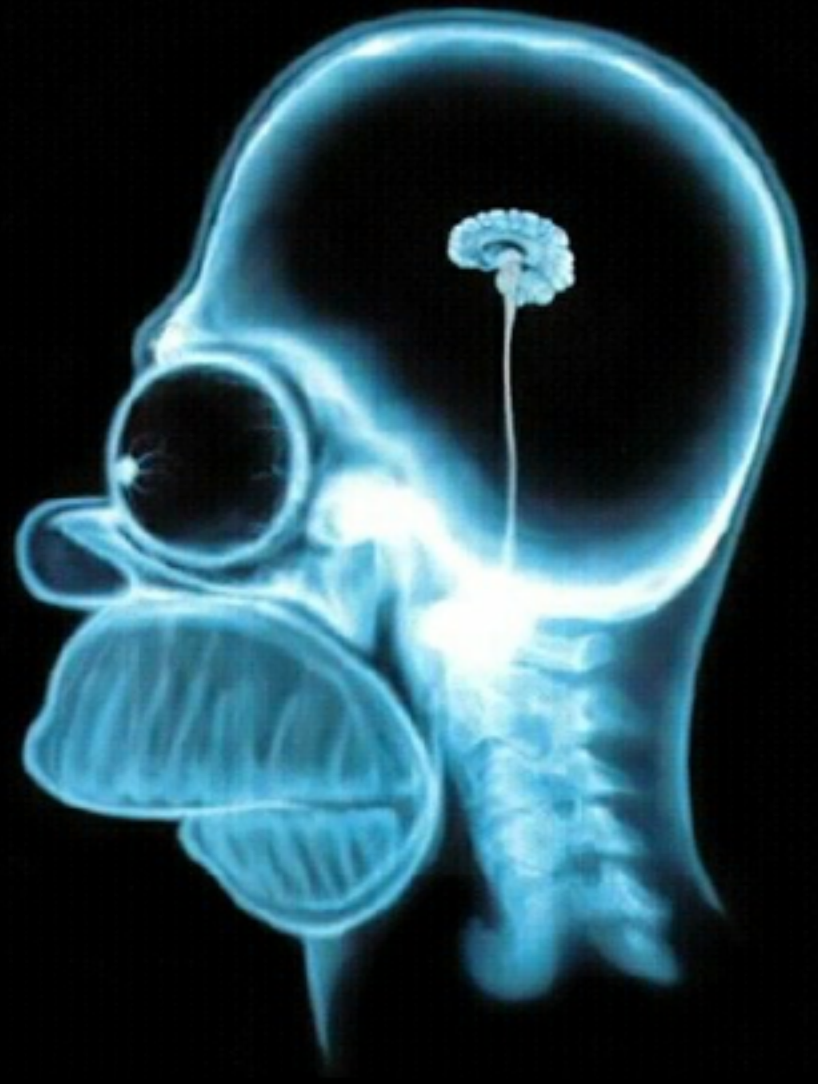
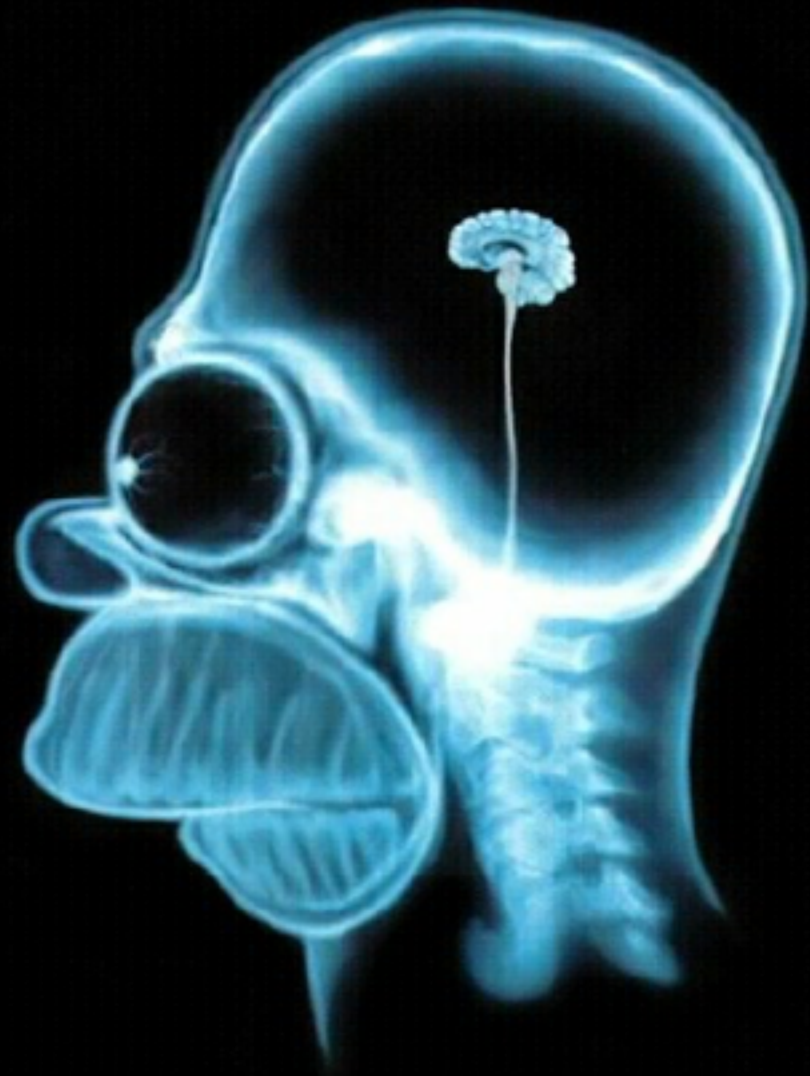
Artificial Intelligence



