

AI – The Movie

Many people will leave the cinema after seeing Spielberg's film AI and think all they saw will become reality soon.

So what is AI and how far has it got?

The AI film was based on a story by Brian Aldiss 'Supertoys last all summer long' written in 1969.

More recently, he wrote: **'Brains are far more than mere computers... Intelligence cannot exist without consciousness. Artificial consciousness: that sounds like a taller order, and indeed it is. ... So what I believed in 1969 is what I do not believe in 2001'** (New Scientist 09/15/01).

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AI – The History

- AI is nearly as old as computing
- 1941 Konrad Zuse, Germany, general purpose computer
- 1943 Britain (Turing and others) Colossus, for decoding
- 1945 ENIAC, US. John von Neumann a consultant
- 1956 Dartmouth Conference organized by John McCarthy (inventor of LISP)
- The term Artificial Intelligence was coined at Dartmouth, which was intended as a two month study.

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AI – The Achievements

Robots make cars in all advanced countries.

Reasonable (?) machine translation is available for a large range of foreign web pages.

Computers land 200 ton jumbo jets unaided every few minutes.

Search systems like Google are not perfect but provide very effective information retrieval

Robots cut slots for hip joints better than surgeons.

Deep blue beat Kasparov in 1997 and the current world Go champion is a computer.

Medical expert systems can outperform doctors in many areas of diagnosis.

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AI – A Comment

Despite all these achievements, one of the major philosophers of Cognitive Science wrote recently:

"... the failure of artificial intelligence to produce successful simulation of routine commonsense cognitive competences is notorious, not to say scandalous. We still don't have the fabled machine that can make breakfast without burning down the house; or the one that can translate everyday English into everyday Italian, or the one that can summarize texts.." (Jerry Fodor, *The Mind doesn't Work that Way*, 2000, p.37).

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What is Artificial Intelligence?

The use of computer programs and programming techniques to cast light on the principles of intelligence in general and human thought in particular (Boden)

The study of intelligence independent of its embodiment in humans, animals or machines (McCarthy)

The pursuit of metaphysics by other means (Longuet-Higgins)

AI is the study of how to do things which at the moment people do better (Rich & Knight)

AI is the science of making machines do things that would require intelligence if done by men. (Minsky)

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What is Artificial Intelligence?

One of major divisions in AI (and you can see it in the definitions on the previous slide) is between

Those who think AI is the only serious way of finding out how **we** work (since opening heads does not yet give much insight into this) and

- Those who want computers to do very smart things, **independently** of how we work.

This is the important distinction between **Cognitive Scientists vs. Engineers.**

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Symbolism vs. Connectionism

There is another major division in the field of Artificial Intelligence:

- **Symbolic AI** represents information through symbols and their relationships. Specific Algorithms are used to process these symbols to solve problems or deduce new knowledge.
- **Connectionist AI** represents information in a distributed, less explicit form within a network. Biological processes underlying learning, task performance, and problem solving are imitated.

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Theory of Computation

- The Theory of Computation existed long before the first computers were built.
- Many computer scientists would call **Alan Turing** the “father” of the Theory of Computation.

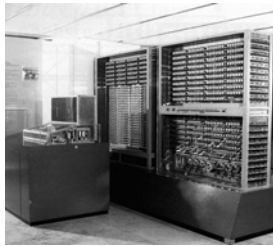


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Theory of Computation



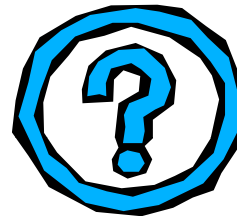
The Theory of Computation led to the construction of the first computer (Z3 by Konrad Zuse, 1941) ...

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Theory of Computation



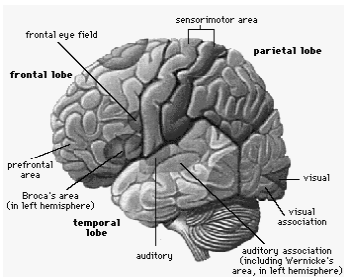
... and applies to any computer that will ever be built, no matter how it works and how powerful it is...

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Theory of Computation



... and therefore, it even applies to the human brain!

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What is the Theory of Computation about?

Theoretical things, of course. For example:

- what classes of computers (automata) there are and which types of functions they can compute,
- a paradigm for a minimally complex universal computer, i.e., one that can compute all functions that can be computed in principle,
- functions that no computer can compute, no matter how powerful and sophisticated it is.
- analyzing the complexity (space and time requirements) of algorithms.

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Automata Theory

We will start our exploration of the Theory of Computation with **automata theory**.

Automata theory studies the computational capabilities of machines with different levels of complexity.

