# 183.253 VO
# Informationssysteme des Gesundheitswesens

## Knowledge-based Systems

Reinhard Pitsch

reinhard.pitsch@inso.tuwien.ac.at

# Agenda

1. Knowledge-based Systems
2. Hepaxpert
3. Rheumexpert
4. Toxopert
5. Thyrexpert
6. Moni
7. FuzzyKBWean

# Knowledge-based Systems

**Motivation**

- Develop artificial systems making intelligent decisions available typically only provided by professionals.

**Advantages**

- Availability
- Reliability
- Explanation
- …

**Disadvantages**

- Use without criticism
- Closed world assumption
- Knowledge engineering
- Development costs
- Artificial systems are expected to be flawless
- Maintenance
- …

# Knowledge-based Systems

**Definition**

- A *knowledge-based system* is an artificial intelligent tool working in a narrow domain to provide intelligent decisions.
- Ein *wissensbasiertes System* ist ein intelligentes Informationssystem, in dem Wissen mit Methoden der Wissensrepräsentation und Wissensmodellierung abgebildet und nutzbar gemacht wird.

**Components**

- Knowledge base
- Inference engine
- User interface

# Knowledge-based Systems

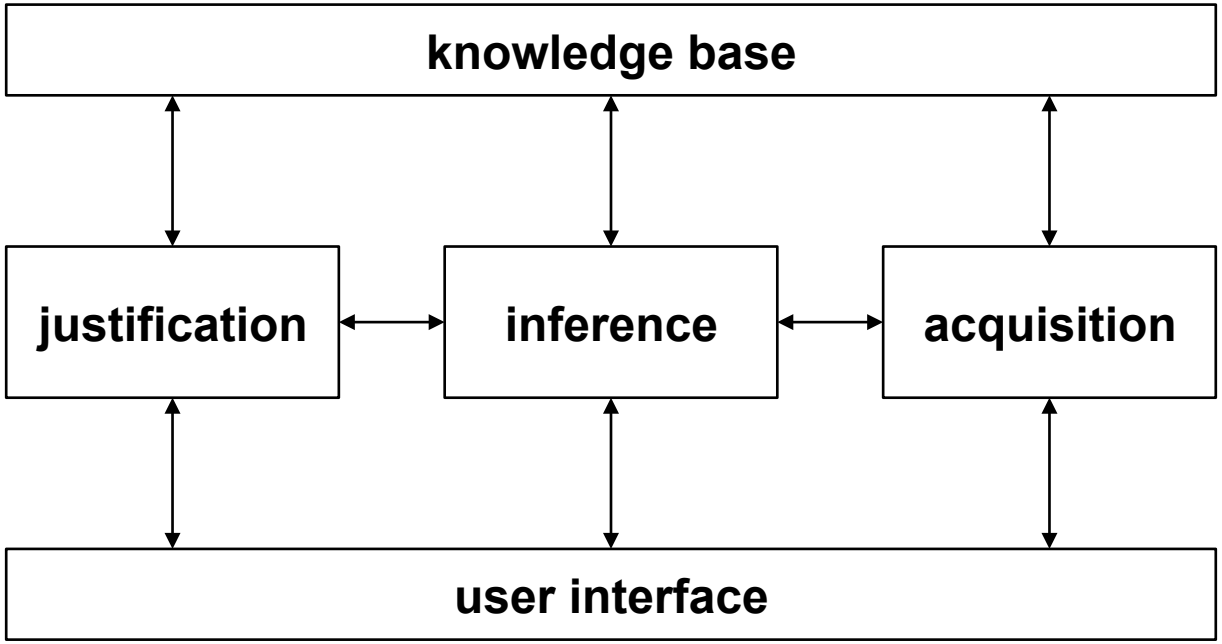
**Definition**

- An *expert system* is a computer system that emulates the decision-making ability of a human expert.
- Ein *Expertensystem* ist ein Computerprogramm, das Menschen bei der Lösung von komplexeren Problemen wie ein Experte unterstützen kann, indem es Handlungsempfehlungen aus einer Wissensbasis ableitet.

