

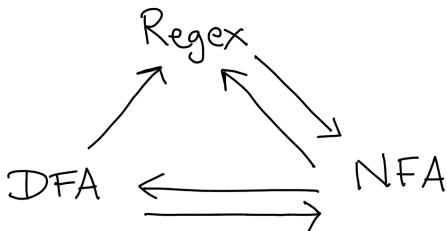
# Games, graphs, and machines



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October 1, 2025

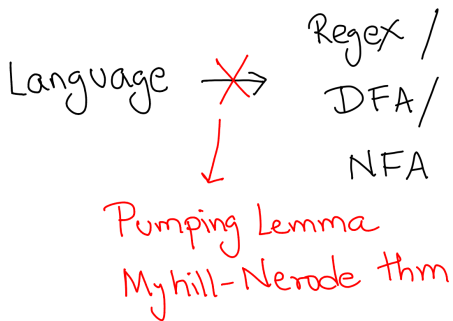
# All are equivalent



# Language?

Language  $\rightarrow$  Regex /  
DFA /  
NFA

# Sometimes impossible!

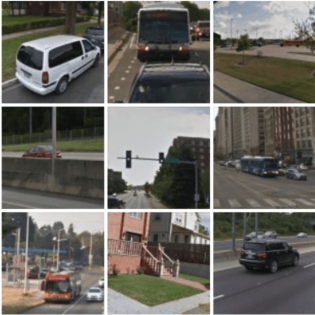


# Automatons are very limited

Even “easy” patterns are beyond automatons!

# What about...

Select all images with a  
**bus**  
Click verify once there are none left.



⌂ 🎧 ⓘ

VERIFY

## **Using machine learning to identify undiagnosable cancers**

A new model that maps developmental pathways to tumor cells may unlock the identity of cancers of unknown primary.

# Turing machines

Turing machine = Finite automaton + memory

# Turing machines?

- Two dimensional memory
- Many reading heads
- Random-access memory
- Non-determinism
- Parallelism
- Cellular automata
- Crystalline automata
- ...

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... are all equivalent to a Turing machine!

# Church-Turing thesis

*Anything that is computable is computable by a Turing machine.*

# Non-computable patterns?

- Truth vs falsehoods
- Correct vs incorrect computer programs

## Further developments

How efficiently computable?

- Polynomial time versus exponential time?

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- Multiplying  $n \times n$  matrices: best method takes about  $n^{2.37}$  operations. Can we do faster?
- Can we do faster with parallelisation? Quantum computers? Probabilistic computation?

## Futher questions

- Are there any physical processes that are more capable than a Turing machine?
- Is the human brain (theoretically) more capable?