Philosophy.

What's intelligence, anyway? Can we mechanize it? Model it with math or some electric or chemical device? Can we solve this guy's poor intellectual limitations?

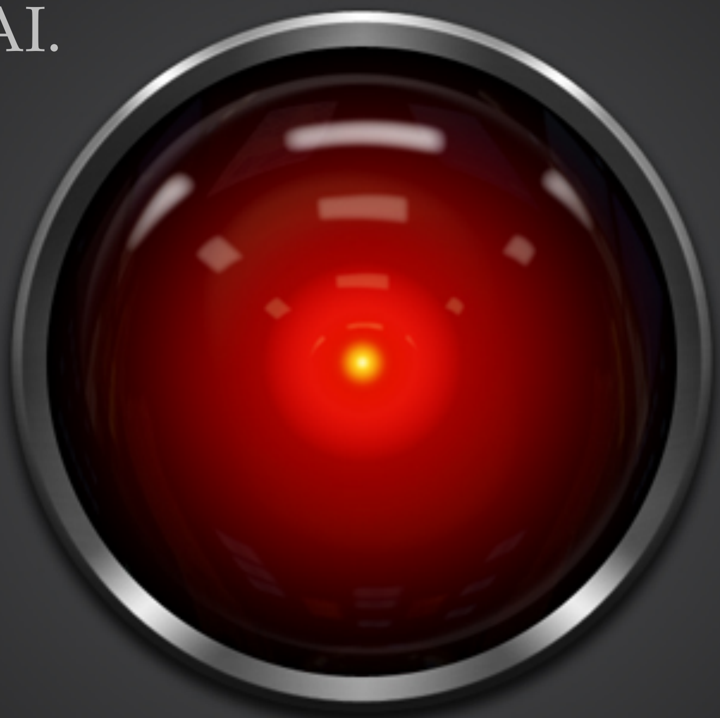


In other words,

can we build an electric brain that works at least as well as his real one?

This is a **very** high level overview of AI.

Very.



