- What is AI and When is it AI?

Rational behavior based on
- ↳ previous knowledge
- ↳ observations
- ↳ Success measurements

} (What not how) → Rational Agent

- Strong AI
  - a, Reasoning
  - b, Decisions in Uncertainty
  - c, Planing
  - d, Learning
  - e, Natural communication

- Weak AI a, Specific fields

Symbolic vs Sub-Symbolic :

↑ Symbols, understandable

↖ representation of brain

Schools of Thought

Deductive Reasoning

general → specific

↑

VB, Asumptich

Rules needed

Inductive Learning.

specific → general

↑

Learn from Specific via Algorithm

Data needed

Agent

→ acts in Env

Types: 1, Reflex Agents
2, Reflex Agents with State
3, Goal-Based Agent
4, Utility-Based Agent
5, General Learning Agent

Envs

Performance → measure
Environment → area, state
Actuators → Actions
Sensors → Lookaround

PEAS

Types: 1, Observable (fully / Partially)
2, Deterministic / Stocastic
3, Episodic / Sequential
4, Static / Semidynamic / dynamic
5, Discrete / continuous
6, Single-agent / multi-Agent

Search

[Problem-solving Agents]

- Initial State
- Expand nodes
- Goal state
- Path cost
- Actions

BFS
DFS
A*
Heuristic - Degering

Adversorial Search (gegensätzlich) z.b. Mini Max

Alpha - Beta - Pruning

Local Search

- Path is irrelevant
- Goal itself is solution
- Goes always to a just better state
- Iterative Improvement
- More systematic

Hill-Climbing

Simulated-Annealing

/ Cost Function is key \

Logic

[Goal - Driven - Agents]

Implicit knowledge

- State of Problem implicit encoded.

Explicit Knowledge

- Knowledge Base

Wumpus

P : +1000 escape with gold; -1000 killed; -10 using Arrow; -1 action

E : 4x4 Grid; init state; chances

A : Forward; TurnLeft; Turn Right; Shoot; Take; Climb

S : Smell; Breeze; Glitter; Bump; Scream

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characterization of Environment

Observable: No, only local perception
Deterministic: Yes, outcomes exactly specified
Episodic: No, sequential at the level of actions
Static: Yes, Wumpus and Pits don't move
Discrete: Yes
Single-Agent: Yes, Wumpus is just a natural feat.

Logical Entailment

Sentence : α

World : m

"m is a model of α"
iff α is satisfied in m

All possible models for α : $M(\alpha)$

Entailment: $M(\alpha) \subseteq M(\beta)$ or $\alpha \models \beta$

$KB \models \alpha$

"KB entails sentence α"

Inference & Model Checking

Model checking is a Inference algorithm

↳ Deriving a sentence from a KB

$KB \vdash_i \alpha$

Inference Algos Properties:

Sound: (maintains truth) if it only returns sentences that can be infered from KB $KB \vdash_i \alpha \Rightarrow KB \models \alpha$

Complete: if it can infer all conclusions from a KB

$KB \models \alpha \Rightarrow KB \vdash_i \alpha$

Propositional Logic

'$\Rightarrow$' implication $(\neg a \vee b)$

'$\Leftrightarrow$' equivalenz $(a \Rightarrow b \wedge b \Rightarrow a)$

Validity -> true in all models (tautology)

$(\alpha \vee \neg\alpha \; ; \; \alpha \Rightarrow \alpha)$

Satisfyability -> true in at least 1 sentence.

Reductio Ad Absurdum

$KB \models \alpha$ iff $KB \wedge \neg\alpha$ is not satisfiable

Inference via a) Modus Ponens

b) Elimination of And $\left(\frac{\alpha \wedge \beta}{\alpha}\right)$

c) Logical Equivalence $\left(\frac{\alpha \Rightarrow \beta}{\neg\alpha \vee \beta}\right)$

Definitive Clauses

Disjunction with **EXACTLY** 1 positive literal

$\neg\alpha \vee \neg\beta \vee \gamma$

Horn Clauses

Disjunction with **At most** 1 positive Literal

$$\neg\alpha \vee \neg\beta \vee \neg\gamma$$

Propositional Logic

Describes the world m with facts

+	−
– declarative language – negation, disjunction, partial infos – context independent	– Limited expressive power

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First Orders Logic

Describes the world m with objects, relations and functions

"is to the right" → $\forall u \forall v$ is_further_right(u, v)

Interpretation I of a model m is a mapping from constants and variables to objects and names.

Universal Quantifiers

$\Rightarrow$ for $\forall x$

$\wedge$ for $\exists x$

$a \Rightarrow b \Rightarrow c$

Transform FOL → Propositional Logic

1. Universal quantifier → universal instantiation
2. Existential quantifier → constant instance
3. Predicat → symbol

Semidecidable Entailment

A FOL with functions cannot be transformed into a finite KB in propositional Logic

FOL Inference Algo (answer querys)

* Unification *

$$Unify(p, q) = \theta$$

with the Generalized Modus-Ponens (GMP)

Resolution

1. KB and α to CNF
2. $KB \wedge \neg \alpha$ $\square$

For FOL it needs to be transformed to

1. Prenex normal form

first and then use

2. Skolemization

Learning

Agent who improves its performance.

↳ no intelligence without learning

Supervised Learning

find a function f' that aproximates a function f that generates tuples y e.g. (x_1, y_2)

discrete output → classification problem

continuous output → regression problem

Decision Trees (classification)

disjunction of conjunction of constrains

(outlook = overcast ∧ humidity = normal) ∨ (outlook = overcast)

Mission: find the smallest possible tree consistent with the training data

small generalized

How?

1. Find feature with largest IG (information gain)
   - ↳ use entropy for this
2. If pure, create leaf
3. Repeat.

Entropy Algorithm

	Outlook	Temperature	Humidity	Wind	Play Tennis
0	Sunny	Hot	High	Weak	No
1	Sunny	Hot	High	Strong	No
2	Overcast	Hot	High	Weak	Yes
3	Rain	Mild	High	Weak	Yes
4	Rain	Cool	Normal	Weak	Yes
5	Rain	Cool	Normal	Strong	No
6	Overcast	Cool	Normal	Strong	Yes
7	Sunny	Mild	High	Weak	No
8	Sunny	Cool	Normal	Weak	Yes
9	Rain	Mild	Normal	Weak	Yes
10	Sunny	Mild	Normal	Strong	Yes
11	Overcast	Mild	High	Strong	Yes
12	Overcast	Hot	Normal	Weak	Yes
13	Rain	Mild	High	Strong	No

Source: Mitchell - Machine Learning

$S = [9+, 5-]$

↑ outcome

$$\text{Entropy}(S) = -\frac{9}{14}\log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right) = 0.94$$

↑ Information

$$\text{Entropy}(S) - \frac{3}{14}\,\text{Entropy}(\text{Feature}_+) - \frac{11}{14}\,\text{Entropy}(\text{Feature}_-) = IG(S, \text{Feature})$$