Logical Agents

Slides adopted from
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Week 6: Introduction to logical agents

Week 7: Logical reasoning

Week 8: Knowledge representation

Week 9: Planning

Outline

Fundamental concepts

General principles of logic

Propositional logic

First order logic

Agents

Problem solving agent

- Solution is given, the agent executes it
- Might not face dynamic problems well

Knowledge based / Planning agents

- Given explicit goals
- Can achieve competence quickly by being told or learning
- Adapt to changes in environment

Knowledge-based Agents

Maintain a representation of the world

infer new representations of the world

Use the representation to decide what to do

representation -> reason -> take action

Representations

Atomic:
State considered as a whole, No internal structure available to the agent

Factored:
Assignment of values to variables

Structured:
Objects and relations
Facts: knowledge about relations

Knowledge ?

“Knowing things which helps to reach goals efficiently”

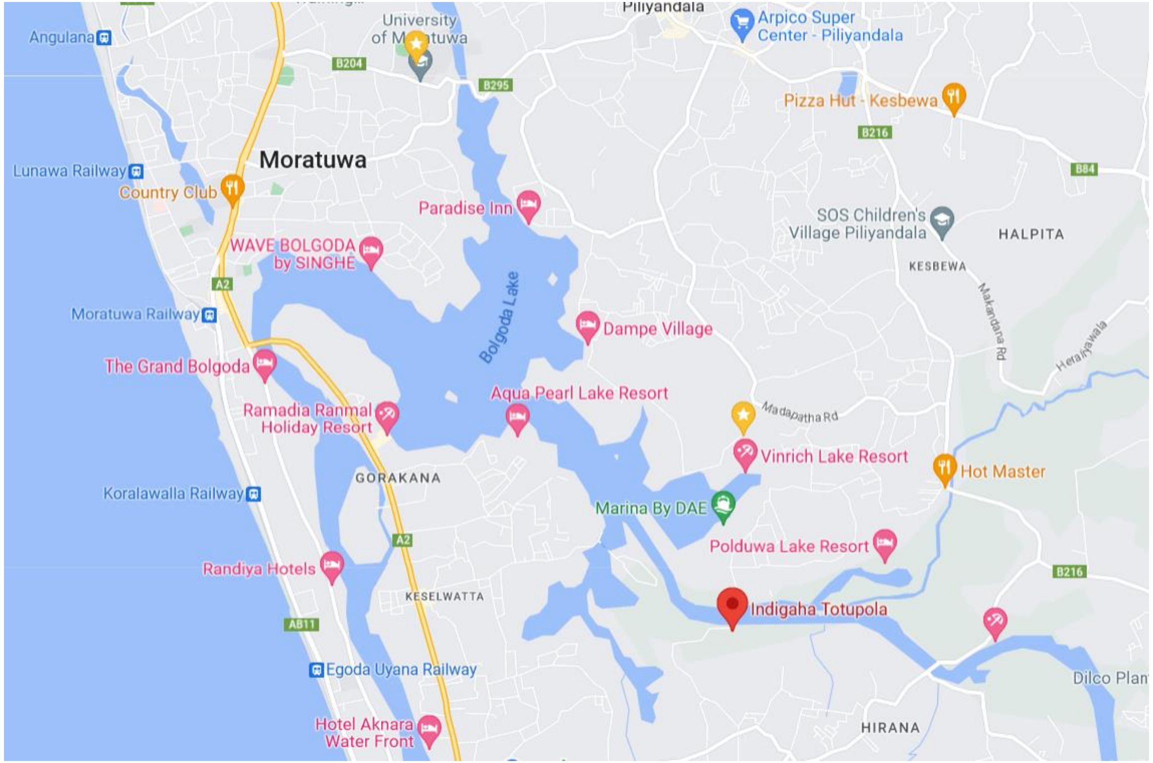
Example:

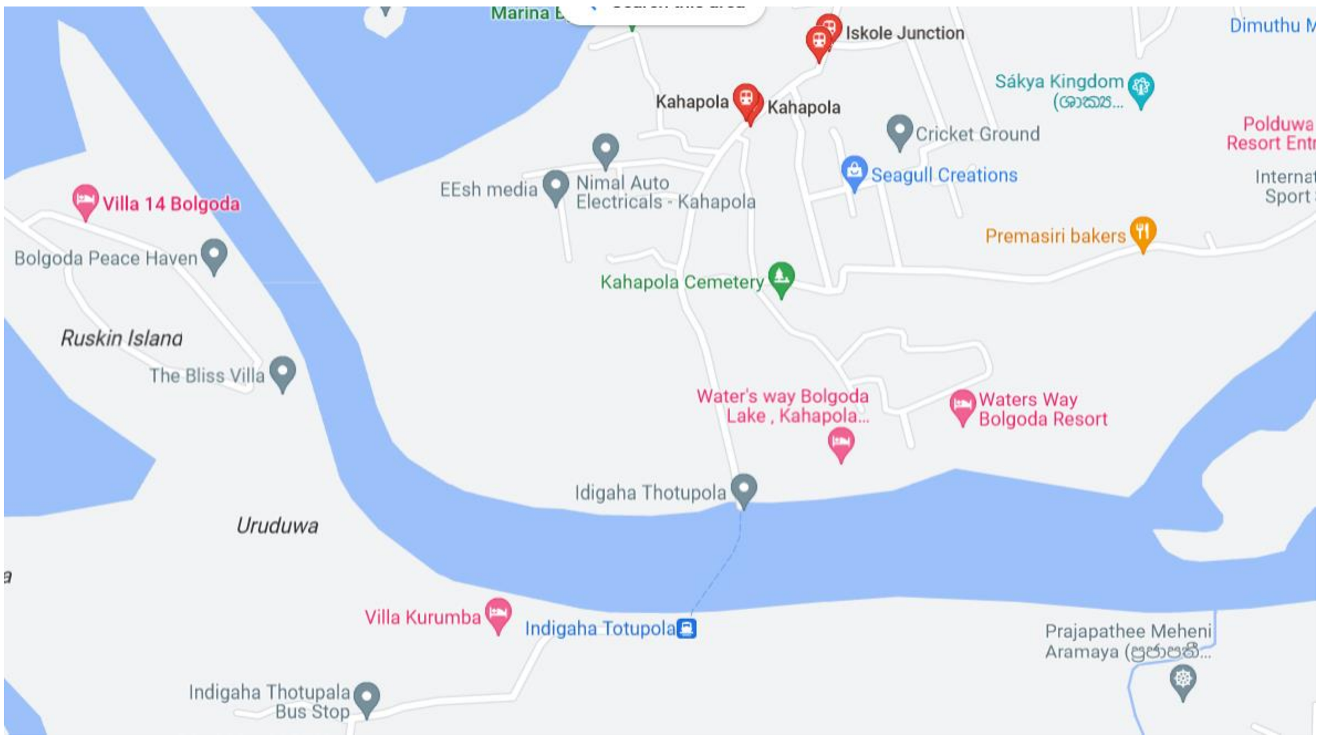
How to go from San Francisco to Marin County?

How to go from University of Moratuwa to Indigaha Thotupola

Procedural

Declarative





Learning Agents?

Knowledge Base (KB)

Where the representation of the world is maintained

Consists of a set of "sentences" -> written in a knowledge representation

language Base -> a set of axioms

Axiom: ?

KB

Need to

Add new info to the KB (TELL)

Retrieve info from KB (ASK)