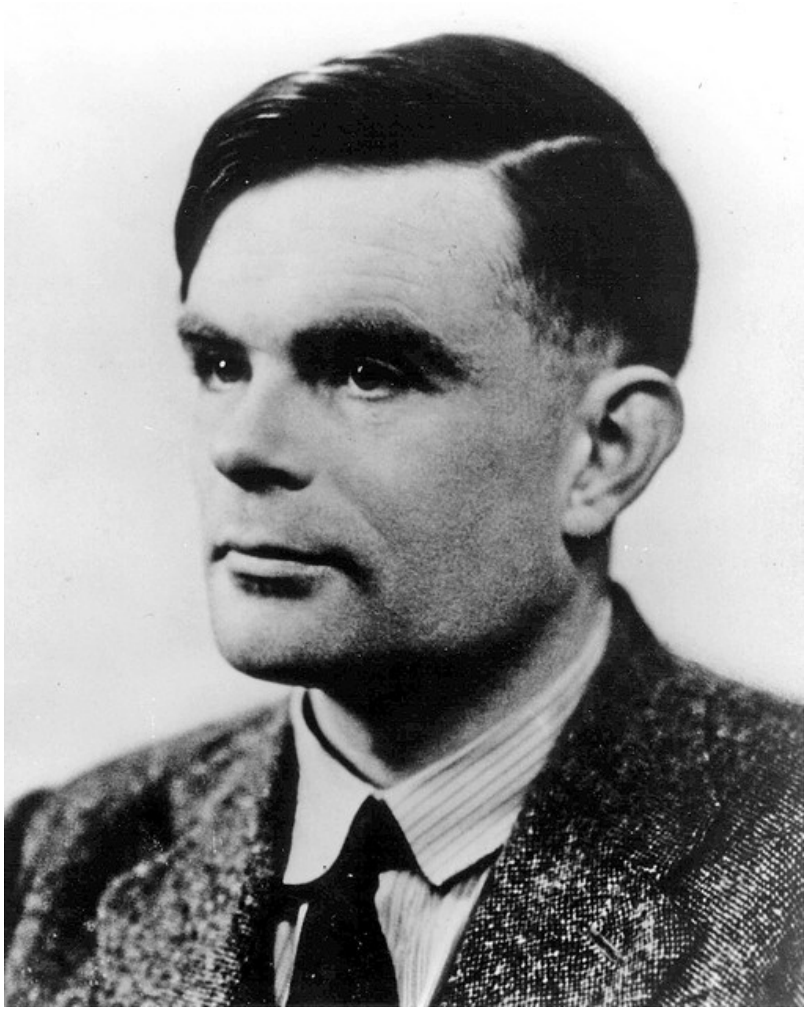
Artificial Intelligence is the field concerned with creating synthetic devices (hardware/software/other) that can do one or more of these things:

* Learn
* Reason
* Predict
* Understand
* Carry out a robot uprising

What's one way to know if we've made an AI (aside from the characteristic robot uprising)?

With the Turing Test, of course.

The **Turing Test** involves two parties in a conversation where the others' identity is unknown. One is a human, and the other could be human or an AI. If the first human can't reliably determine if the other conversant is a person or an AI, then we say the AI passes the Turing Test, and we all break out the champagne.

