Artificial Intelligence im industriellen Umfeld

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für Artificial Intelligence

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What is Artificial Intelligence?

Systems that think like humans	Systems that think rationally
"The exciting new effort to make computers think... machines with minds, in the full and literal sense" (Haugeland, 1985)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985)
"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning..." (Bellman, 1978)	"The study of the computations that make it possible to perceive, reason and act" (Winston, 1992)
Systems that act like humans	**Systems that act rationally**
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990)
"The study of how to make computers do thinks at which, at the moment, people are better" (Rich and Knight, 1991)	"The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

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History of AI

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's *Computing Machinery and Intelligence*
1952-69	Look, Ma, no hands! - Phase
1950s	Early AI programs: Samuel's checkers, Newell & Simon's Logic Theorist; Winograd's Blocks World
1956	Dartmouth meeting: Artificial Intelligence adopted
1965	Robinsons complete logical reasoning algorithm
1966-74	AI discovers computational complexity
1969-79	Early development of knowledge-based systems
1980-88	Expert systems industry booms
1988-93	Expert systems industry busts: "AI Winter"
1988-	Resurgence of probability; increase in techn. depth "Nouvelle AI": ALife, GAs, soft computing
1995-	Agents metaphor, Bayes Theory, Machine Learning

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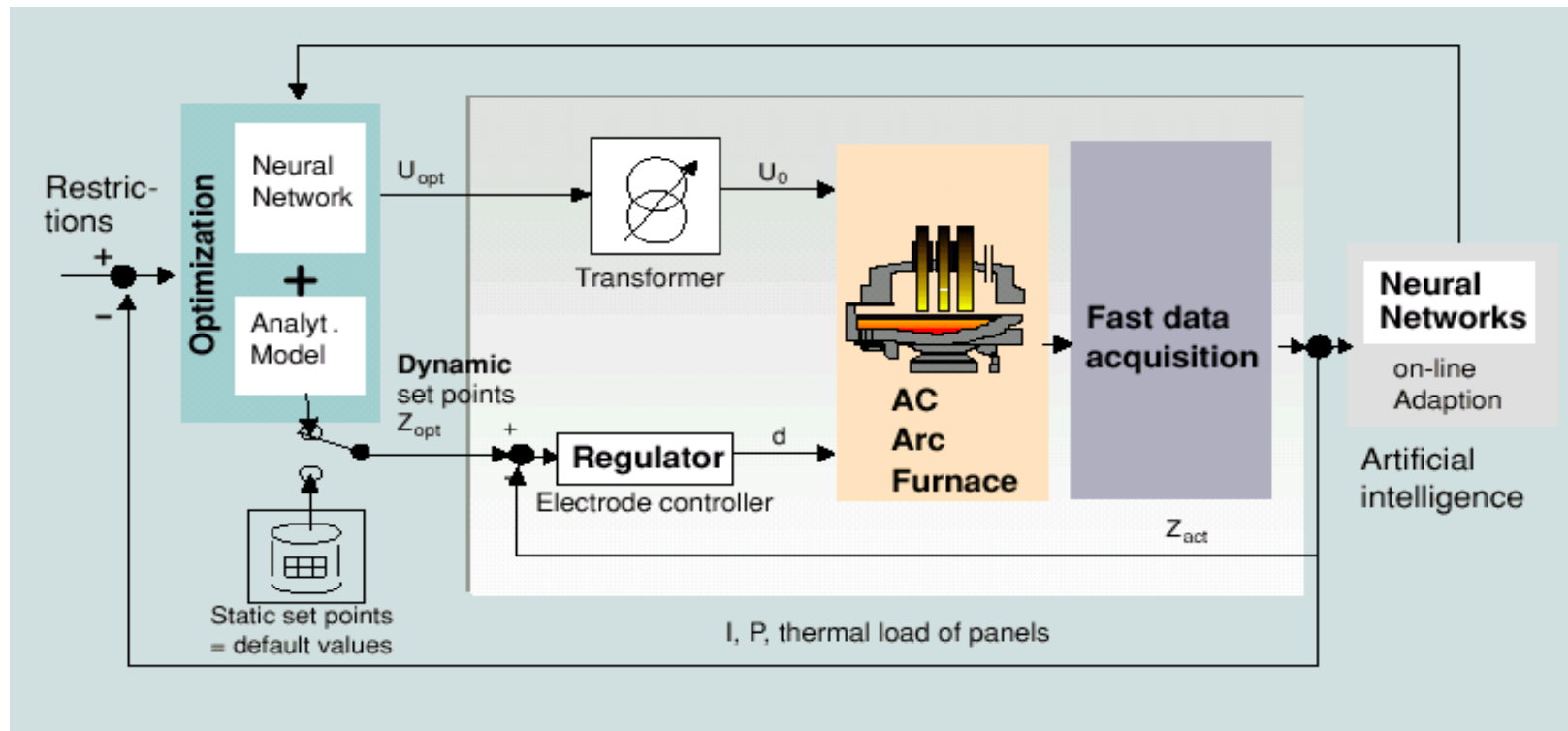alex@seewald.at / alex.seewald.at

