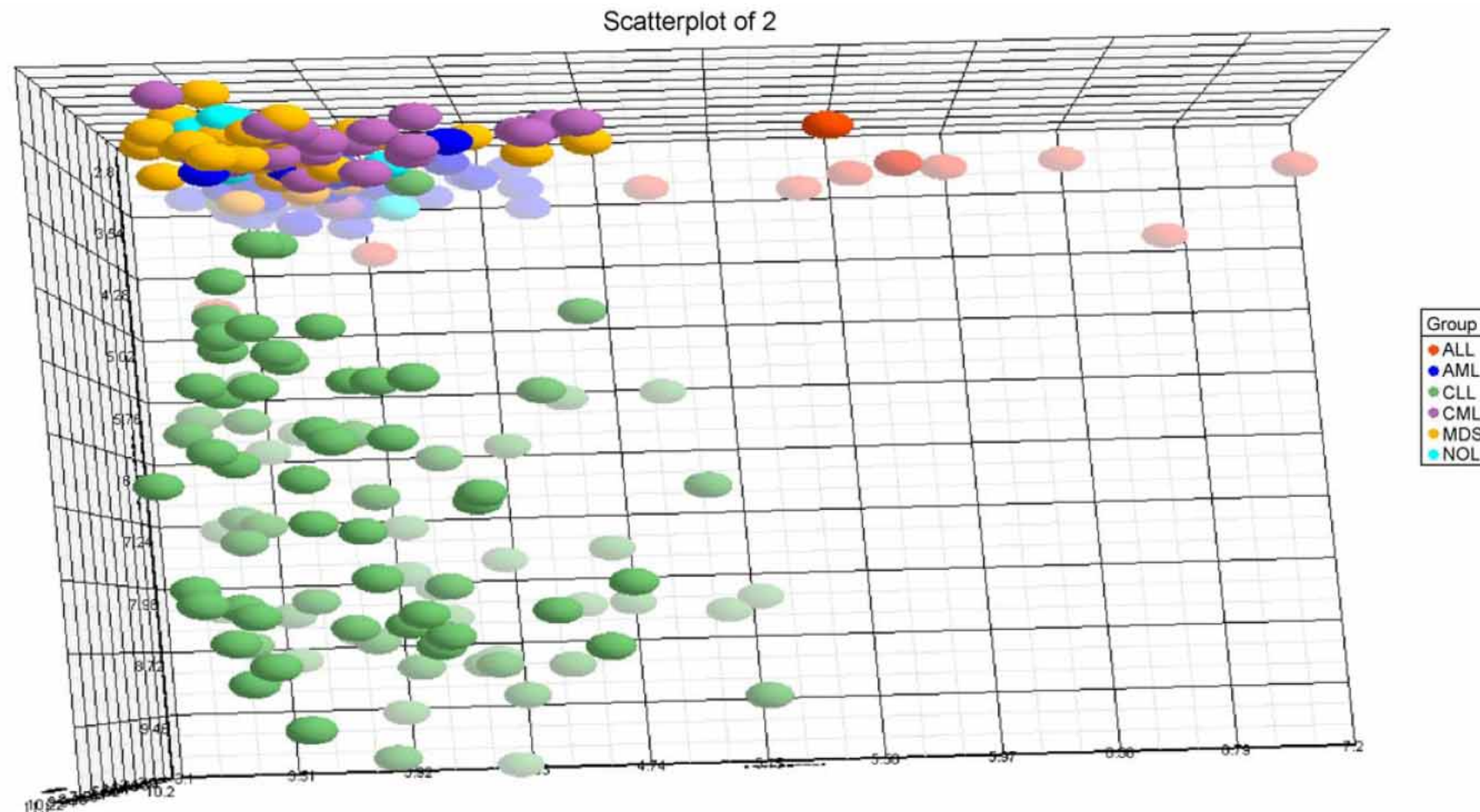
Corchado et al. (2009)





Corchado et al. (2009)

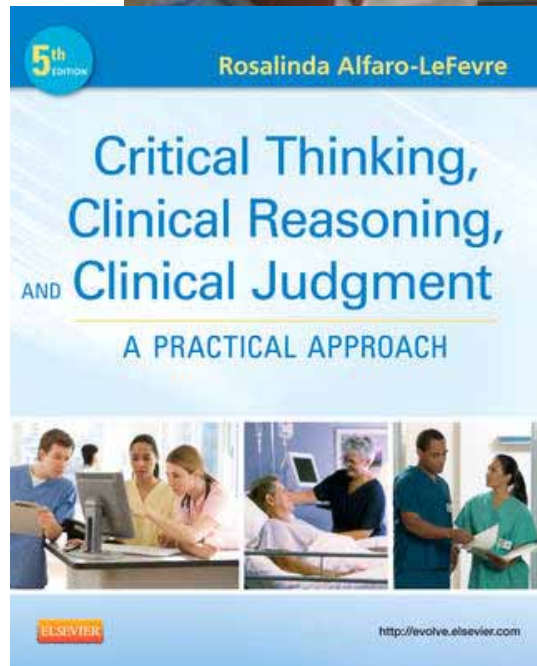
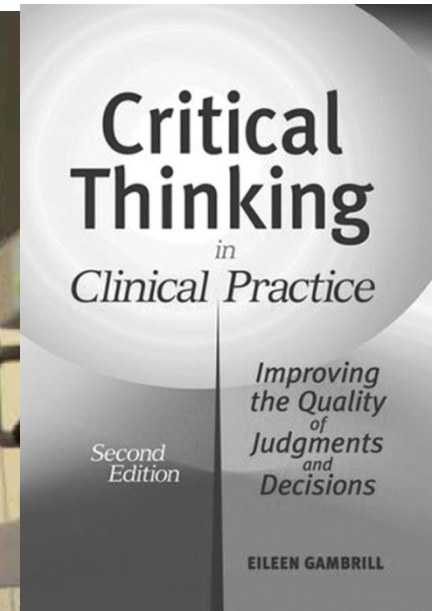
Classification CLL—ALL. Representation of the probes of the decision tree which classify the CLL and ALL to 1555158_at, 1553279_at and 1552334_at

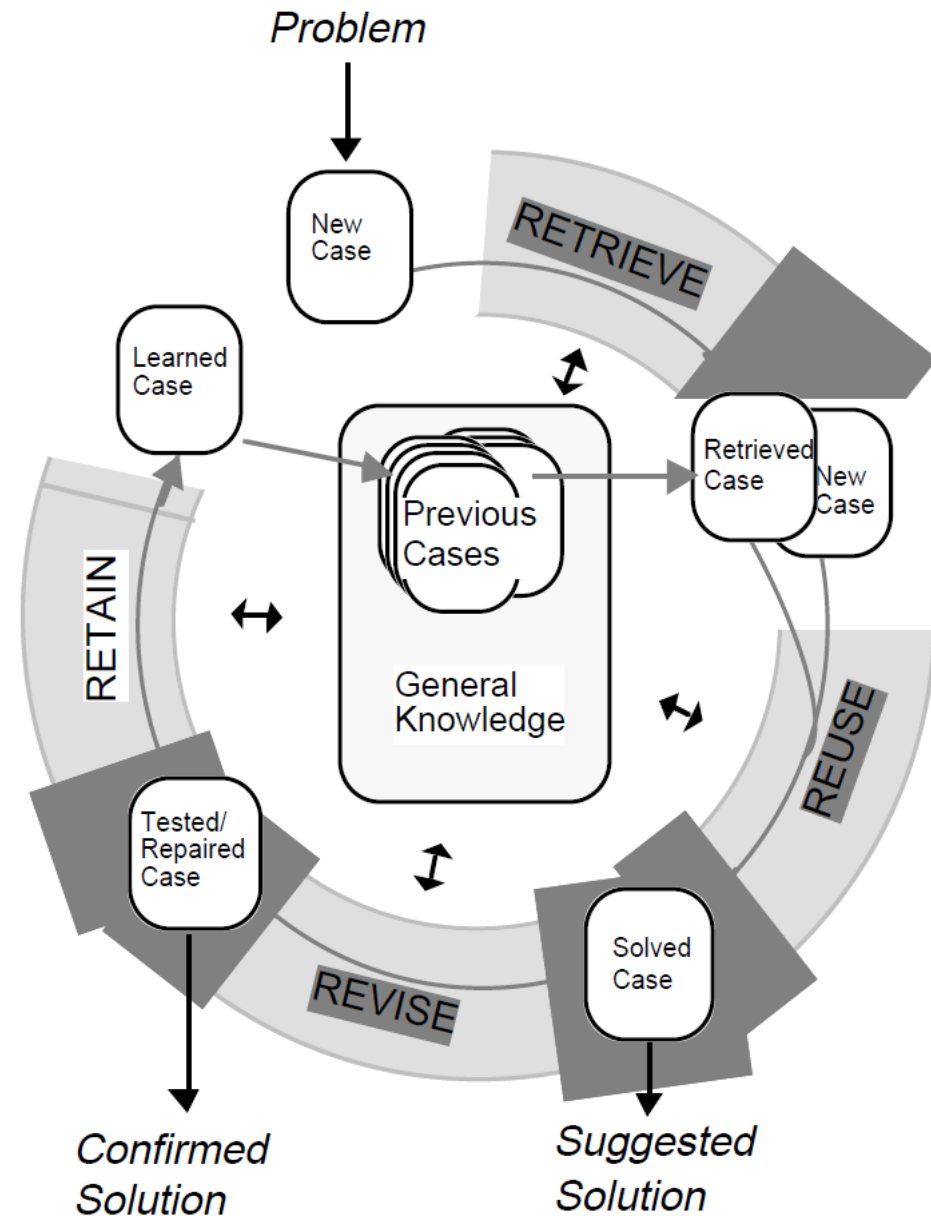


Corchado et al. (2009)