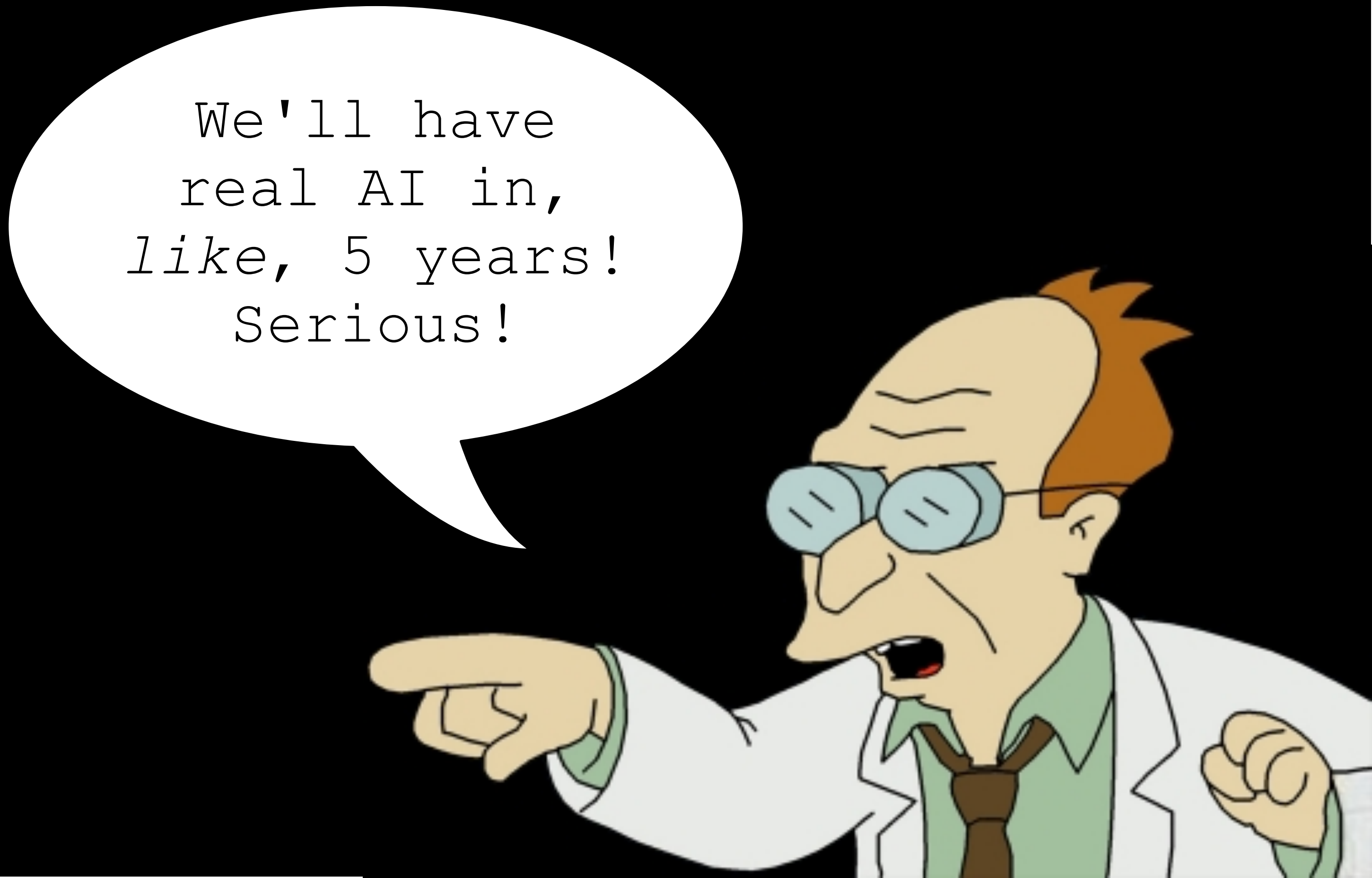


Alan Turing
1912--54

He was awesome.