Vacuum cleaning robots

Percepts: clean/dirty, wall, stairs

Actions: move, rotate, clean

Goals: maximize amount of dirt collected / cleanliness

Environment: single-level household

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- Optimization of melting process with NN and analytical model: Steel production +6,0%; Energy consumption -3,1%

- Autopilot for one-person sailing
- Race-proven with various state-of-the-art AI and ML components.
- Human jargon like *gust, close-hauled, luff* as background knowledge!

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- Commercially available guard robot, developed and produced by German company.
- Navigation along fixed path, identification of any unknown object with fingerprint sensor.
- Works in static environments, Operator cancels false alarms.
- Focus on supporting humans, not replacing them!

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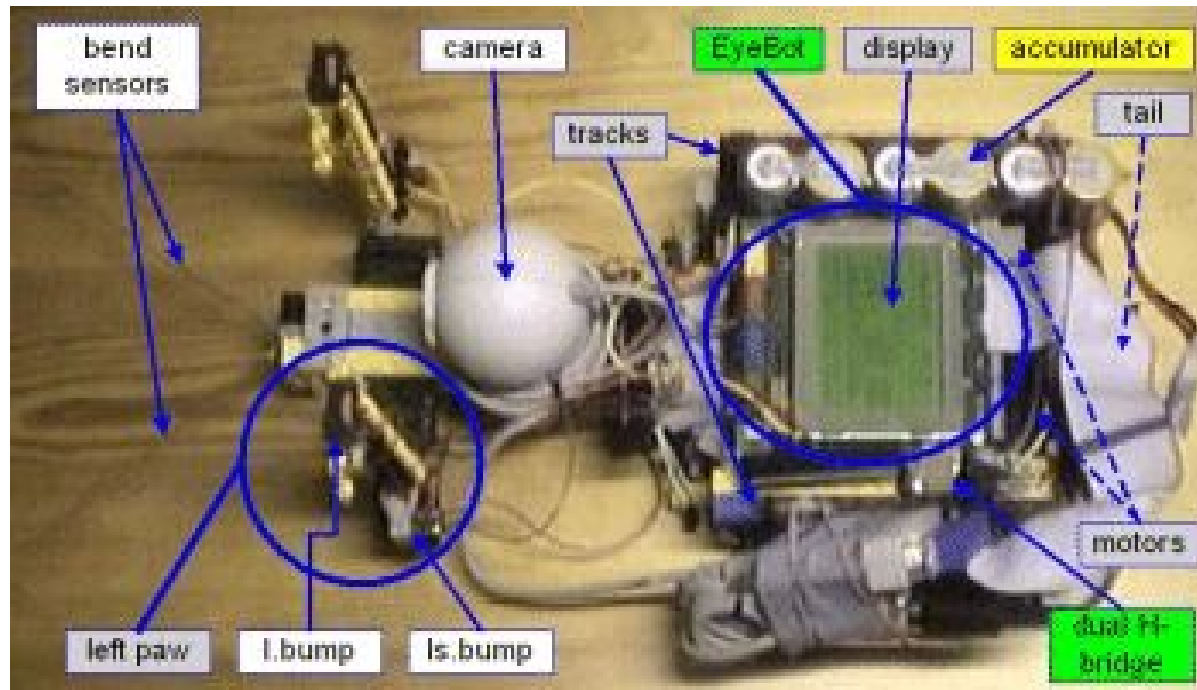
RoboCat (Seewald, 1999; Diploma thesis) is a mobile robot toy cat, whose design was inspired by ethology (Tinbergen's central hierarchy)