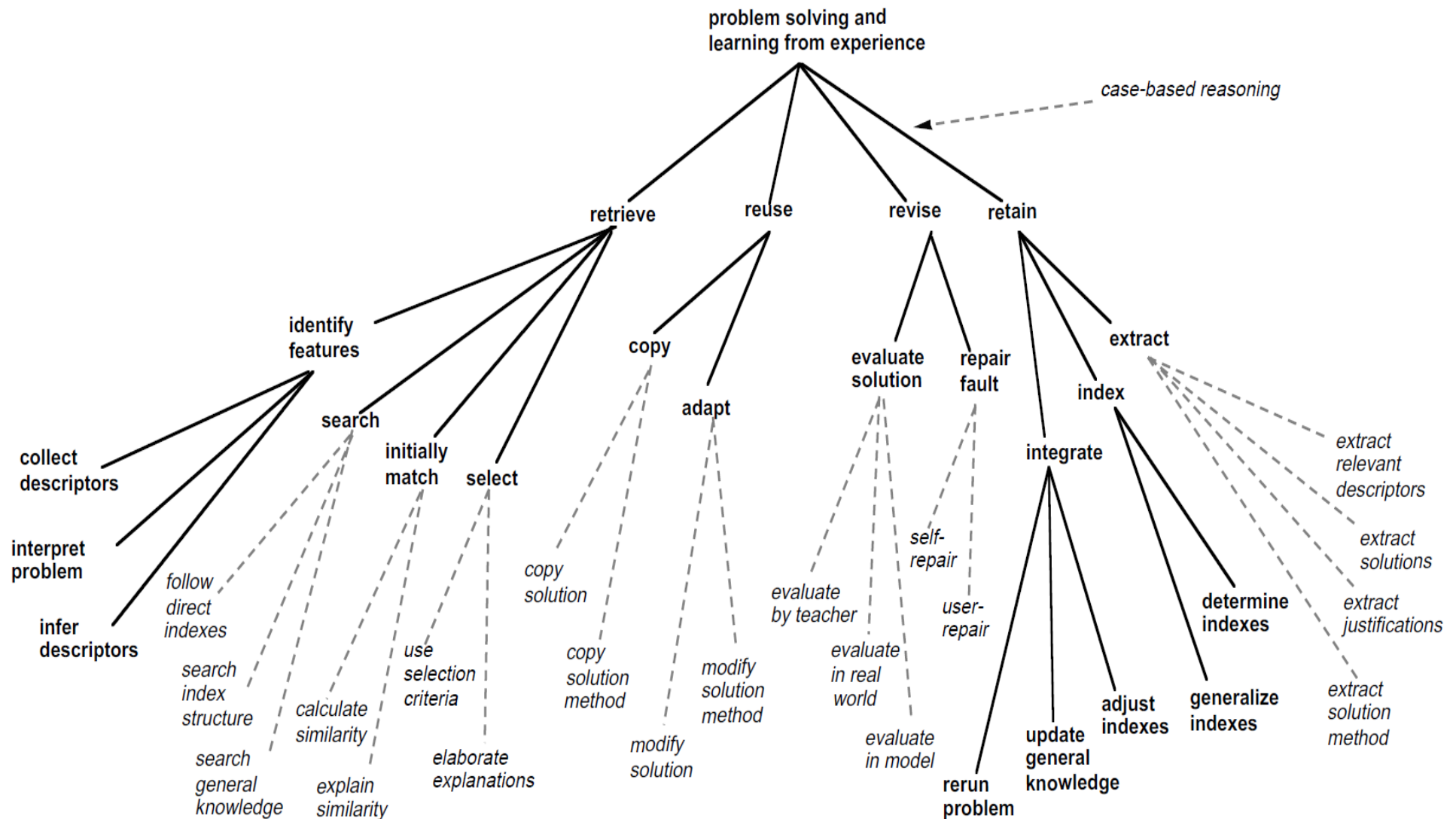
- The model of Corchado et al. (2009) combines:
- 1) methods to **reduce the dimensionality** of the original data set;
- 2) pre-processing and data filtering techniques;
- 3) a clustering method to classify patients; and
- 4) extraction of knowledge techniques
- The system reflects how human experts work in a lab, but
- 1) **reduces the time** for making predictions;
- 2) **reduces the rate of human error**; and
- 3) **works with high-dimensional data** from exon arrays

06 Case Based Reasoning (CBR)



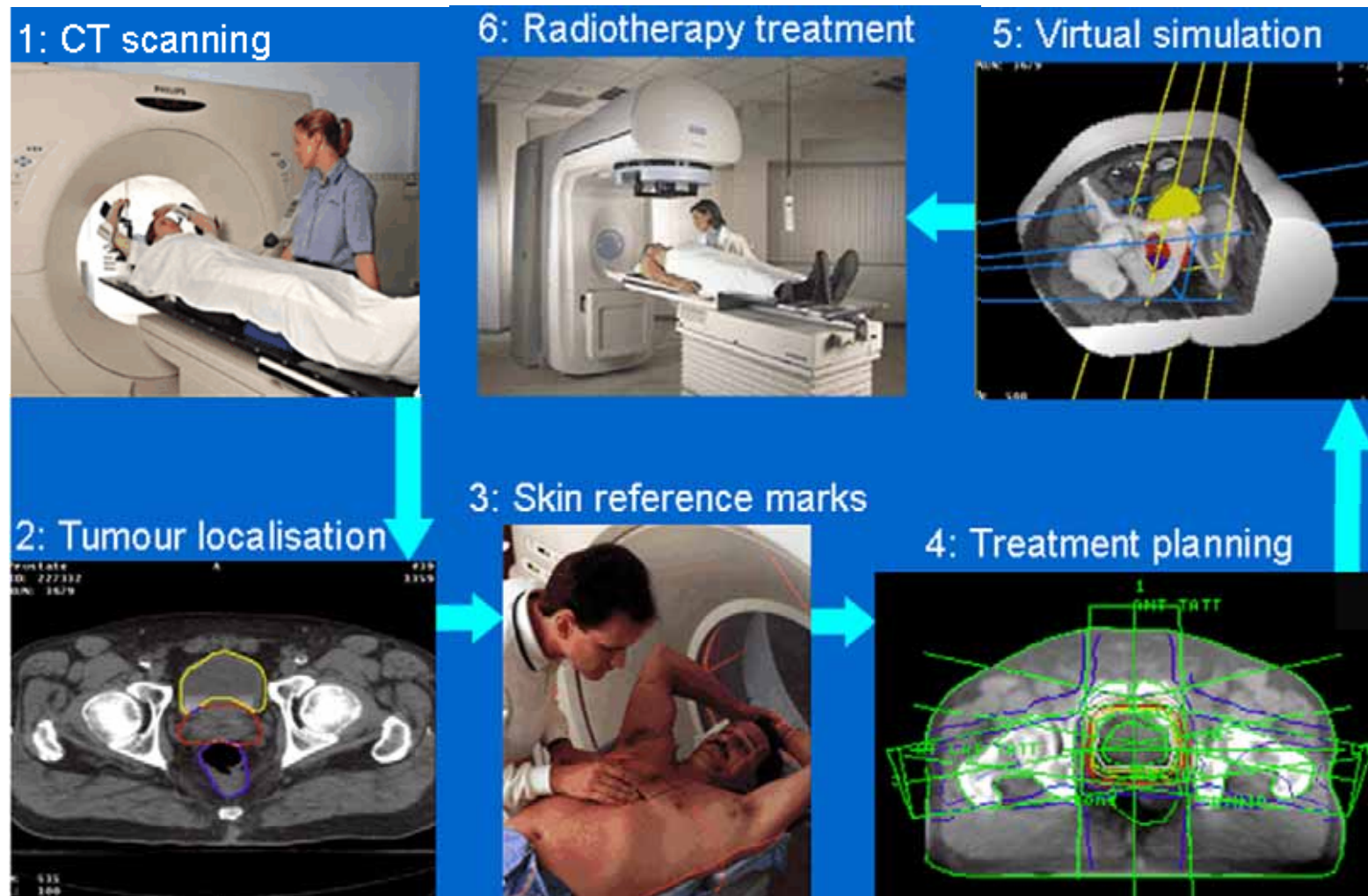


Aamodt, A. & Plaza, E. (1994) Case-based reasoning: Foundational issues, methodological variations, and system approaches. *AI Communications*, 7, 1, 39-59.