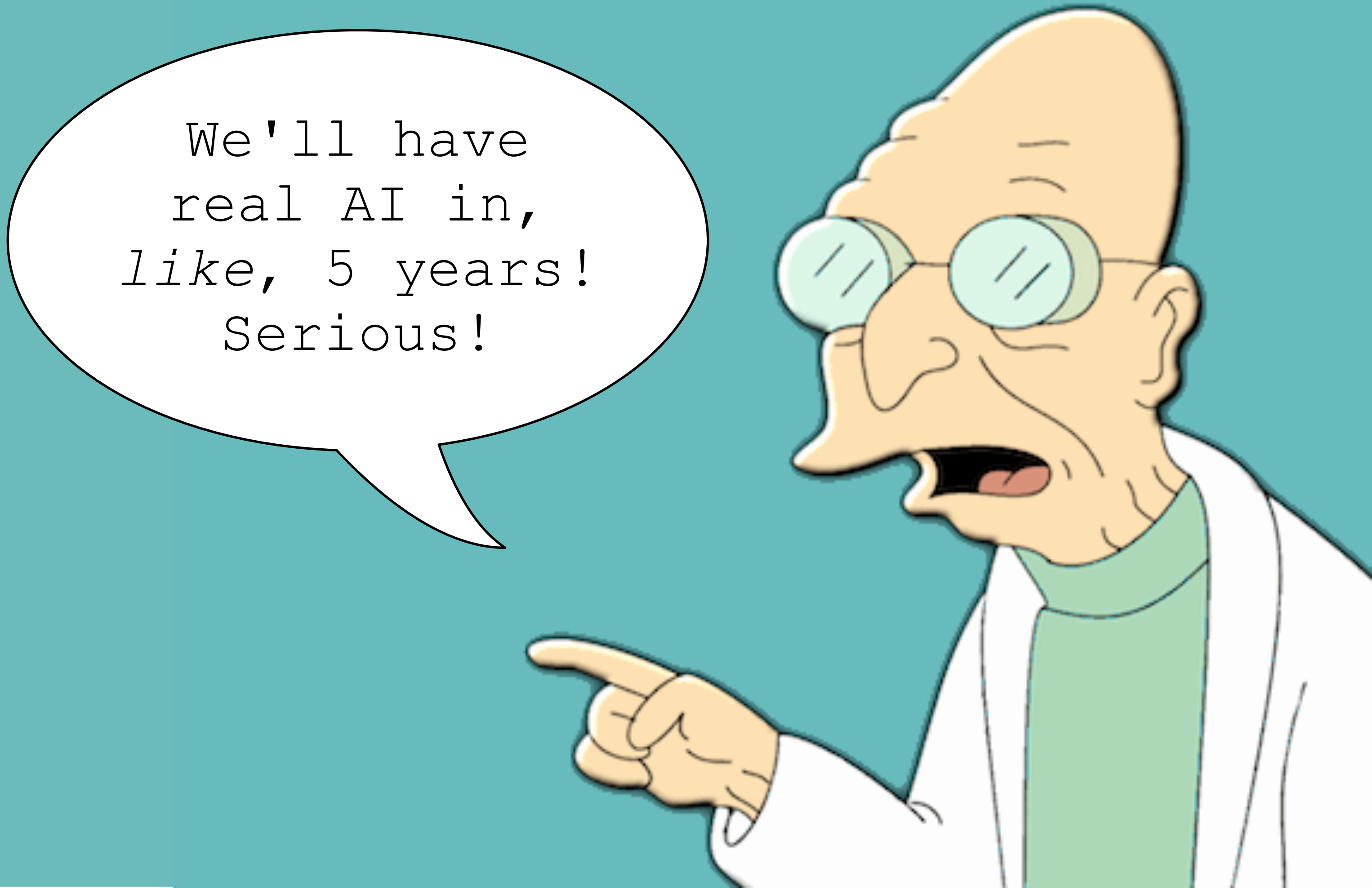
To see what the current state-of-the-art is, try this out with SIRI.

AI was a *really big deal* starting in the 1950s, through the end of the 60s. But after repeatedly promising that real AI was just about to arrive (every year for about two decades) the funding agencies gave up, and research money evaporated. This is called the *AI Winter*.