- **Search / Problem Solving**
- **Knowledge and Reasoning; Planning**
- **Acting under Uncertainty**
- **Decision Theory**
- **Communication / NLP**

- **Learning**

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A problem consists of: the **initial state**, a set of **operators**, a **goal test** function, and a **path cost** function. The environment of the problem is represented by a **state space**.
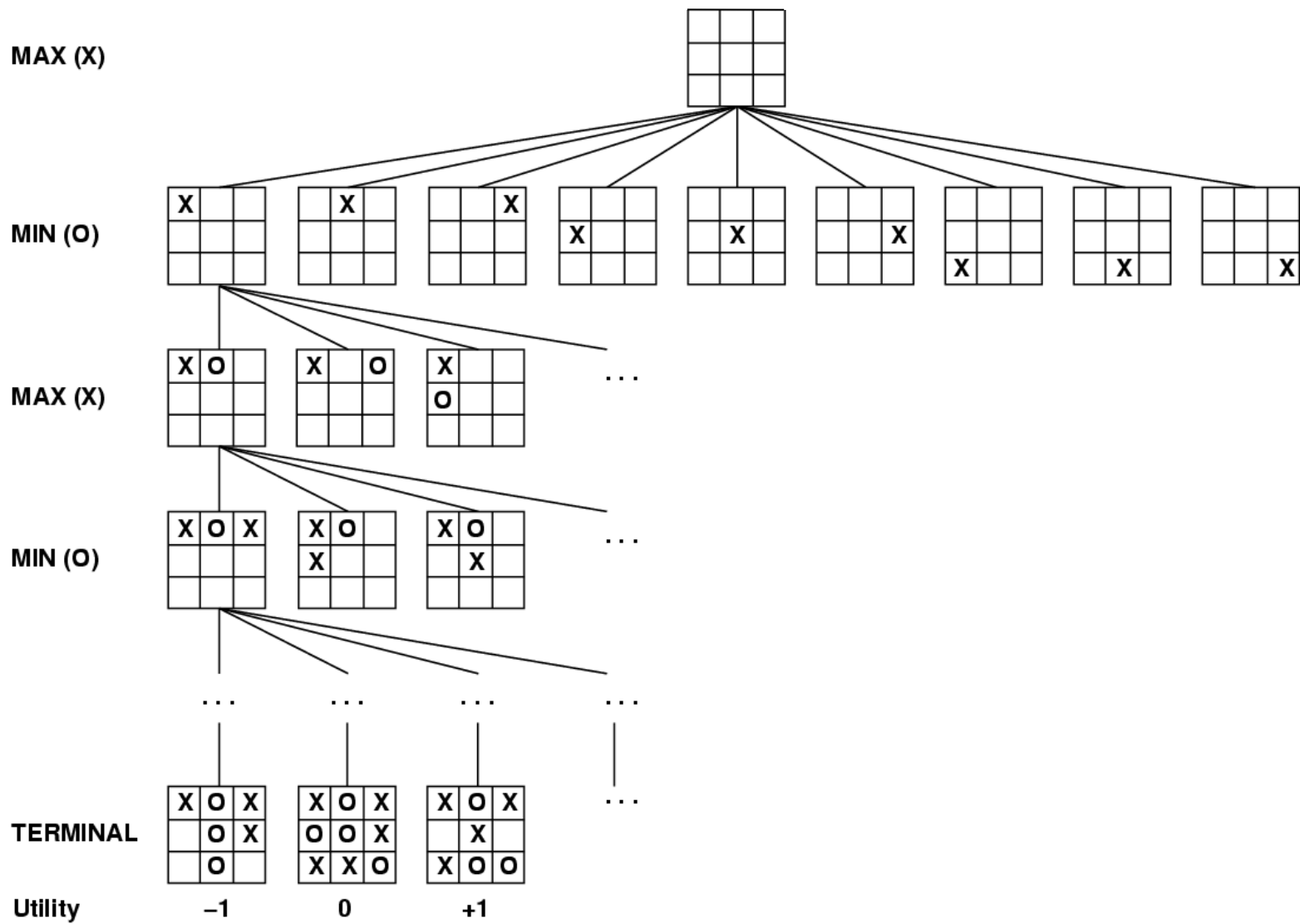