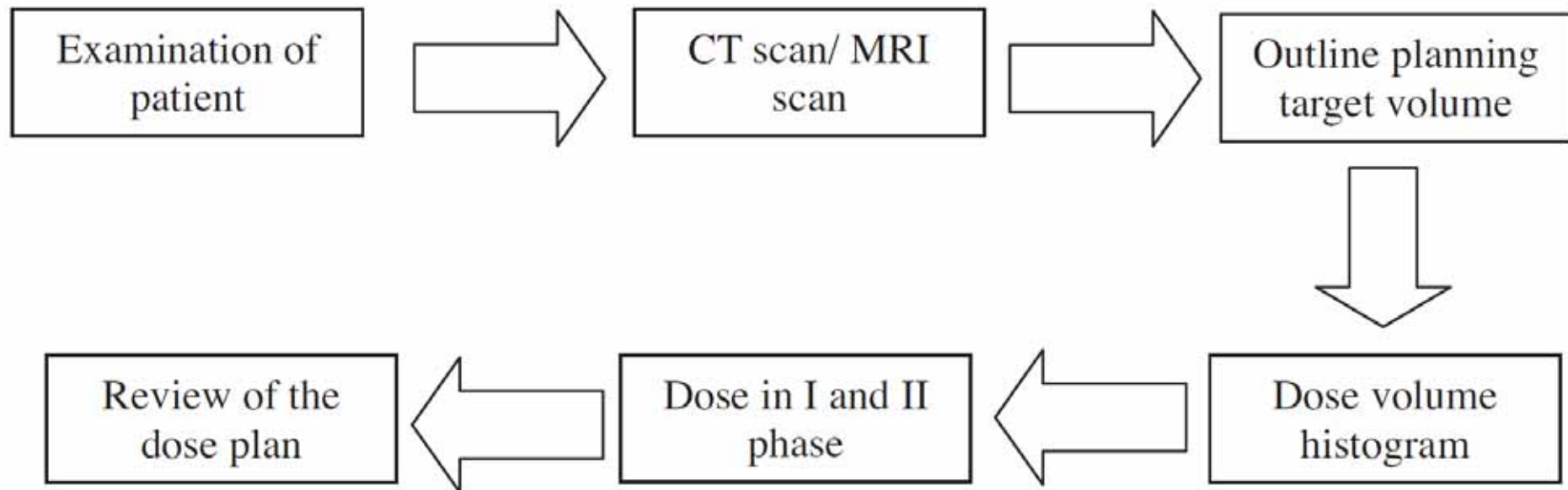


Aamodt & Plaza (1994)





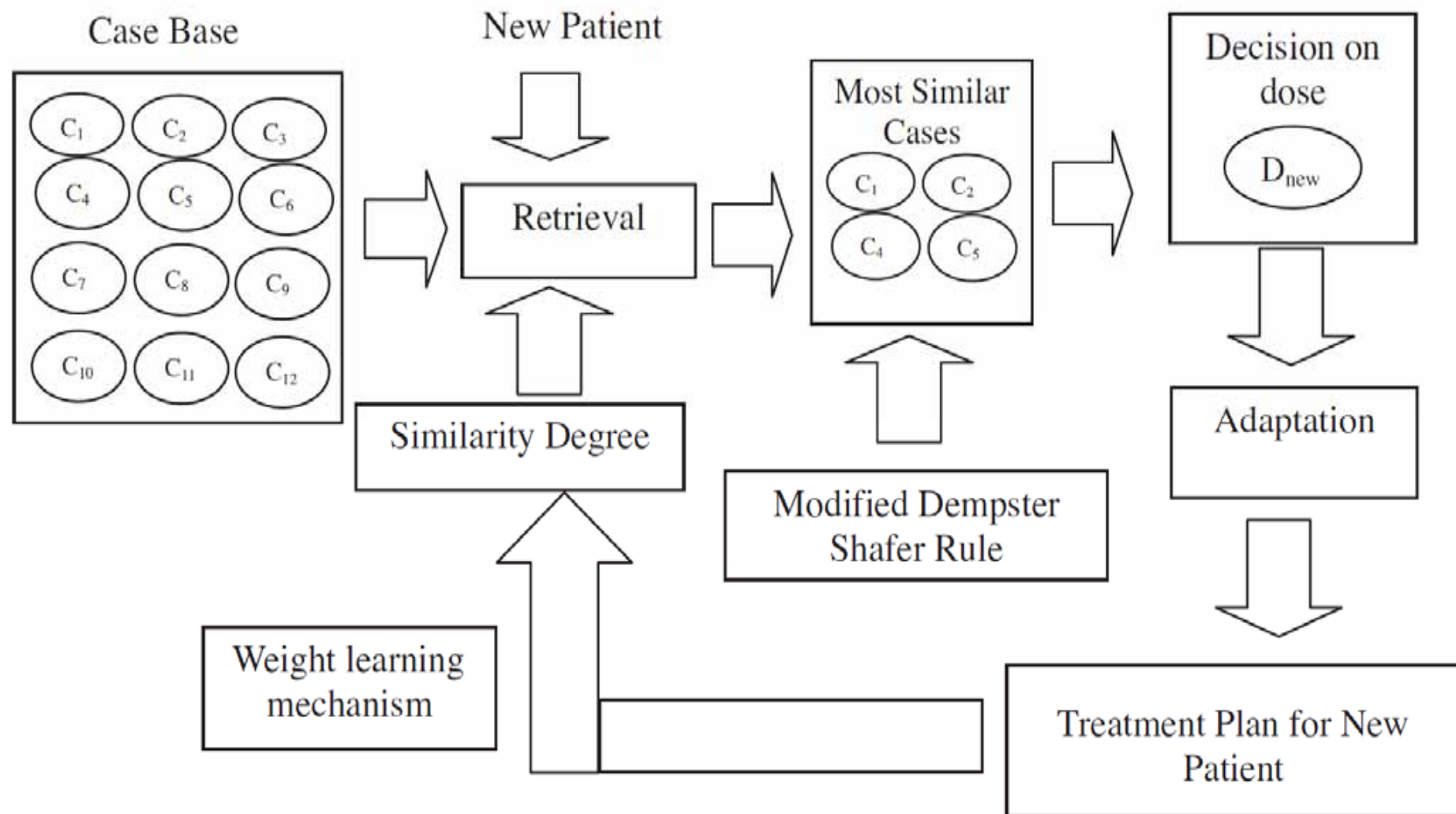
Source: Imaging Performance Assessment of CT Scanners Group, <http://www.impactscan.org>



Measures:

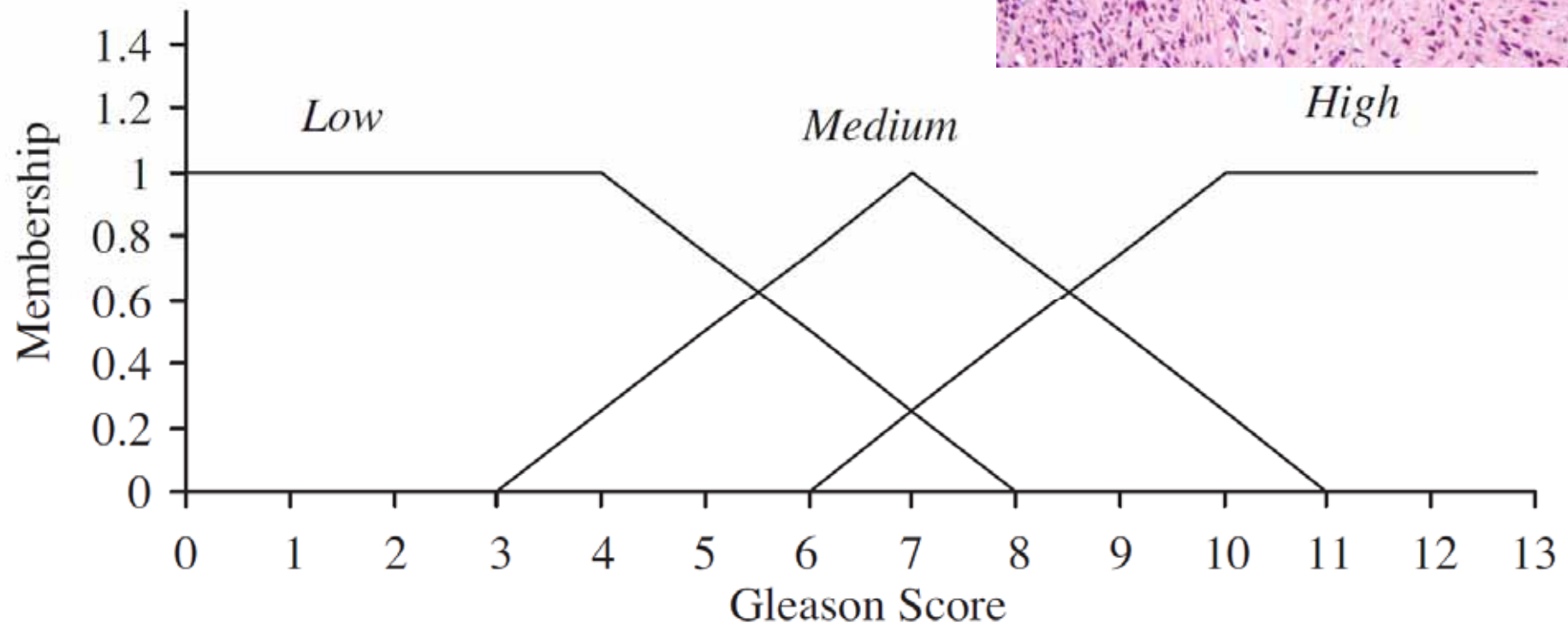
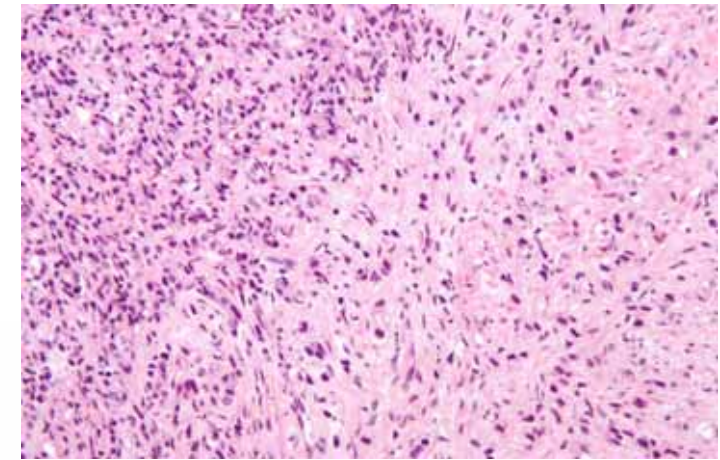
- 1) Clinical Stage = a labelling system
- 2) Gleason Score = grade of prostate cancer = integer between 1 to 10; and
- 3) Prostate Specific Antigen (PSA) value between 1 to 40
- 4) Dose Volume Histogram (DVH) = pot. risk to the rectum (66, 50, 25, 10 %)

