COMP5450M

Knowledge Representation

Lecture KRR-2

Introduction to Knowledge Represenation and Reasoning

AI and the KR Paradigm

The methodology of Knowledge Representation and Automated Reasoning is one of the major strands of AI research.
It employs symbolic representation of information together with logical inference procedures as a means for solving problems.

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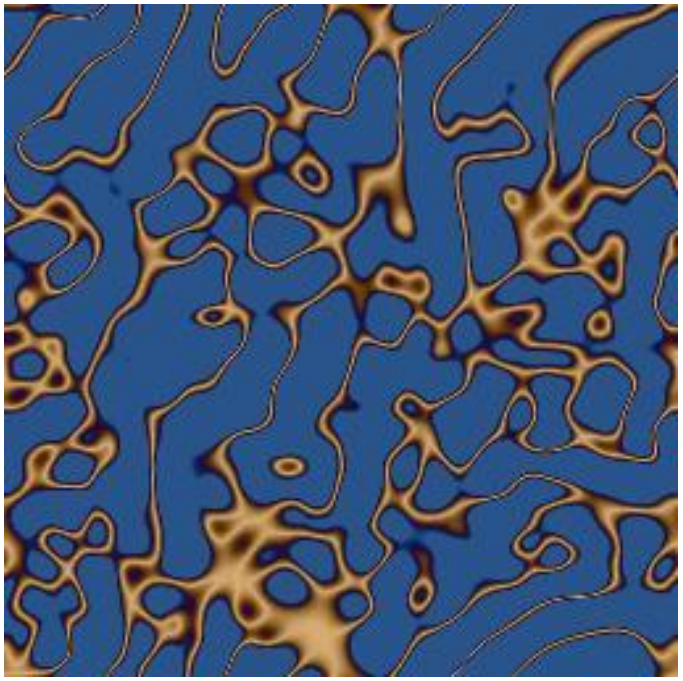
Most of the earliest investigations into AI adopted this approach and it is still going strong.
(It is sometimes called GOFAI — good old-fashioned AI.)

However, it is not the only (and perhaps not the most fashionable) approach to AI.

Neural Nets

One methodology for research in AI is to study the structure and function of the brain and try to recreate or simulate it.



How is intelligence dependent on its physical incarnation?

Situated and Reactive AI

Another approach is to tackle AI problems by observing and seeking to simulate intelligent behaviour by modelling the way in which an intelligent agent reacts to its environment.

A popular methodology is to look first at simple organisms, such as insects, as a first step towards understanding more high-level intelligence.

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Capabilities of ML systems are limited by the data upon which they are trained.
KRR can work in completely novel situations.

Intelligence *via* Language

The KR paradigm takes *language* as an essential vehicle for intelligence.

Animals can be seen as semi-intelligent because they only posses a rudimentary form of language.

The principle role of language is to *represent* information.

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However, it evolved into a much more abstract representation.

Language and Logic

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- Logical representations clean up natural language and aim to make it more definite.

For example:

If it is raining, I shall stay in.	$R \rightarrow S$
It is raining.	R
Therefore, I shall stay in.	$\therefore \quad S$

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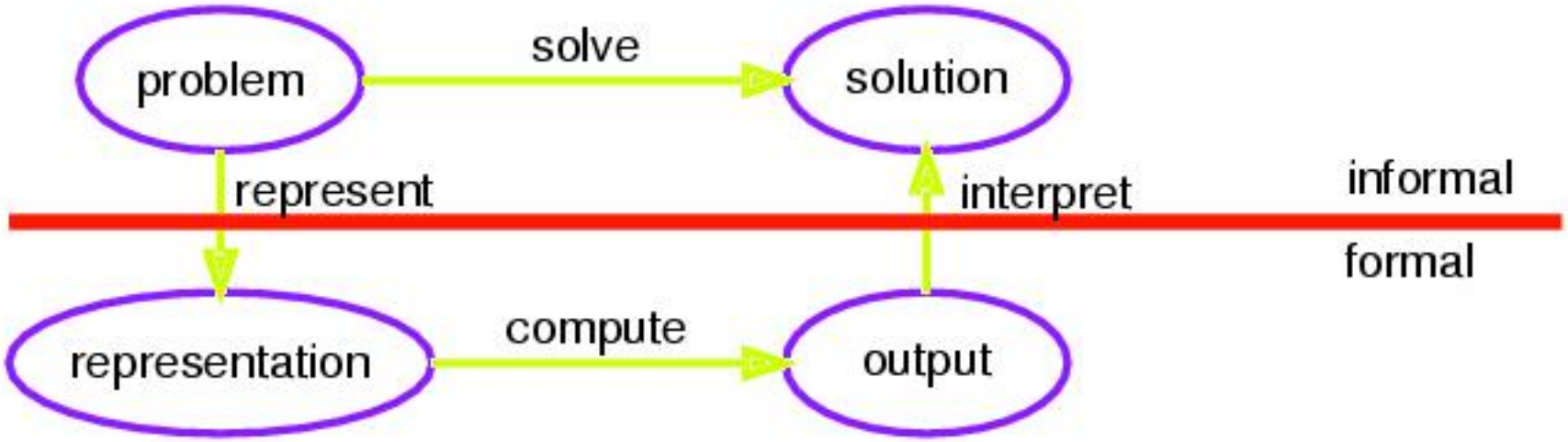
Typically we even ignore much of the logical structure present in natural language because we are only interested in (or only know how to handle) certain modes of reasoning.