Start State

Goal State

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The process of representing knowledge consists of deciding what kinds of **objects** and **relations** (= the ontology) need to be represented. Then a **vocabulary** is selected, and used to encode general knowledge of the domain.

Constructing **knowledge-based systems** has advantages over programming, but is not feasible for all problems. State-of-the-Art are **embedded AI** systems, where AI is used complementary to other programming techniques.

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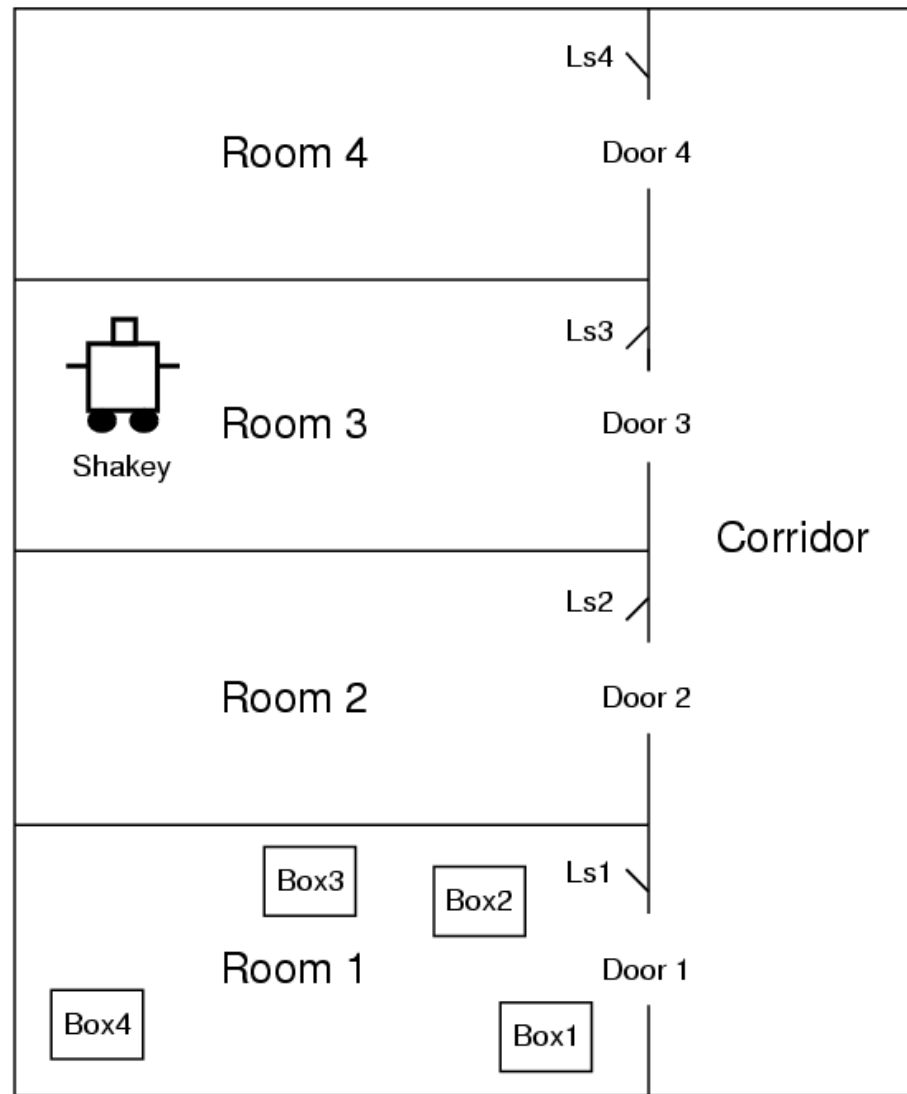alex@seewald.at / alex.seewald.at