Petrovic, S., Mishra, N. & Sundar, S. (2011) A novel case based reasoning approach to radiotherapy planning. *Expert Systems With Applications*, 38, 9, 10759-10769.



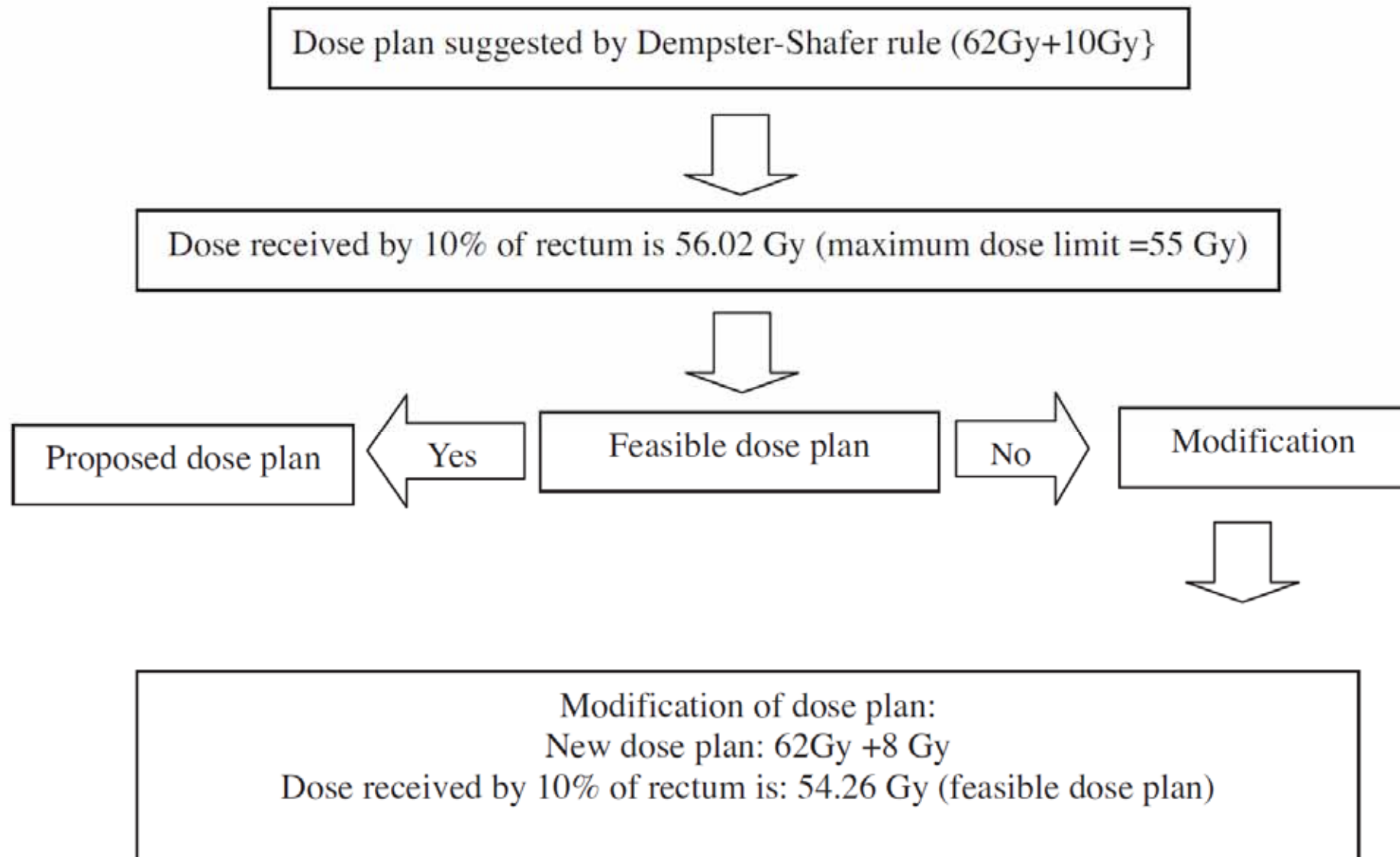
Petrovic, S., Mishra, N. & Sundar, S. (2011) A novel case based reasoning approach to radiotherapy planning. *Expert Systems With Applications*, 38, 9, 10759-10769.

Gleason score evaluates the grade of prostate cancer. Values: integer within the range



Petrovic, S., Mishra, N. & Sundar, S. (2011) A novel case based reasoning approach to radiotherapy planning. *Expert Systems With Applications*, 38, 9, 10759-10769.

Petrovic et al. (2011)





Thank you!

Questions

- Again: What is human intelligence?
- What different decision models can be applied in medical informatics?
- How can we deal with uncertainty in the real world?
- What is the principle of a rule based expert system?
- Sketch the basic architecture of a DSS!
- Which basic design principles of a DSS must be considered?
- How does the U-model work to engineer an DSS?
- Which similarities exist between DSS and KDD?
- What are clinical guidelines?
- What is interesting in the computational method model of cancer detection of Corchado et al. (2009)?
- What is the basic principle of Case Based Reasoning?

- Why was MYCIN no success in the practical clinical world?
- What are clinical guidelines?
- What is a big advantage of the Gamuts-for-Radiology System?
- Why are decision trees so important for DSS?
- Why would radiotherapy planning without computers so difficult?

Appendix

- <http://gaia.fdi.ucm.es/projects/jcolibri>
- <http://www-formal.stanford.edu/jmc/whatisai/whatisai.html>
- <http://aaai.org/AITopics>
- http://www.stottlerhenke.com/ai_general/history.htm
- <http://rfs.acr.org/gamuts> (Gamuts in radiology - DSS for radiological imaging)
- <http://www.scribd.com/doc/16093558/Gamuts-in-radiology> (Reeder & Felsons Original Book on Gamuts)
- <http://www.isradiology.org/gamuts/Gamuts.htm> (Web-based Gamuts in Radiology)

3 July 1959, Volume 130, Number 3366

SCIENCE

Reasoning Foundations of Medical Diagnosis

Symbolic logic, probability, and value theory
aid our understanding of how physicians reason.

Robert S. Ledley and Lee B. Lusted

The purpose of this article is to analyze the complicated reasoning processes inherent in medical diagnosis. The importance of this problem has received recent emphasis by the increasing interest in the use of electronic computers as an aid to medical diagnostic processes