For example, for many purposes we can ignore the tense structure of natural language.

Formal and Informal Reasoning

The relationship between formal and informal modes of reasoning might be pictured as follows:



Reasoning in natural language can be regarded as *semi-formal*.

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- Rules of inference.

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- Need a *correct* formalisation of problem and solution in that language.
- We need a *logical theory* of the modes of reasoning required to solve the problem.

Inference and Computation

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Later in the course we shall make these concepts more precise.

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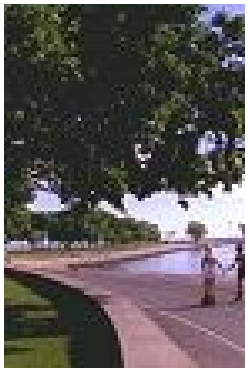
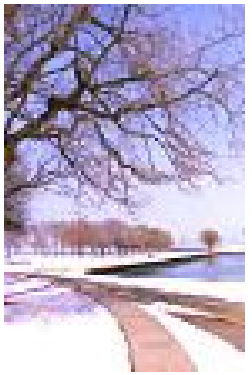


However, time and change play an essential role in many AI problem domains. Hence, formalisms for temporal reasoning abound in the AI literature.



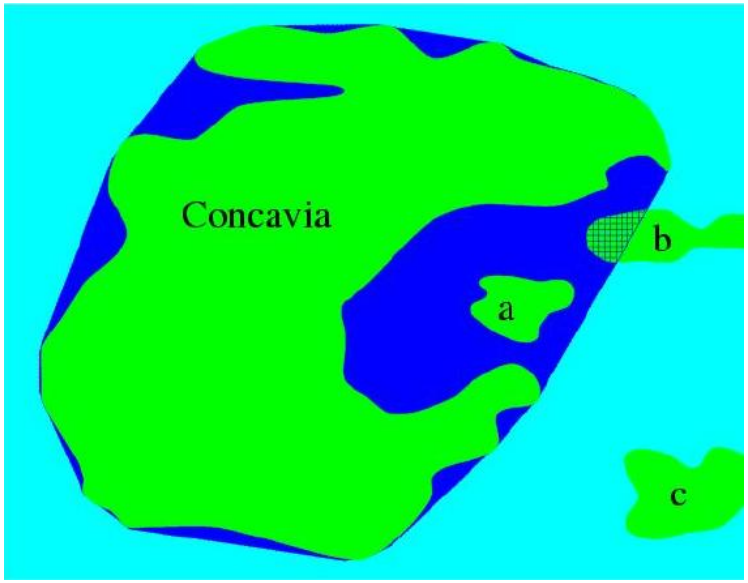
We shall study several of these and the difficulties that obstruct any simple approach (in particular the famous *Frame Problem*).

Spatial Information

Knowledge of spatial properties and relationships is required for many commonsense reasoning problems.

While mathematical models exist they are not always well-suited for AI problem domains.

We shall look at some ways of representing qualitative spatial information.



Describing and Classifying Objects

To solve simple commonsense problems we often need detailed knowledge about everyday objects.

Can we precisely specify the properties of type of object such as a cup?