- Knowledgebased system for neo-natal nutrition
- Rules derived from expert knowledge.
- HTML-based interface.
- In clinical use for >5 years at AKH Vienna

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Planning systems can be seen as efficient special-purpose reasoning systems designed to reason about actions; or as efficient search algorithms for the space of possible plans.

Automatic planners and schedulers have proven capable of handling complex domains such as **spacecraft missions** and **manufacturing.**

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Uncertainty is inescapable in complex, dynamic or inaccessible worlds; and means that many simplifications that are possible with deductive inference are no longer valid. **Probability theory** provides a way of summarizing the uncertainty that comes from laziness and ignorance.

Belief networks are a natural way to represent conditional independence information.

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A Simple Belief Network: Burglar Alarm
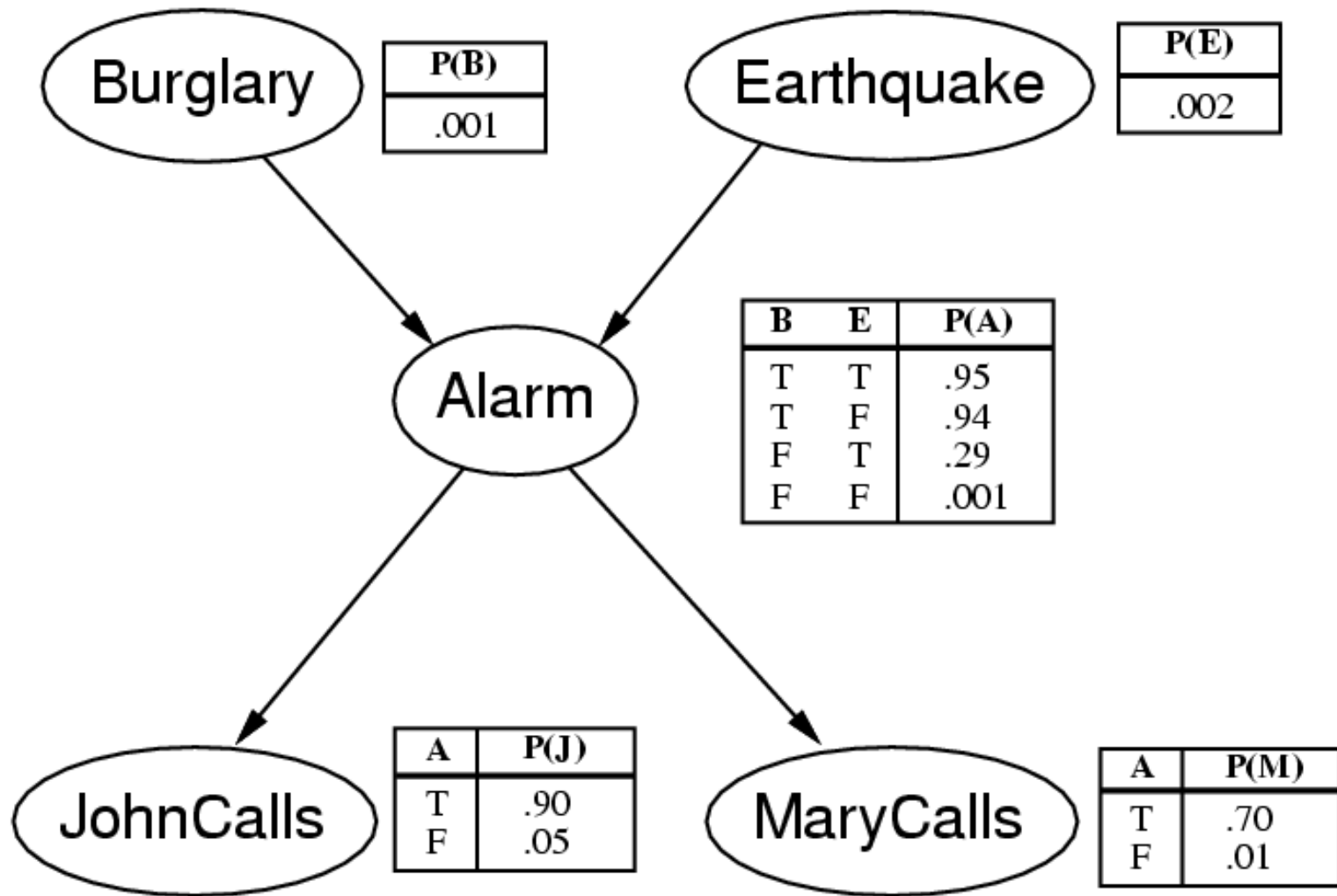
Simple decision problems can be solved by **decision theory**, which relates what to want (**utility theory**) and what to believe on the basis of evidence (**probability theory**).