both involve inference -> derive new info from old

knowledge level (world representation, agents goals) vs implementation level

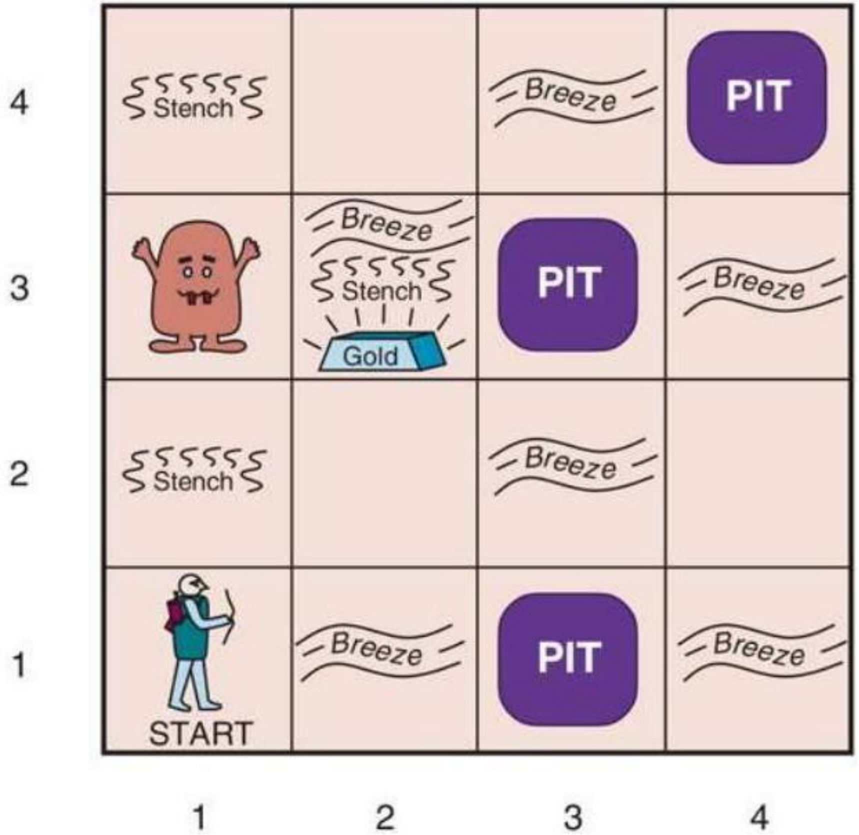
function KB-AGENT(*percept*) **returns** an *action*
  persistent: *KB*, a knowledge base
                   t, a counter, initially 0, indicating time

  TELL(*KB*, MAKE-PERCEPT-SENTENCE(*percept*, *t*))
  action ← ASK(*KB*, MAKE-ACTION-QUERY(*t*))
  TELL(*KB*, MAKE-ACTION-SENTENCE(*action*, *t*))
  $t \leftarrow t + 1$
  return *action*

Real-world applications of the Wumpus World :

Designing intelligent agents for autonomous vehicles, robotics, and game creation.