**Components**

- Knowledge base
- Inference engine
- User interface
- Justification
- Knowledge aquisition

# Knowledge-based Systems



# Knowledge-based Systems

**Components**

- Knowledge base
- Inference
- Justification (*user* acceptance)
- Acquisition
- Evaluation (*developer* acceptance, goldstandard)

**Interaction types**

| | |
|---|---|
| Consultant | active, current state |
| Influencer | passive, current state |
| Debiaser/watch dog | passive, current state |
| Pilot/director | active, accompanying |

# Medical Domain

**Integration**

- Data integration: Collaborative use of clinical data
- Functional integration: Provision of functionality of knowledge-based systems

**Systems**

- HIS, KIS, LIS, …
- Health insurance company
- ELGA, eCard, …

**Law**

- Pseudonymization
- Anonymization
- Privacy

# Medical Domain

**Typical references**

- MYCIN [Shortliffe 76] … diagnosis and therapy of bacterial infections. Introduced separation of rule-based knowledge base and inference.
- PIP (Present Illness Programm) [Pauker 76] … diagnosis of kidney diseases.
- CASNET [Kulowsky 82] … initially diagnosis of glaucoma only.
- INTERNIST-1 [Miller 82] … should support physicians in diagnosing of 75% of all internistic diseases.

# References


**Informatikhandbuch**

- Herausgeber: Peter Rechenberg, Gustav Pomberger
- Verlag: Carl Hanser Verlag München Wien
- 2. Auflage, 1999

**Handbuch der Medizinischen Informatik**

- Herausgeber: Thomas M. Lehmann
- Verlag: Carl Hanser Verlag München Wien
- 2. Auflage, 2005

**Basiswissen Medizinische Statistik**

- Herausgeber:
- Verlag:Springer-Verlag Berlin Heidelberg New York
- 2. Auflage, 2002

# Examples

**Medical University of Vienna**

- Section on Medical Expert and Knowledge Based Systems of the Core Unit for Medical Statistics and Informatics
- Some Systems
  - Hepaxpert
  - Rheumexpert
  - Toxopert
  - Thyrexpert
  - Moni
  - FuzzyKBWean

# Hepaxpert

**Hepaxpert®; Knowledge-based decision support for hepatitis A, B, and C serology test results**

- People
  - Wolfgang Horak (Univ.-Prof. Dr. med.)
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
  - Reinhard Pitsch (bachelors thesis, medical informatics)
- Development of the knowledge base
  - Investigation (medical experts, books)
  - Simple/flat if-then-rules
  - Pre-Interpretation of single diagnostic findings
  - Interpretation of whole diagnostic findings
- Status
  - KFJ Vienna (Kaiser-Franz-Josef-Spital)
  - Consideration of „time lapse“ currently developed
  - AKIM

# Hepaxpert

**Rule I-10:**

IF

| anti-HAV | IgM anti-HAV | HAV (stool) |
|---|---|---|
| + | – | – ± • |

| | | |
|---|---|---|
| + | = | positive |
| – | = | negative |
| ± | = | borderline |
| • | = | not measured |

THEN

Positive results for total anti-HAV antibodies in combination with negative results for IgM anti-HAV antibodies indicate immunity to the hepatitis virus A and exclude the possibility of a recent hepatitis A. This immunity may either have been acquired naturally through an earlier infection or it may have been induced by active vaccination or passively acquired immunization.

| anti-HAV | | IgM anti-HAV | | HAV (Stool) |
|---|---|---|---|---|
| positive | AND | negative | AND | negative |
| | | OR | | |
| positive | AND | negative | AND | borderline |
| | | OR | | |
| positive | AND | negative | AND | not measured |

# Rheumexpert

**Rheumexpert bzw. RheumaDiff®; Differential diagnostic decision support in rheumatology**

- People
  - Gernot Kolarz (Univ.-Prof. Dr. med.)
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
  - Reinhard Pitsch (bachelors thesis, medical informatics)
- Development of the Knowledge Base
  - 615 symptoms - 71 symptom groups
  - 3 main diagnoses - 7 sub diagnoses
  - Target group: general practitioner
  - Suspection- and exclusion-diagnoses
  - Evaluation
  - Certainty factors (MYCIN; Shortliffe and Buchanan, 1975)
- Status
  - AKIM

# Rheumexpert

**Rheumexpert bzw. RheumaDiff®; Differential diagnostic decision support in rheumatology**

- Inference
  - Data-Symbol-Conversion
  - Certainty factors
  - Correction
  - Interpretation
- Architecture
  - Client/Server, relational DBMS
  - Multi-client capability, versioning
  - Consultation
  - Explanation
  - Knowledge acquisition
  - Evaluation