Decision theory is **normative** - it describes rational behaviour. It is probably not **descriptive** - people systematically violate the axioms of utility theory.

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What would you prefer?

A)   80% chance of winning €4000

B) 100% chance of winning €3000

[Allais, 1953] found that people strongly prefer B)

C) 20% chance of winning €4000

D) 25% chance of winning €3000

[Allais, 1953] found that people strongly prefer C)

No consistent utility theory for humans is possible!

$0.8U(€4000)<U(€3000)$ and $0.25U(€3000)<0.2U(€4000)$ cannot both be satisfied.

Natural language processing techniques make it practical to develop programs that make queries to a database, extract information from texts, translate languages, or recognize spoken words.

In all these areas, there exist programs that are useful, but there are no programs that do a throrough job in an open-ended domain.

"one of the biggest **breakthroughs** in music recognition"
- BBC

Shazam Entertainment has developed a new service which identifies music over any mobile phone. In the UK, we have had over 1 million calls in less than nine months.
Shazam's database contains over 1.7 million tracks, and we are now taking our service to other countries, and finding new applications - both mobile and non-mobile - for this revolutionary technology.

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AI as Programming Metaphor

- Procedural (classic) programming
- Object-oriented programming
- Declarative/constraint logic programming
- Knowledge-based software engineering
- Agent-based software engineering

...

Each of these gives an unique viewpoint on programming; makes solving some problems easier and others harder... *But* you still need a programmer!

For learning systems, you don't!

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Learning a function from examples of its inputs and outputs is called **inductive learning**. Learning in the inductive setting is supervised and needs a set of training inputs and outputs.

Inductive logic programming can learn relational knowledge, as used in knowledge-based systems. This kind of learning is generally very hard.

Unsupervised learning uses the structure of training data to infer hidden relationships.

Within the EU IST project *Systemic Intelligence for Growing up Artifacts that Live (SIGNAL),* our robotics group is currently involved in creating a general learning agent.

Human-level intelligence is still decades if not centuries away - useful learning systems are already here.

ÖFAI Projects

Automated sleep staging (SIESTA, EU project)

- Sleep staging from EEG data; Spin-Off company: *The Siesta Group*

A Meta-Learning Assistant for Providing User Support in Machine Learning and Data Mining (METAL, ESPRIT-LTR EU project)

Biological Textmining (BioMinT, QLRI EU project)

Automated Quality Control for Industrial Printing (MONOTONE)

Commercial projects

- The Use of Machine Learning Methods for Quality Prediction in Steel Casting (+ Data Mining Library) for VÖEST-Alpine.
- Risk analysis for an Austrian insurance company.
- Sales forecasting for a large Austrian supermarket chain.
- Discovering inefficiencies in supply chains of international firms.

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