The Wumpus World



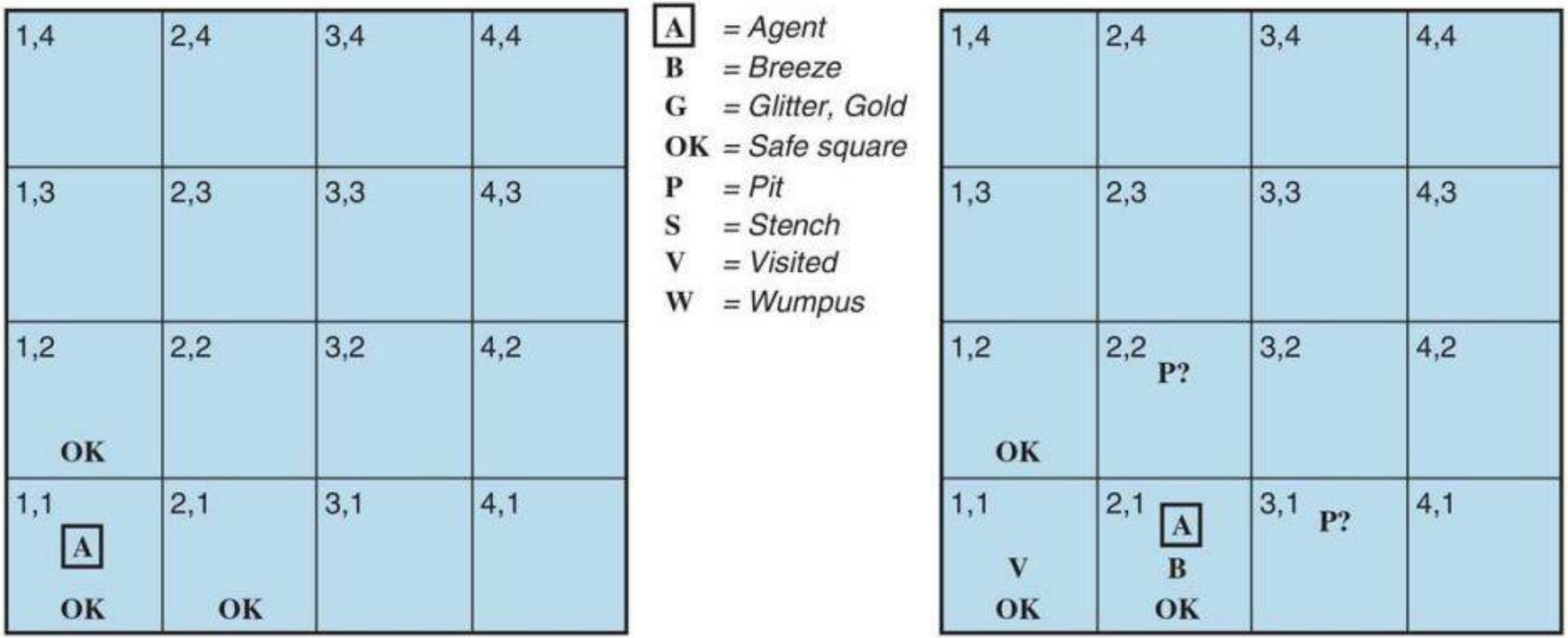
Describing the Environment

Properties of the Wumpus World

- Partially observable: The Wumpus world in AI is partially observable because the agent can only sense the immediate surroundings, such as an adjacent room.
- Deterministic: It is deterministic because the result and end of the world are already known.
- Sequential: It is sequential because the order is essential.
- Static: It is motionless because Wumpus and Pits are not moving.
- Discrete: The surroundings are distinct.
- One agent: The environment is a single agent because we only have one agent, and Wumpus is not regarded as an agent.