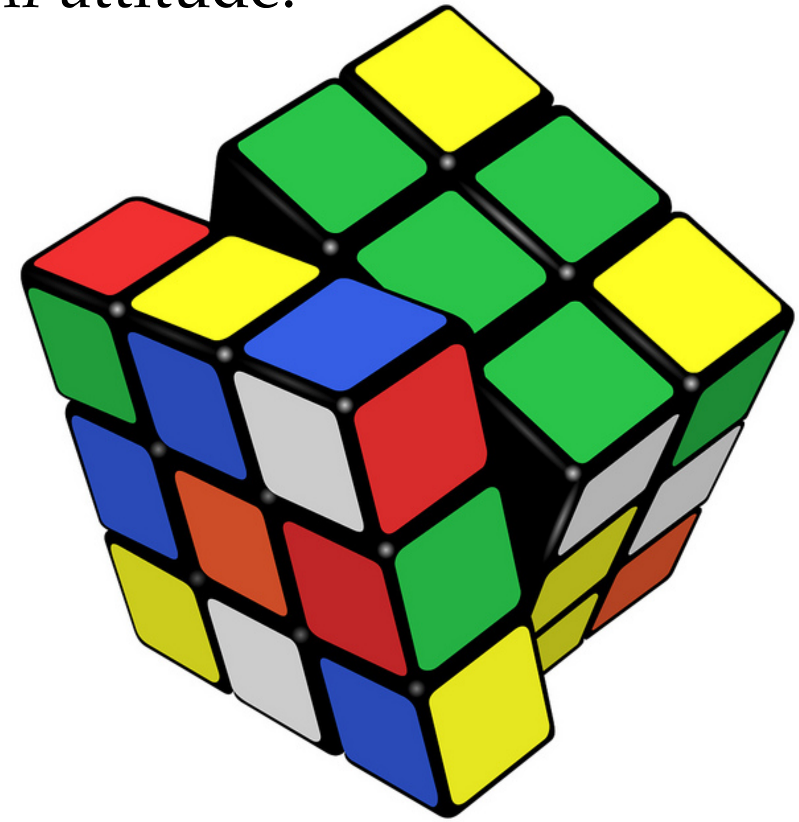


Later, after the first AI winter, loads of 1980s VC money sprung up on the promise of *expert systems* which were really just AI projects with a different name that focused on specific domains (so they could be experts in them).

Eventually this 1980s bubble burst because (a) researchers kept saying things like *dude real AI is five years away*, and (b) the business interests stopped believing them.

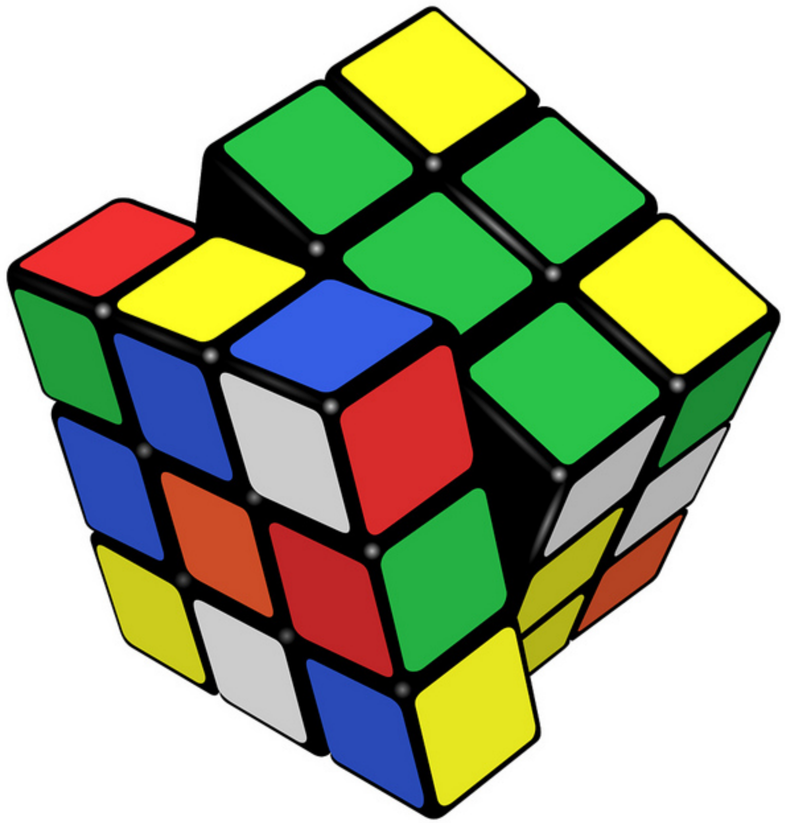


These days AI is called various things from **data mining** to **machine learning**. There's much less of the *dude we're five years away from real AI* attitude.



