Automata Theory

Abstract machines and their computational power

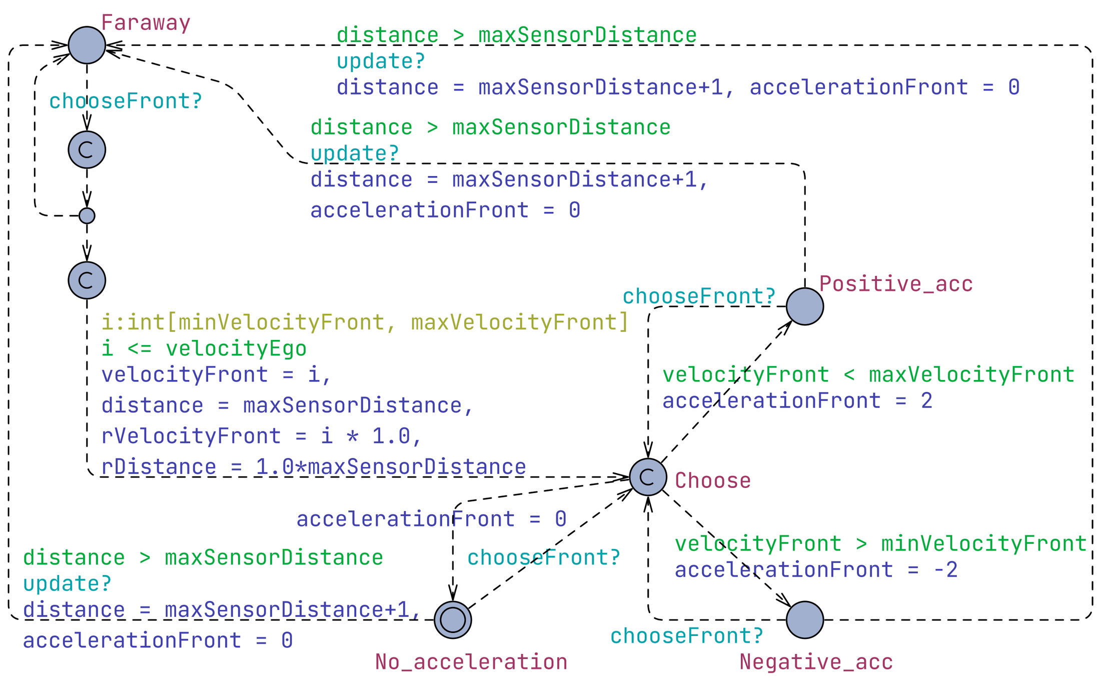
Automata Theory is one of the oldest research areas in Computer Science. Historically, it developed with the theory of formal languages, since automata were categorised by the classes of languages they can recognise. Today, automata-based formalisms are widely applied in modern computing. Indeed, every computing device has "automata inside!"

WHAT IS AUTOMATA THEORY?

Automata Theory is a research area that is concerned with the study of abstract computing devices and of their computational power. It emerged from A. Turing's study of the power of general-purpose computation and from S.C. Kleene's formalisation of an earlier proposal by McCulloch and Pitts that was motivated by the study of networks of neurons.

WHERE IS AUTOMATA THEORY USED IN COMPUTER SCIENCE?