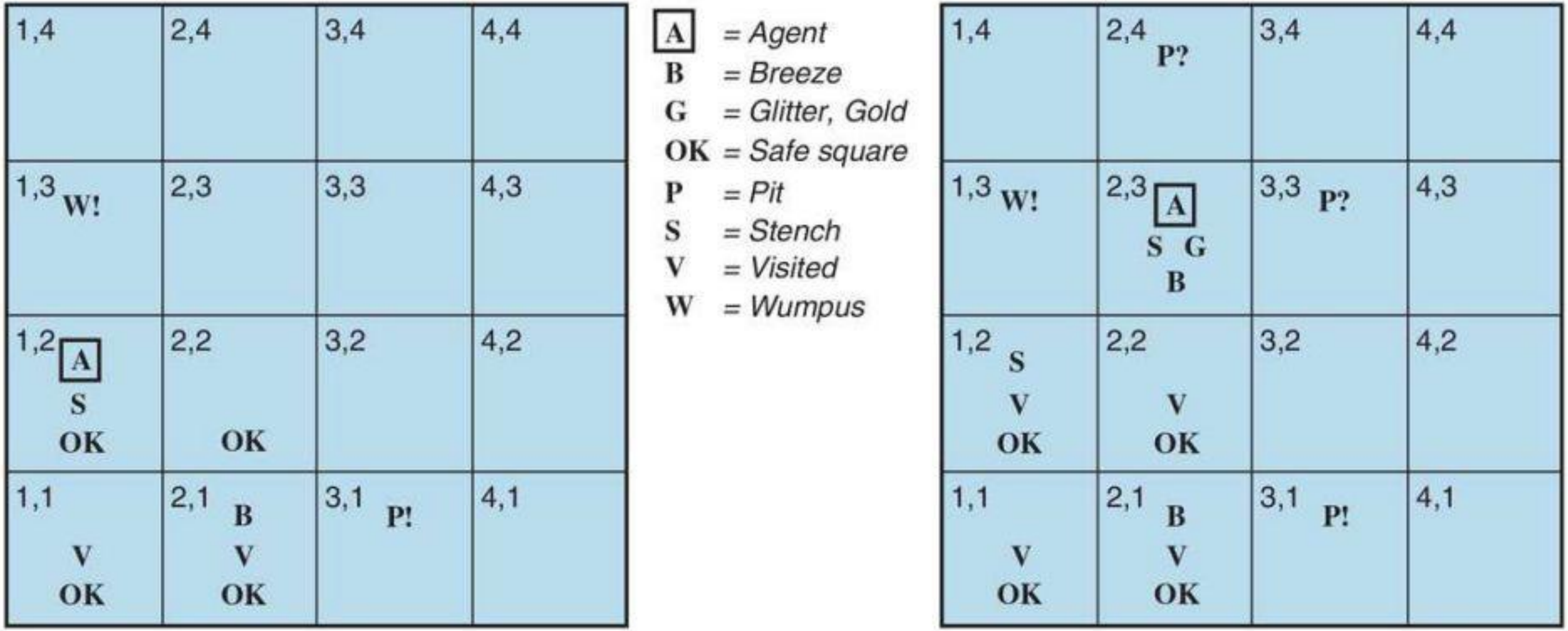
Agent’s initial KB

Rules of the environment



(a) (b)

[stench, breeze, glitter, bump, scream]


1,4
2,4
3,4
4,4
1,3 W!
2,3
3,3
4,3
1,2 A S OK
2,2 OK
3,2
4,2
1,1 V OK
2,1 B V OK
3,1 P!
4,1
A = Agent
B = Breeze
G = Glitter, Gold
OK = Safe square
P = Pit
S = Stench
V = Visited
W = Wumpus
1,4
2,4 P?
3,4
4,4
1,3 W!
2,3 A S G B
3,3 P?
4,3
1,2 S V OK
2,2 V OK
3,2
4,2
1,1 V OK
2,1 B V OK
3,1 P!
4,1

(a) (b)

Logic

Fundamental concepts of logical representation and reasoning

Logical Languages

A KB has sentences

Expression of sentences should be syntactically correct

x+y =9

+2+= y

Syntax??

Semantics

Define the truth of sentences wrt each possible world

Possible world = model = an abstraction where each sentence is either true or false

x+y = 9 ???

If a sentence ***s*** is true in a model ***m*** => ***m*** satisfies ***s*** / ***m*** is a model of ***s***

Set of *m* which are models of ***s* :** M(s)

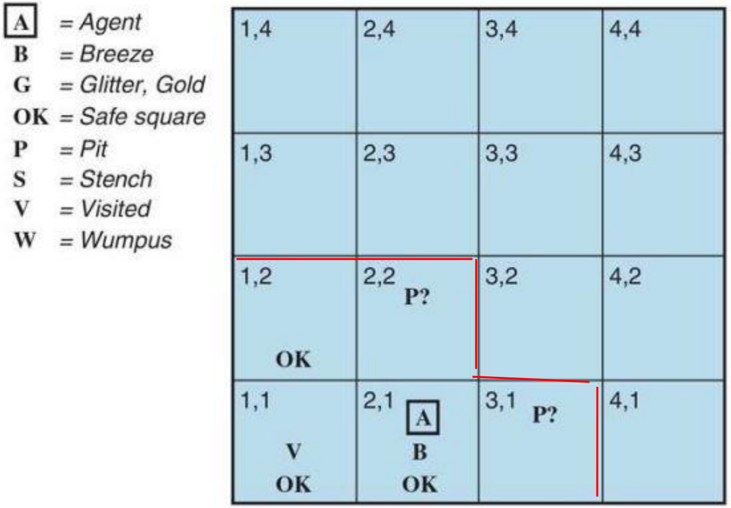
Logical Reasoning

Logical **entailment** between sentences

$\alpha \models \beta$ if and only if, in every model in which α is true, β is also true