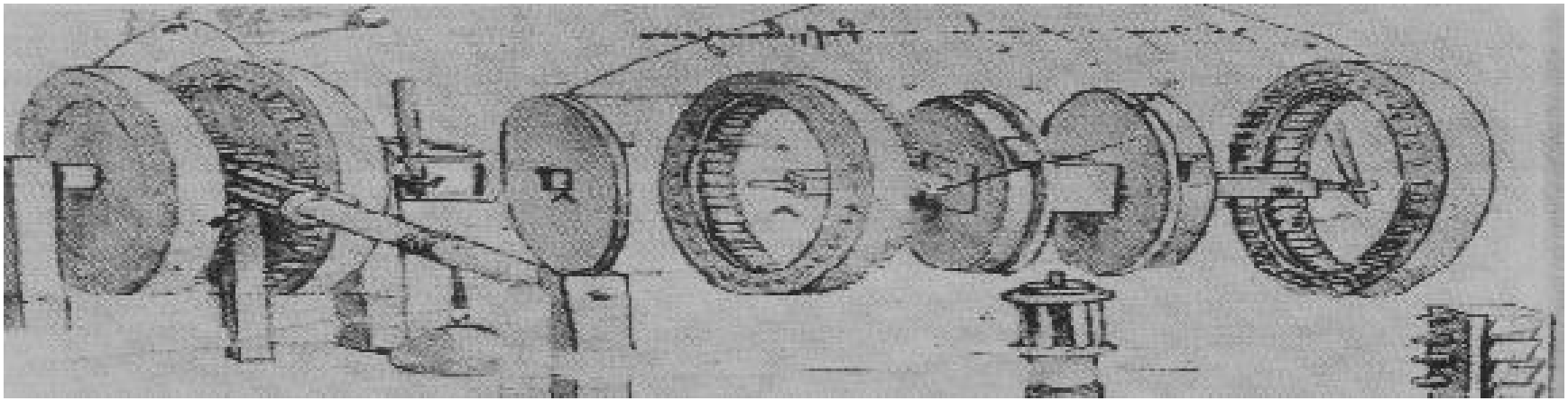


Which properties are essential?

Combining Space and Time

For many purposes we would like to be able to reason with knowledge involving both spatial and temporal information.

For example we may want to reason about the working of some physical mechanism:



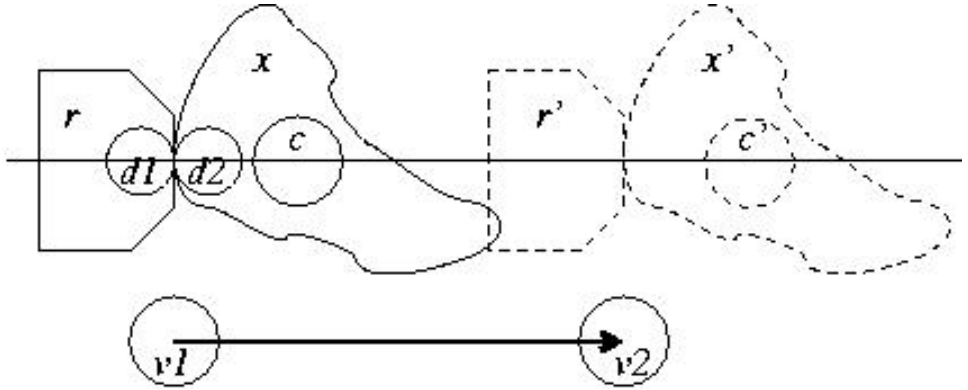
Robotic Control

An important application for spatio-temporal reasoning is robot control.

Many AI techniques (as well as a great deal of engineering technology) have been applied to this domain.

While success has been achieved for some constrained envioronments, flexible solutions are elusive.

Versatile high-level control of autonomous agents is a major goal of KR.



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This is a big problem for AI and has attracted much attention. Popular approaches include *probabalistic* and *fuzzy* logics.

But ordinary classical logics can mitigate the problem by use of *generality*. E.g. instead of $\mathrm{prob}(\phi) = 0.7$, we might assert a more general claim $\phi \vee \psi$.

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Ontologies are intended to guarantee the coherence of information and to allow relyable exchange of information between computer systems.

Use of ontologies is one of the main ways in which KRR techniques are exploited in modern software applications.

Issues of Ambiguity and Vagueness

A huge problem that obstructs the construction of rigorous ontologies is the widespread presence of *ambiguity* and *vagueness* in natural concepts.

For example: tall, good, red, cup, mountain.