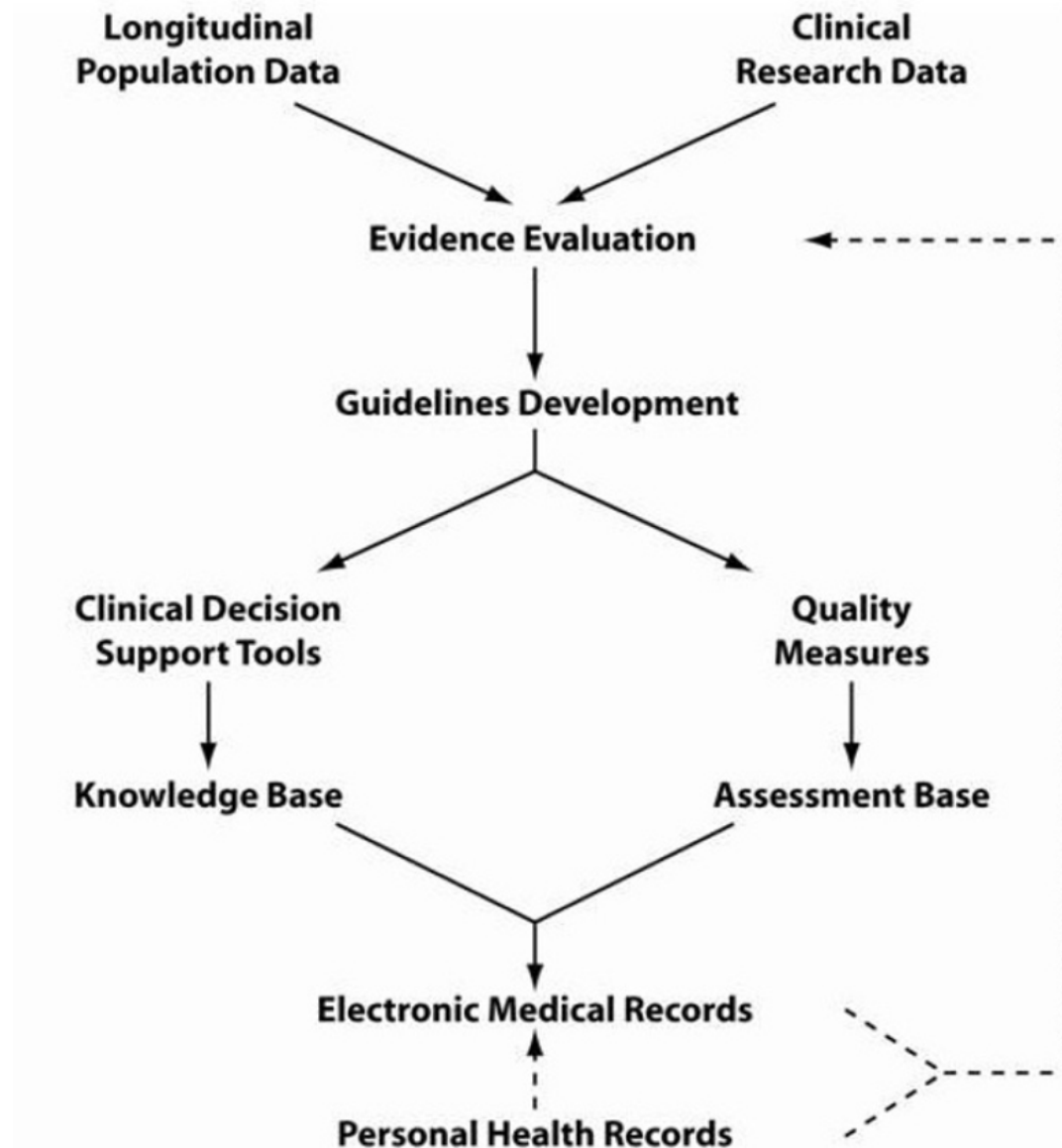
fitted into a definite disease category, or that it may be one of several possible diseases, or else that its exact nature cannot be determined." This, obviously, is a greatly simplified explanation of the process of diagnosis, for the physician might also comment that after seeing a

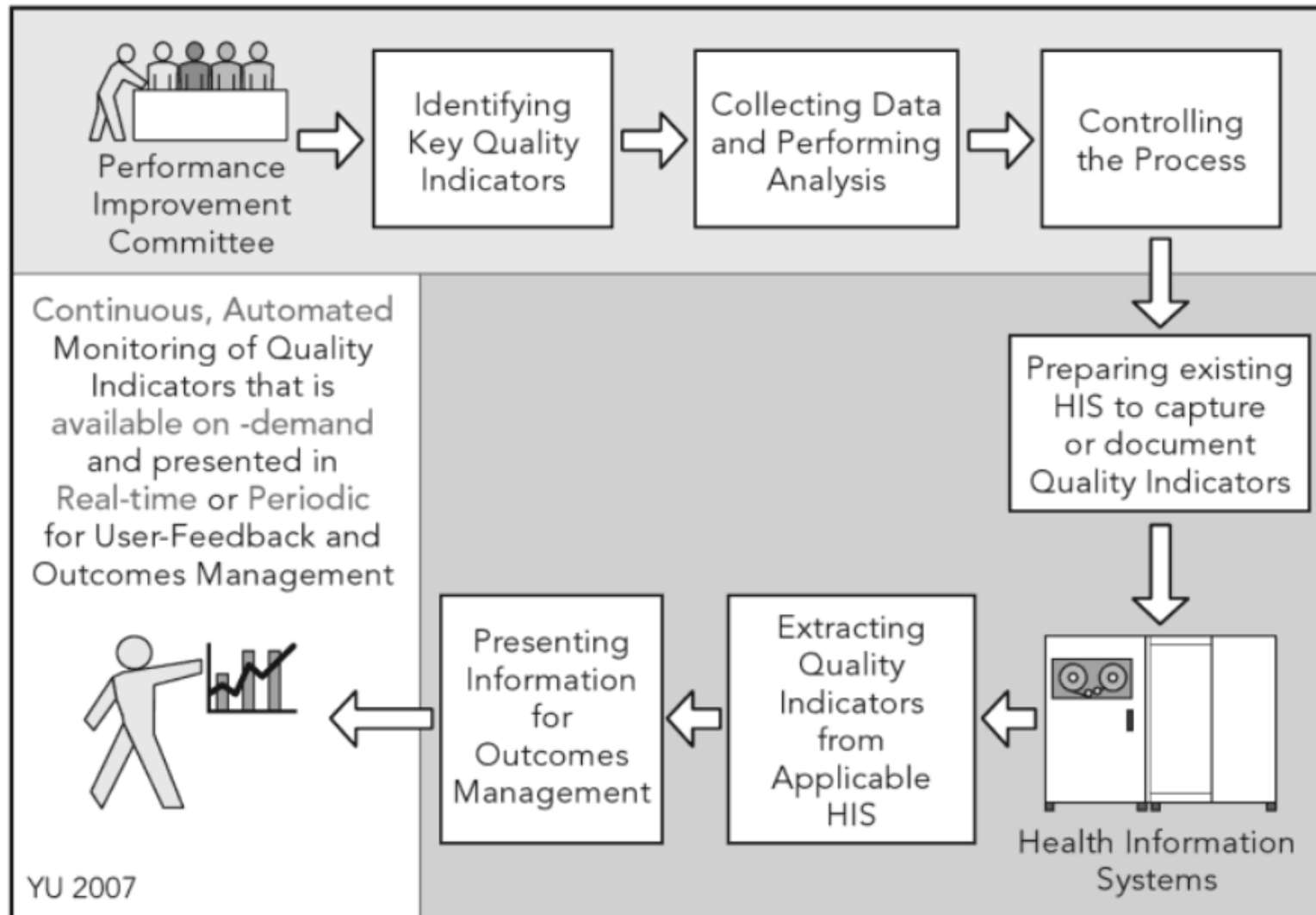
ance are the ones who do remember and consider the most possibilities."

Computers are especially suited to help the physician collect and process clinical information and remind him of diagnoses which he may have overlooked. In many cases computers may be as simple as a set of hand-sorted cards, whereas in other cases the use of a large-scale digital electronic computer may be indicated. There are other ways in which computers may serve the physician, and some of these are suggested in this paper. For example, medical students might find the computer an important aid in learning the methods of differential diagnosis. But to use the computer thus we must understand how the physician makes a medical diagnosis. This, then, brings us to the subject of our investigation: the reasoning foundations of medical diagnosis and treatment.

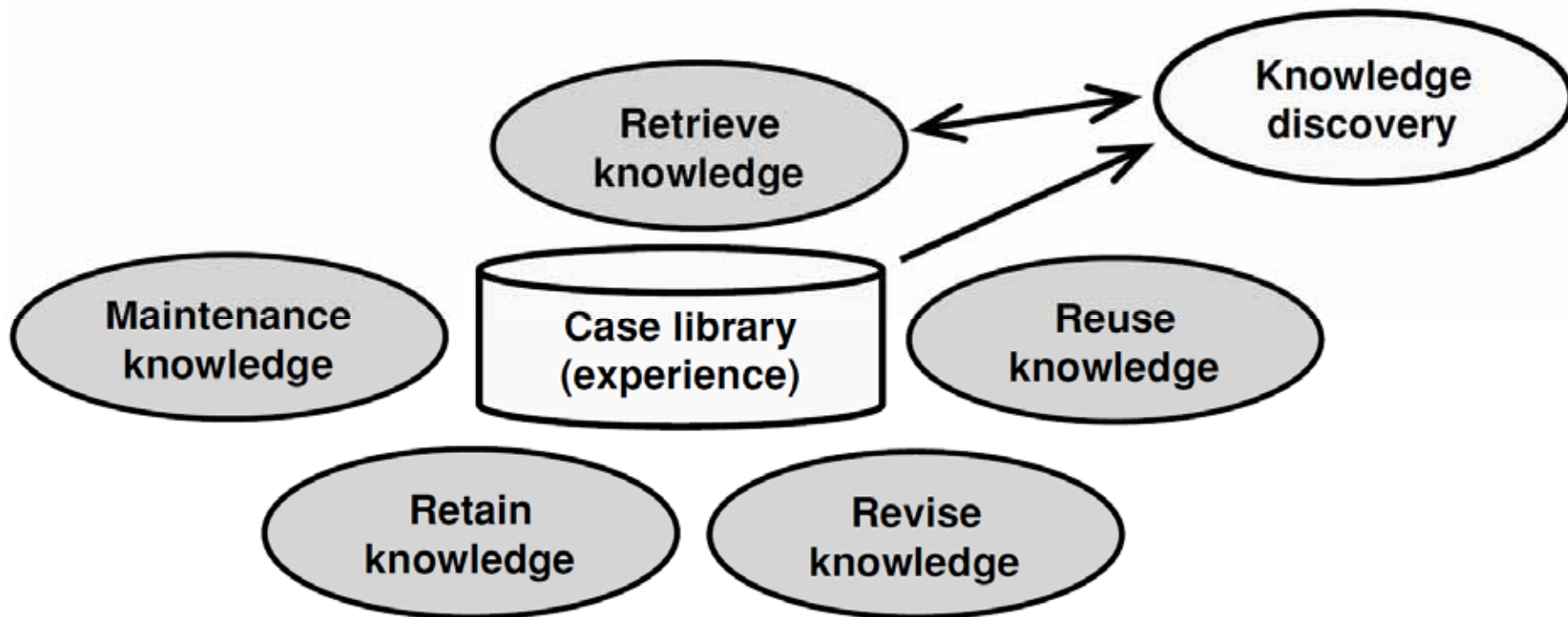
Medical diagnosis involves processes that can be systematically analyzed, as well as those characterized as "intangible." For instance, the reasoning foundations of medical diagnostic procedures

Downing, G., Boyle, S., Brinner, K. & Osherooff, J. (2009) Information management to enable personalized medicine: stakeholder roles in building clinical decision support. *BMC Medical Informatics and Decision Making*, 9, 1, 1-11.