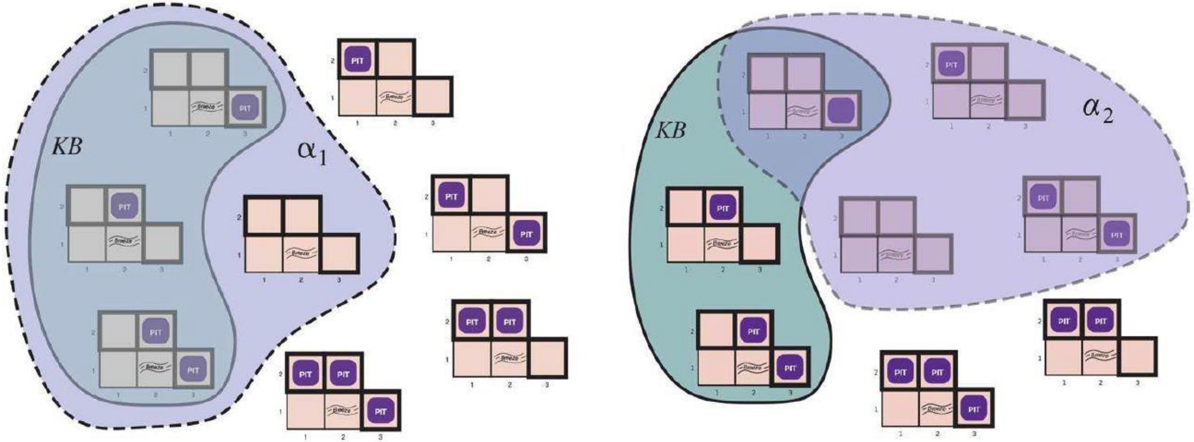
$\alpha \models \beta$ if and only if $M(\alpha) \subseteq M(\beta)$

$x=0 \models xy=0$



(b)

α_1 =" There is no pit in [1,2]." α_2 =" There is no pit in [2,2]."



(a) (b)

Logical Inference

Derive conclusions using entailment

Model checking - enumerates all possible models to check that a sentence is true in all the models where the KB is true

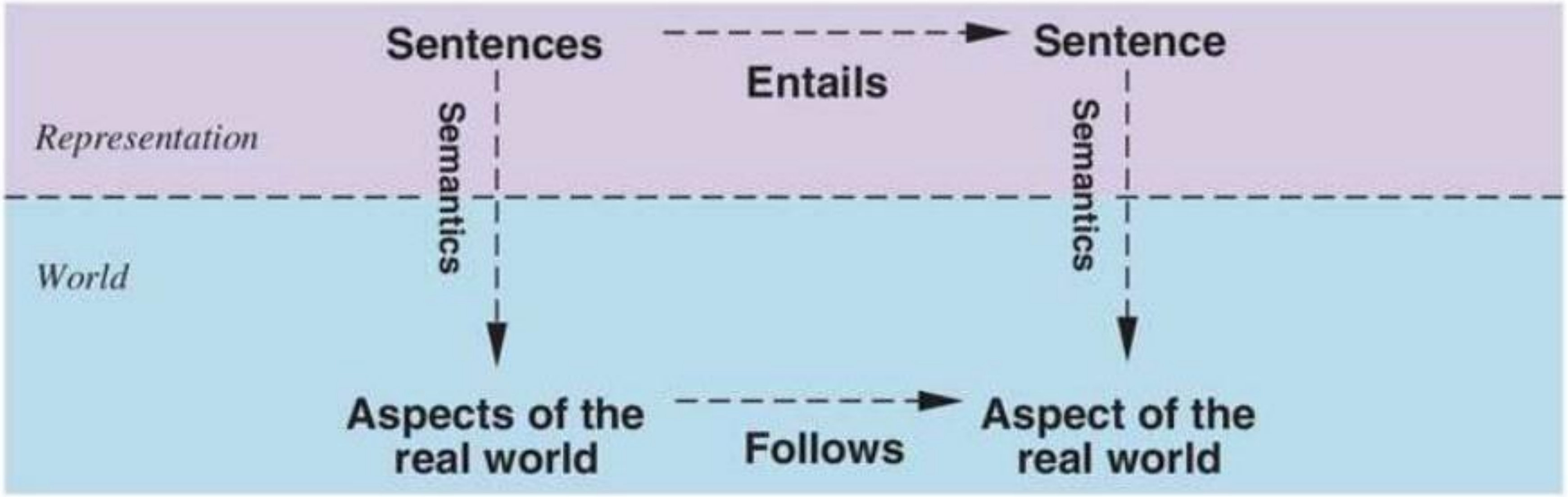
$KB \vdash_i \alpha$

i - inference algorithm, should be **sound**, **truth preserving** and **complete**

Model checking works if your space of models is finite

Later….. Theorem proving

Grounding



if KB is true in the real world, then any
sentence derived from KB by a sound inference procedure is also true in the real world