In the next classes, we will focus on the following question:

How do the **amount and accessibility of memory** determine the computational capabilities of a machine?

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Finite Automata

The first case that we want to study is the class of finite automata.

With regard to the amount and accessibility of memory, these machines are only minimally equipped.

Finite automata read their input tape from left to right and cannot print anything on the tape (which would be useless, since they could not return to read anything they printed.

(So you could also think of their input being "fed" to them symbol by symbol instead of being on a tape.)

The only piece of memory that these machines have is their current state.

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Finite Automata

The next state of a finite automaton is given by its current state and the current symbol being read.

If, after reading the input, the finite automaton is in an accepting state, we say that it **accepted** the input string.

Finite automata also **accept a language**, which is the set of all strings that they accept.

Now let us define all this more formally (not required for the exam).

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Finite Automata

Definition:

A finite automaton \mathcal{M} on the alphabet $A = \{s_1, \dots, s_n\}$ with states $Q = \{q_1, \dots, q_m\}$ is given by

- a function δ that maps each pair (q_i, s_j) , $1 \leq i \leq m$, $1 \leq j \leq n$, into a state q_k , and
- a set $F \subseteq Q$.

One of the states, usually q_1 , is singled out and called the **initial state**.

The states belonging to the set F are called the **final or accepting states**.

δ is called the **transition function**.

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Finite Automata

Let \mathcal{M} be a finite automaton with transition function δ , initial state q_1 , alphabet A , and accepting states F .

If q_i is any state of \mathcal{M} , and $u \in A^*$, we will write $\delta^*(q_i, u)$ for the state which \mathcal{M} will enter if it begins in state q_i at the left end of the string u and moves across u until the entire string has been processed.

A formal definition by recursion is

$$\delta^*(q_i, 0) = q_i,$$

$$\delta^*(q_i, us_j) = \delta(\delta^*(q_i, u), s_j).$$

Obviously, if there is only a single symbol to be read,

$$\delta^*(q_i, s_j) = \delta(q_i, s_j).$$

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Finite Automata

We say that \mathcal{M} accepts a word u if and only if $\delta^*(q_1, u) \in F$; otherwise, \mathcal{M} rejects u .

We write $L(\mathcal{M})$ for the language accepted by \mathcal{M} and define it as:

$$L(\mathcal{M}) = \{u \in A^* \mid \delta^*(q_1, u) \in F\}.$$

A language is called **regular** if there exists a finite automaton that accepts it.

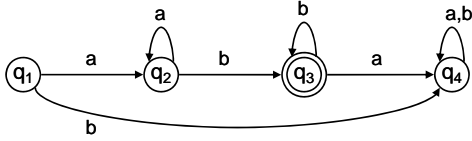
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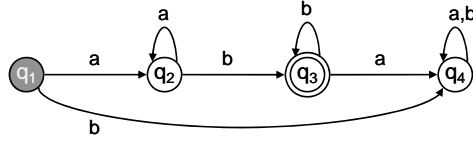
Finite Automata

Example 1: What is the language accepted by the following finite automaton with $A = \{a, b\}$, initial state q_1 , and $F = \{q_3\}$?



Finite Automata

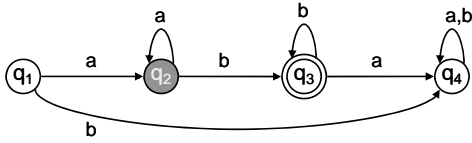
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Sample string: aabbb
↑

Finite Automata

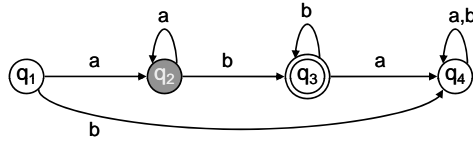
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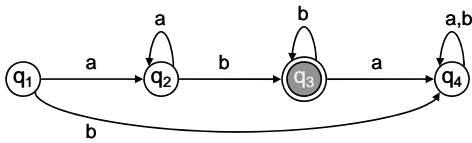
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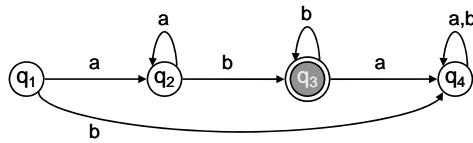
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Finite Automata

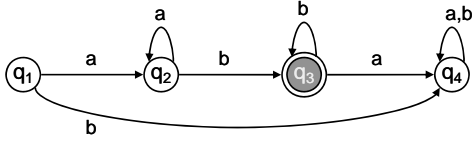
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Finite Automata

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Sample string: aabbb accepted!

The language accepted is $L = \{a^n b^m \mid n, m > 0\}$.

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