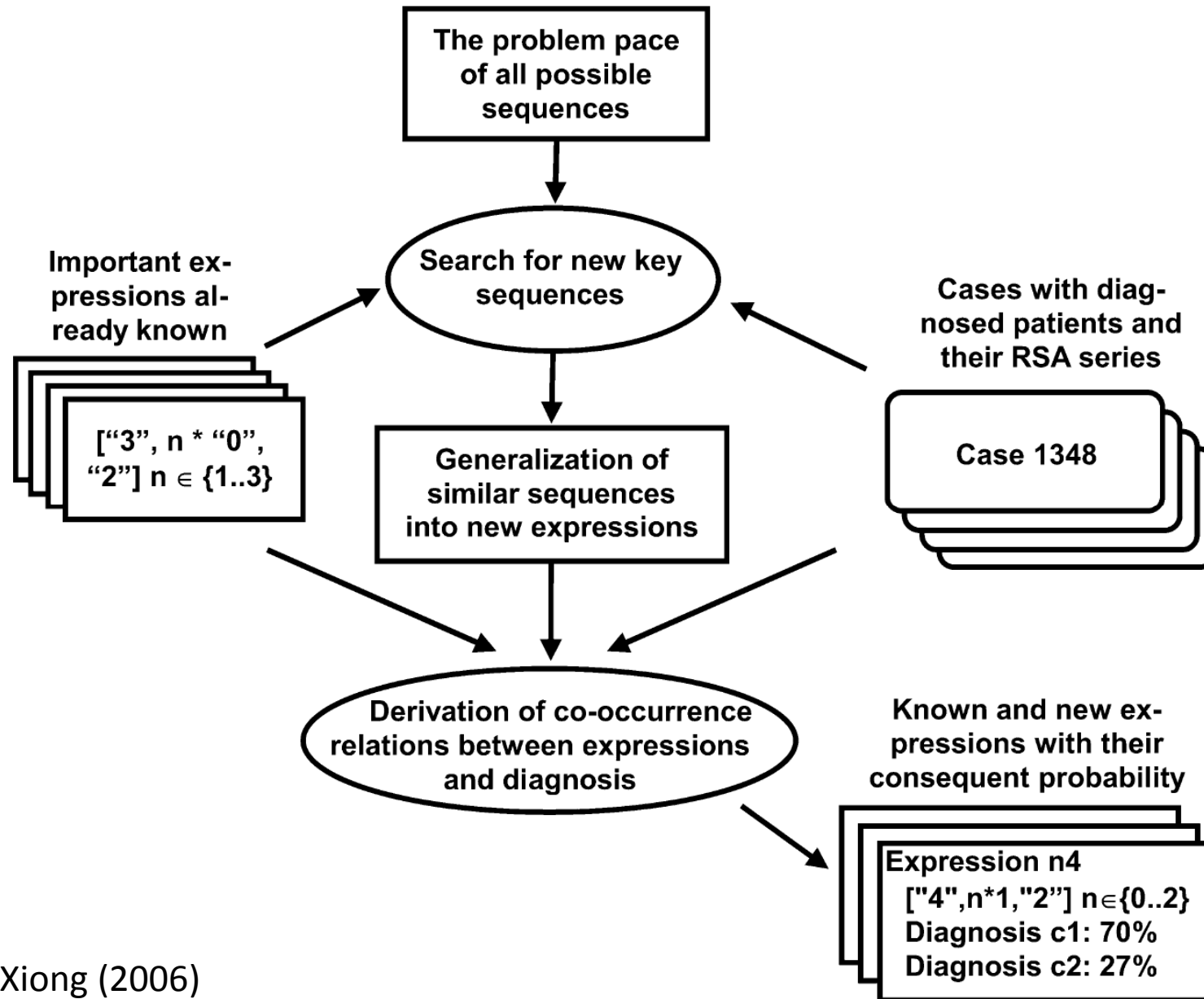




Yu, F.B., Allison, J.J., Houston T.K. (2008) Quality Improvement & the Electronic Health Record: Concepts and Methods. In: Carter, J. H. (2008) *Electronic health records: a guide for clinicians & administrators*. ACP Press.



Funk, P. & Xiong, N. (2006) Case-based reasoning and knowledge discovery in medical applications with time series. *Computational Intelligence*, 22, 3-4, 238-253.



Funk & Xiong (2006)

Given a sequence s there may be a set of probable consequent classes $\{C_1, C_2, \dots, C_k\}$

The strength of the co-occurrence between sequence s and class C_i ($i = 1, \dots, k$) can be measured by the probability, $p(C_i | s)$, of C_i conditioned upon s

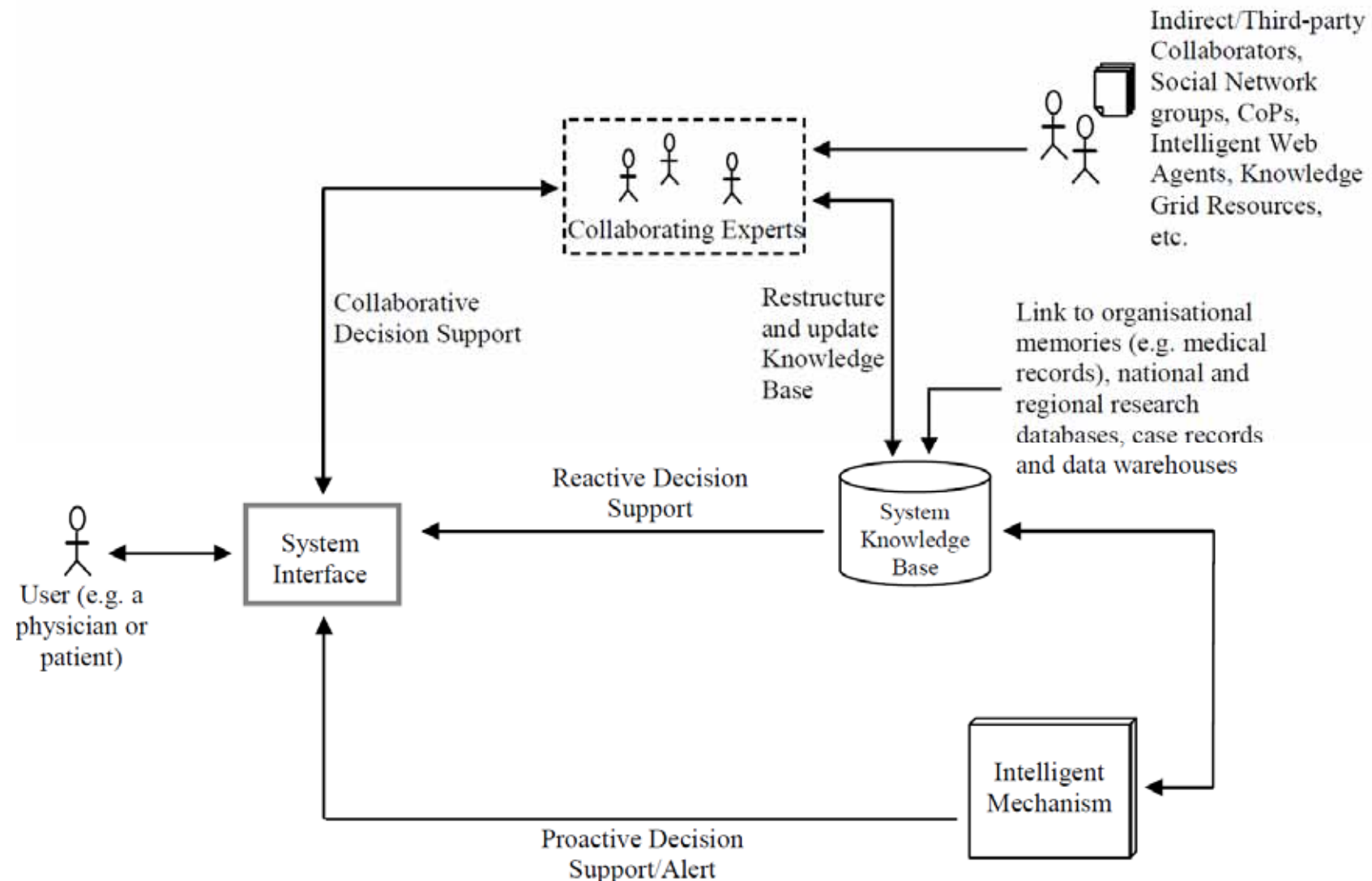
$$PD(s) = \max_{i=1 \dots k} P(C_i | s) \qquad P(C_i | s) = \frac{P(s | C_i)P(C_i)}{P(s)}$$