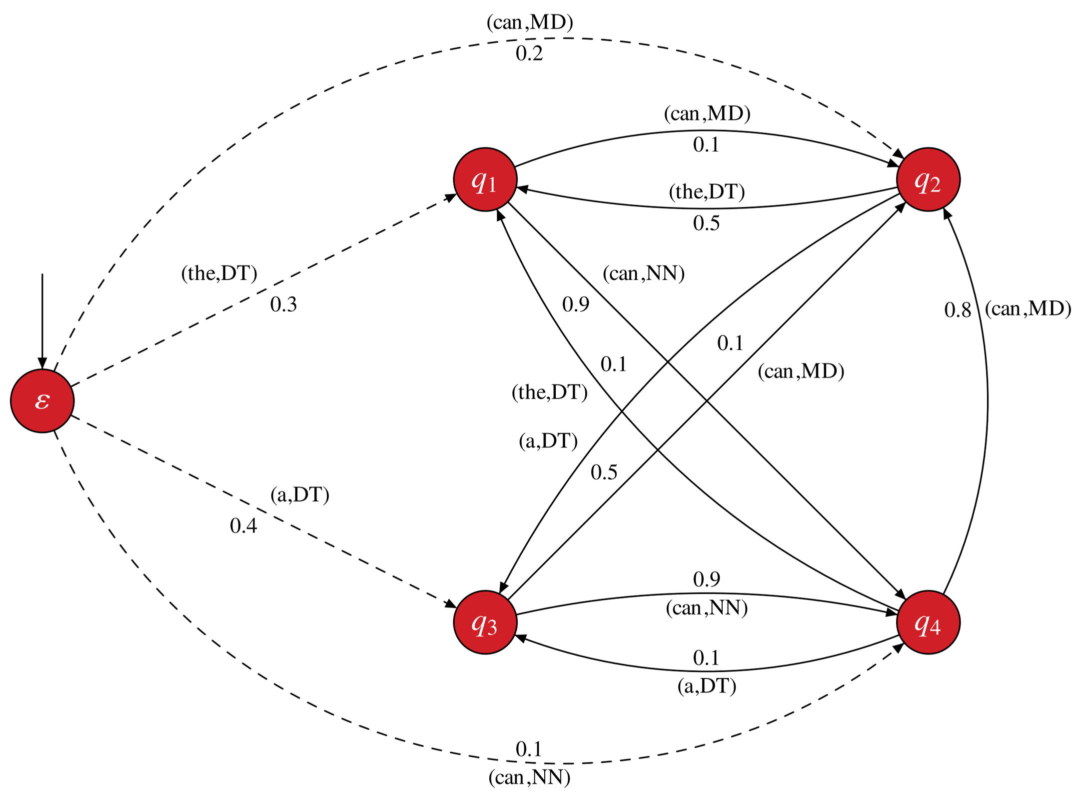
The short answer is that automata are *everywhere* in Computer Science! Initially, their study was motivated by, and had immediate application in, fields such as computer design, compilation of programming languages, and search and pattern matching. Their use then spread across the whole field.



An automaton describing the behaviour of a car driving in front of an autonomous vehicle as a player in a stochastic priced timed game. The tool Uppaal Stratego can be used to synthesise winning strategies in such games.

CONNECTIONS WITH MATHEMATICS?

Automata Theory uses increasingly sophisticated mathematical techniques to study the power of abstract computational devices. It has close connections with classic and novel fields of Mathematics such as group theory and the theory of algebraic structures, logic, (finite) model theory, number theory, (automatic) real function theory, symbolic dynamics, and topology.



A weighted word automaton for part-of-speech tagging in English.

SELECTED KEY MILESTONES IN AUTOMATA THEORY

- **1936** — **A. Turing:** Turing machines
- **1943** — **W. McCulloch, W. Pitts:** Nerve nets as finite automata
- **1948** — **J. von Neumann:** The general and logical theory of automata
- **1951** — **S.C. Kleene:** Regular expressions, Kleene's Theorem
- **1955** — **M.P. Schützenberger:** Algebraic theory of automata: Syntactic semigroups and variable-length codes
- **1956** — **E.F. Moore:** Minimal automata
- **1957** — **J. Myhill:** Non-deterministic automata and determinisation.
- **1958** — **A. Nerode:** Nerode equivalence
  J.R. Büchi, C.C. Elgot, B.A. Trakhtenbrot: Finite automata and monadic second-order logic (MSO)
- **1959** — **M.O. Rabin, D. Scott:** Finite automata and their decision problems
- **1963** — **N. Chomsky, M.P. Schützenberger:** Context-free languages and pushdown automata
- **1965** — **M.P. Schützenberger:** Star-free expressions and group-free monoids
  K. Krohn and J. Rhodes: Decomposition of automata
- **1969** — **M.O. Rabin:** Automata on infinite tees and MSO
- **1982** — **Y. Gurevich, L. Harrington:** Trees, automata and games
  W. Thomas: Classifying regular events in symbolic logic
- **1988** — **N. Immerman, R. Szelepszenyi:** Complementation of linear bounded automata
  K. Hashiguchi: Solution of the restricted star-height problem