# Toxopert

**Toxopert®; Knowledge-based decision support for toxoplasmosis serology test results**

- People
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
  - Nadejda Anastassova (phd thesis, physician)
  - Christoph Adl (masters thesis, medical informatics)
- Development of the knowledge base
  - Automata theory (deterministic finite automaton)
  - Crisp and fuzzy Implementation
  - Gain and expense of fuzzyfication
  - Issues: accurracy versus acceptance
- Status
  - AKIM

# Toxopert

**Toxopert®; Knowledge-based decision support for toxoplasmosis serology test results**

- Pathogen: Toxoplasma gondii
- Primary infection during pregnancy in the second or third trimester
- Toxoplasmosis screening in Austria since 1975 („Mutter-Kind-Pass“)
- Diagnosis (General Hospital of Vienna)
  - SFT-Test; Sabin-Feldman-Dye-Test (titre, sensitivity, specifity, goldstandard)
  - ISAGA-IgM (acute/latent)
  - Toxo-IgG-Avidity (bond strength of antibody and antigen)
  - PCR (direct evidence of protozoa in the amniotic fluid)

# Thyrexpert

**Thyrexpert®; Knowledge based interpretation of thyroid hormone test results**

- People
  - Heinrich Vierhapper (Univ.-Prof. Dr. med.)
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
  - Martin Reitstätter (phd thesis, informatics)
- Development of the Knowledge Base
  - TSH, T4, T3, and TRH-Test
  - Via XML sheet + export function
  - Interpretation versus Reminder
  - „Completing the Knowledge Base“
- Status
  - AKIM

# Thyrexpert

**Thyrexpert®; Knowledge based interpretation of thyroid hormone test results**

- Interpretation vs. Reminder
- Diagnosis (General Hospital of Vienna)
  - TSH (thyroid stimulating hormone)
  - T4 (total thyroxin)
  - T3 (trijodthyronin)
  - TBG (thyroxin-bindendes Globulin)
  - TRH-Test (thyroid releasing hormone (TRH) stimulated TSH)

# Moni

**Moni®; Microbe and infection alert, monitoring, and surveillance systems**

- People
  - Alexander Blacky (Dr. med.)
  - Walter Koller (Univ.-Prof. Dr.med.)
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
  - Harald Mandl (formerly Heisz, Mag. rer. nat. Dr. techn.)
- Development of the Knowledge Base
  - Surveillance of nosocomial infections
  - Adapted from published CDC, HELICS, and KISS rules
  - „Data Mining“
  - Gain (Patient Health, Money)
- Status
  - Test and Development at General Hospital of Vienna (AKH-Wien)
  - AKIM

# Moni

**Moni®; Microbe and infection alert, monitoring, and surveillance systems**

- Nosocomial Infections
- Surveillance
- Dimensions (Koller, AKH, 2006)
- 5% of all in-patients
- 7500 NI per 1.000.000 per year (EU: 3.000.000 NI/year)
- Costs/NI:
  - 2.225 € (US'92)
  - 3.100 € (BE'98)
  - 5.200 € (UK'99)
  - 1-2% mortality
- Causes for Costs
- Hospital expenses (employees, medicine, lab, etc.)
- Post-discharge costs,

# Moni

**Moni®; Microbe and infection alert, monitoring, and surveillance systems**

- Antibiotic Resistance
  - Broad-spectrum antibiotic
  - Inappropriate prescribing of antibiotics
  - Unnecessary prescribing of antibiotics
- Intensive Care Units
- Potential (Haley et al. Am J Epidemiol 1985; 121(2):182-205)
  - infection of the wound (35%)
  - urinary tract infection (31%)
  - pneumonia (28%)
  - septicemia (35%)

# FuzzyKBWean

**FuzzyKBWean®; Knowledge Based Weaning from Artificial Ventilation**

- People
  - Christian Schuh (Dipl.-Ing., phd thesis)
  - Klaus-Peter Adlassnig (Univ.-Prof. Dr. techn.)
- Development of the Knowledge Base
  - Direct cooperation with General Hospital of Vienna
  - Data Privacy Issues
  - Open Loop
- Status
  - „Closed Loop“
  - AKIM