$$P(s) = P(s | C_i)P(C_i) + P(s | \bar{C}_i)P(\bar{C}_i)$$

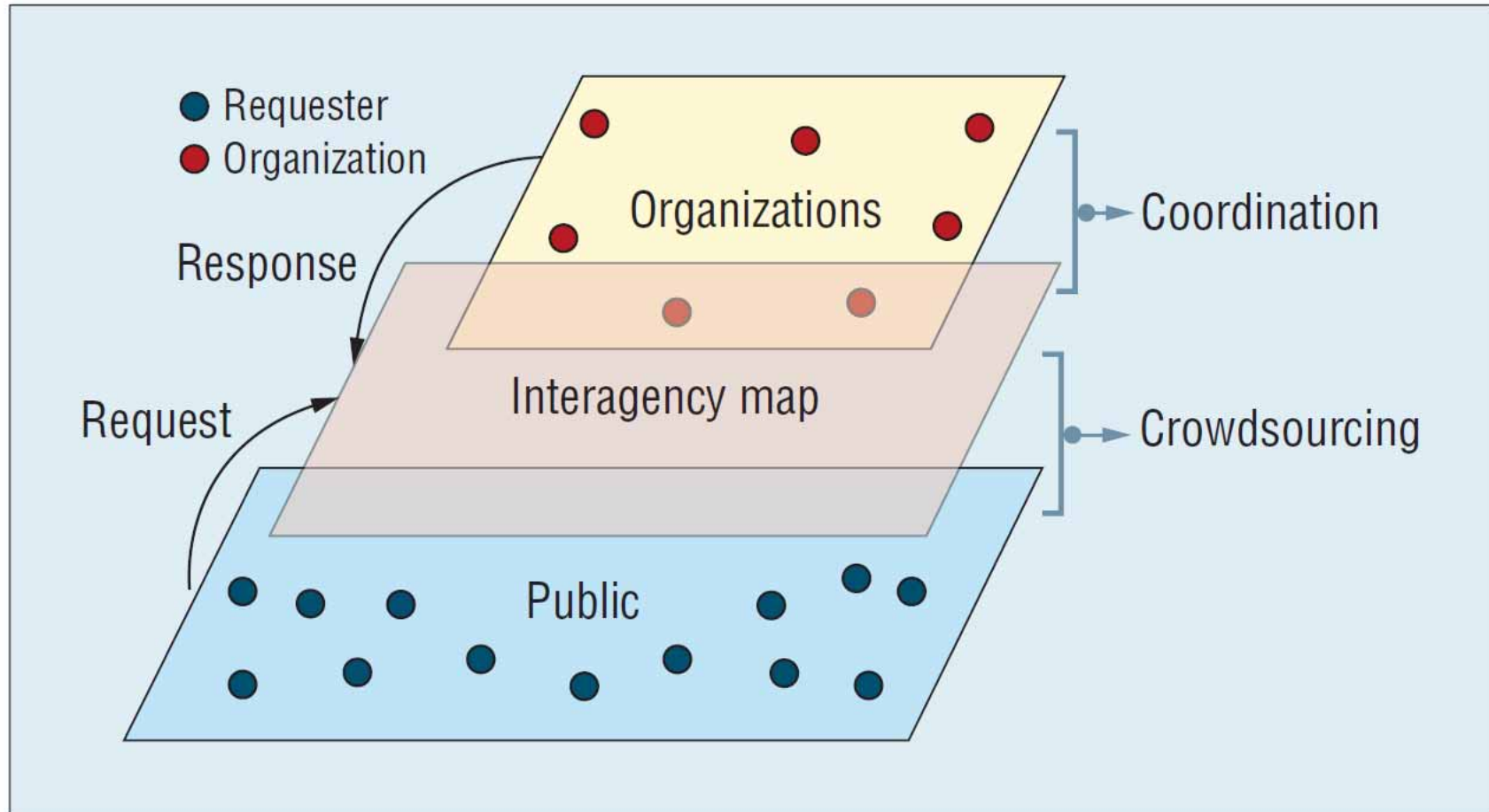
$$P(C_i | s) = \frac{P(s | C_i)P(C_i)}{P(s | C_i)P(C_i) + P(s | \bar{C}_i)P(\bar{C}_i)}$$

$$P(C_i | s) \approx \frac{N(C_i, s)}{N(s)}$$

Funk & Xiong (2006)



Anya, O., Tawfik, H. & Nagar, A. (2011) Cross-boundary knowledge-based decision support in e-health. *International Conference on Innovations in Information Technology (IIT)*. 150-155.



Gao, H., Barbier, G. & Goolsby, R. (2011) Harnessing the Crowdsourcing Power of Social Media for Disaster Relief. *Intelligent Systems, IEEE*, 26, 3, 10-14.

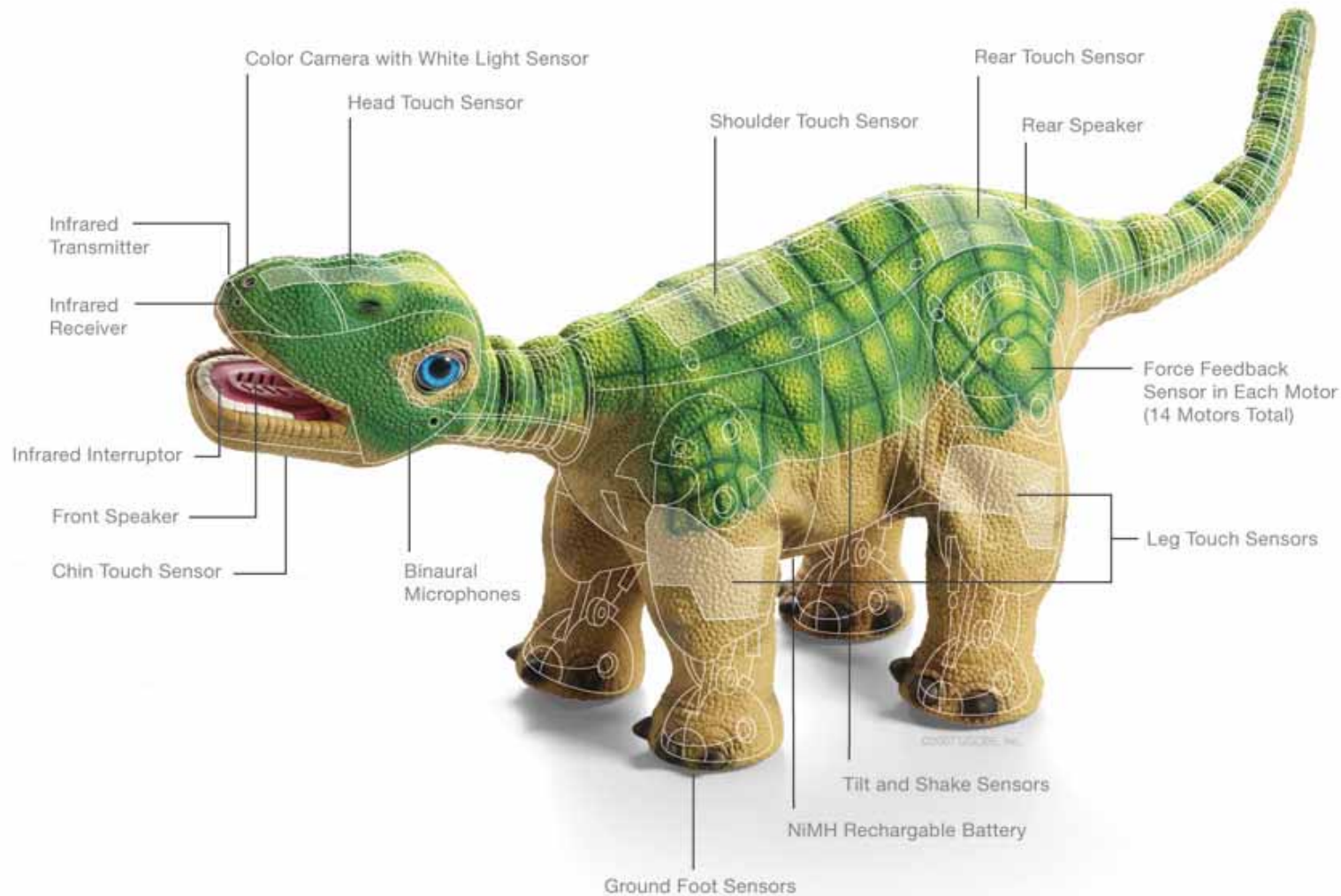
Horrible Histories - Napoleon Bonaparte v The Mechanical Turk

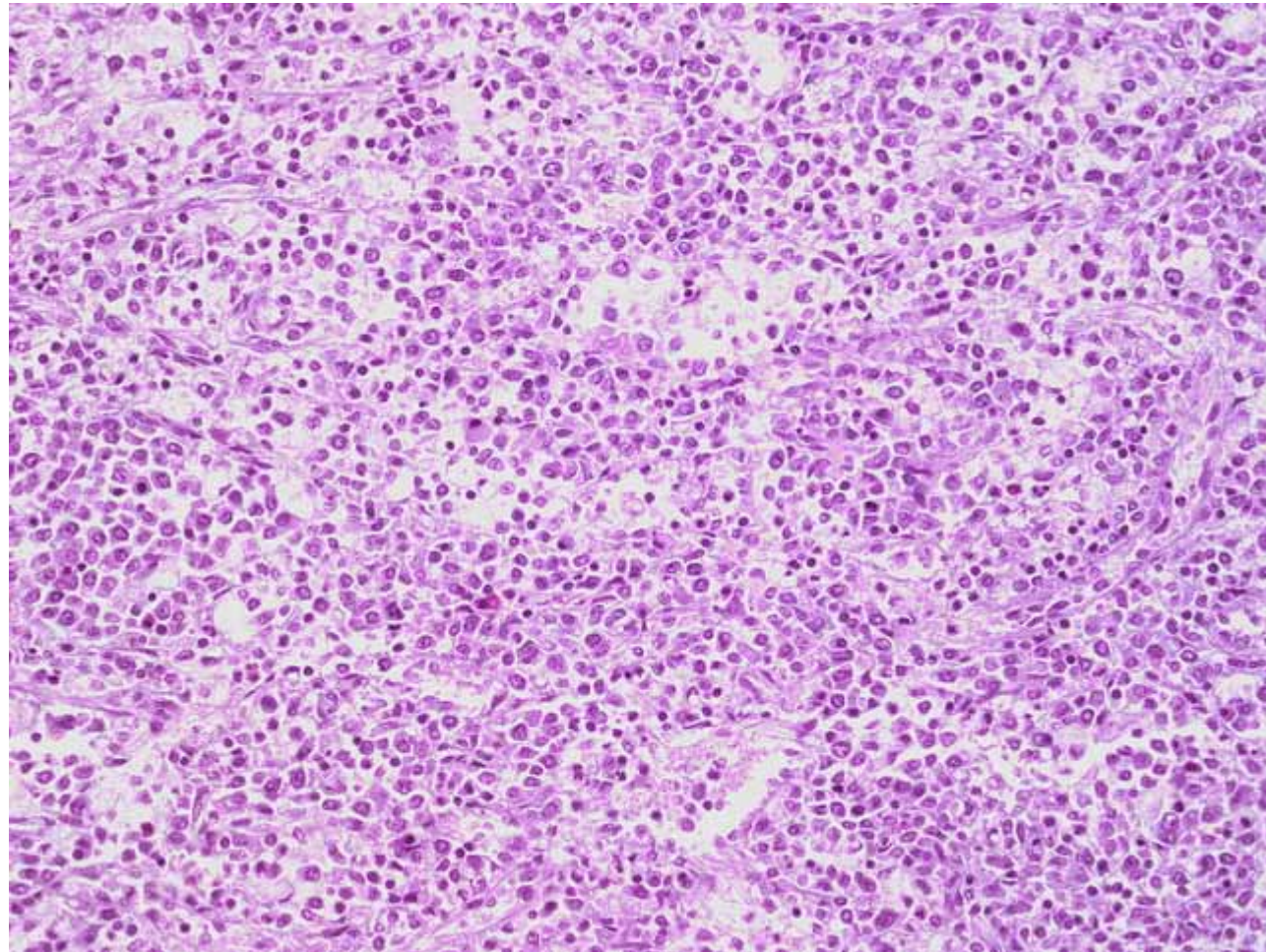
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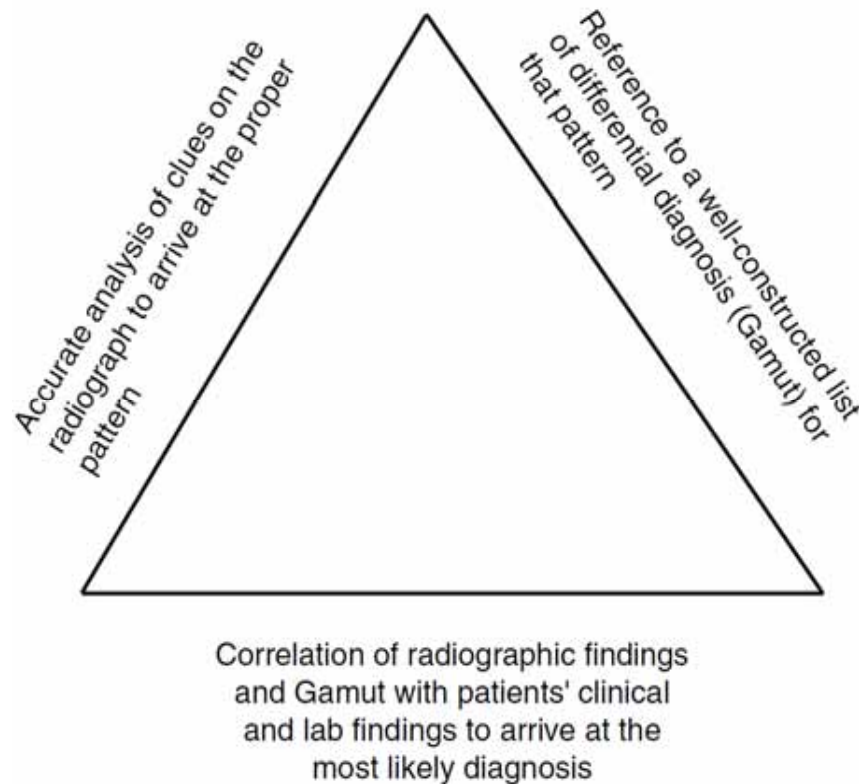
4 Videos ▾







This 79 y/o female with chronic myeloid leukemia presented with rapidly enlarging spleen. The splenectomy specimen showed a dark red surface devoid of white pulp. Majority of the large tumor cells seen here were positive for CD34. This is a case of chronic myeloid leukemia in **blast transformation (Richter's Syndrome)** Source: webpathology.com



Reeder, M. M. & Felson, B. 2003.
Reeder and Felson's gamuts in radiology: comprehensive lists of roentgen differential diagnosis, New York, Springer Verlag.

Gamut F-137

PHRENIC NERVE PARALYSIS OR DYSFUNCTION

COMMON

1. Iatrogenic (eg, surgical injury; chest tube; therapeutic avulsion or injection; subclavian vein puncture)
2. Infection (eg, tuberculosis; fungus disease; abscess)
3. Neoplastic invasion or compression (esp. carcinoma of lung)

UNCOMMON

1. Aneurysm_g, aortic or other
2. Birth trauma (Erb's palsy)
3. Herpes zoster
4. Neuritis, peripheral (eg, diabetic neuropathy)
5. Neurologic disease_g (eg, hemiplegia; encephalitis; polio; Guillain-Barré S.)
6. Pneumonia
7. Trauma

Reference

1. Prasad S, Athreya BH: Transient paralysis of the phrenic nerve associated with head injury. JAMA 1976;236:2532-2533

REEDER AND FELSON'S

GAMUTS IN RADIOLOGY

GAMUT G-25EROSIVE GASTRITIS*

COMMON

1. Acute gastritis (eg, alcohol abuse)
2. Crohn's disease **I** **I**
3. Drugs (eg, aspirin **I** **I**; NSAID **I**; steroids)
4. *Helicobacter pylori* infection **I**
5. Idiopathic
6. [Normal areae gastricae **I**]
7. Peptic ulcer; hyperacidity

UNCOMMON

1. Corrosive gastritis **I**
2. *Cryptosporidium* antritis
3. [Lymphoma]
4. Opportunistic infection (eg, candidiasis {moniliasis} **I**; herpes simplex; cytomegalovirus)
5. Postoperative gastritis
6. Radiation therapy
7. Zollinger-Ellison S. **I**; multiple endocrine neoplasia (MEN) S.

* Superficial erosions or aphthoid ulcerations seen especially with double contrast technique.

[] This condition does not actually cause the gamuted imaging finding, but can produce imaging changes that simulate it.

Reeder, M. M. & Felson, B. (2003) *Reeder and Felson's gamuts in radiology: comprehensive lists of roentgen differential diagnosis*. New York, Springer Verlag.

<http://rfs.acr.org/gamuts/data/G-25.htm>

- Type 1: Decisions related to the diagnosis, i.e. computers are used to assist in diagnosing a disease on the basis of the individual patient data. Questions include:
 - What is the probability that this patient has a myocardial infarction on the basis of given data (patient history, ECG)?
 - What is the probability that this patient has acute appendices, given the signs and symptoms concerning abdominal pain?

Bemmel, J. H. V. & Musen, M. A. 1997. *Handbook of Medical Informatics*, Heidelberg, Springer.

- Type 2: Decisions related to therapy, i.e. computers are used to select the best therapy on the basis of clinical evidence, e.g.:
 - What is the best therapy for patients of age x and risks y , if an obstruction of more than z % is seen in the left coronary artery?
 - What amount of insulin should be prescribed for a patient during the next 5 days, given the blood sugar levels and the amount of insulin taken during the recent weeks?

- Sometimes we do not have “big data”, where aML-algorithms benefit.
- Sometimes we have
 - Small number of data sets
 - Rare events
 - NP-hard problems (e.g. k-Anonymization, Protein-Folding, Graph Coloring, Subspace Clustering, ...)
- Then we still need the “human-in-the-loop”