Fast computers with gigantic memories are available. Many old AI approaches based on comprehensive search (or computationally expensive heuristics) are now reasonable for companies like Google to take on.

E.g.: ~ 35 years of Google CPU time exhaustively tried *everything* and concluded that you can solve a Rubik cube in 20 moves or less, no matter the start state.



OK, 35 years of CPU time to solve this problem. Is that really AI though? Well, it is artificial. And I suppose it is intelligent.

But it isn't really human-like.

So. There are lots of goals we could have in AI that are shared by lots of other domains, and we are unlikely to solve all this in the next 5 years:

* Solving math proofs (e.g. the Rubik Cube thing)
* Having conversations
* Suggesting a good restaurant
* Driving a vehicle
* Finding bad guys on security cameras
* Robots that find damaged pipes and repair them
* Playing games (chess, StarCraft, whatever)
* Telling humans where to find information (web search)

And of course there is the insufferable
and interminable argument about
what intelligence is in the first place.

Learning

One common goal in AI research is to build systems that are capable of *learning*. This can be either…

Supervised	Give the system examples and tell it what it sees. Like teaching words to a kid along with pictures or physical examples of it.
Unsupervised	Give the system a bunch of data and ask it to form a model via data analysis. It is not told what the right answer is (because in many cases even humans don't know).

Reasoning

Another open area of research within AI is *reasoning*. Given some basis of knowledge, can the system reason about what is going on? Is it possible for a computer to read an ambiguous statement and reason about which interpretation is most likely correct?

"One morning I shot an elephant in my pajamas. How he got in my pajamas, I don't know."

(What does 'he' refer to?)

Prediction

An intelligent person can predict consequences of action (or inaction) and use those predictions in decision-making.

Simple example: If an AI robot wants to catch the projectile, it must predict where it will land and be able to move into position. If it is windy, it must account for the wind in its prediction.

Trickier example: An AI robot reads your email and learns that Paris Hilton got a new purse. Can it predict how you will react if it wakes you up at 3am to tell you? What if your house is on fire?

Understanding

What is this?

Understanding

What is this?

Understanding

What is this?

Understanding

What is this?

Understanding

An intelligent agent can understand on a number of levels, from explicit data (top) to nuanced emotion (bottom).

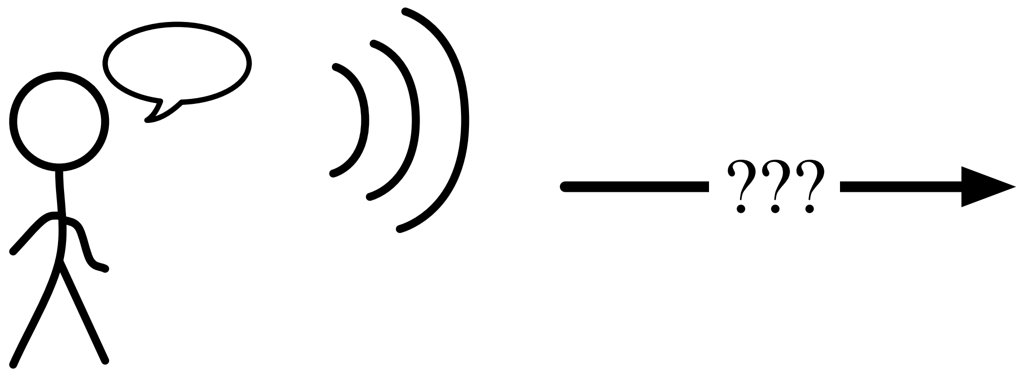
(1) Pixels, colors
(2) B&W photograph
(3) Urban scene
(4) People kissing
(5) Sailor kissing nurse
(6) Famous pic from NYC V-J Day
(7) Huge relief of war ending

Information as Features
Computing with Features as Intelligence (?)

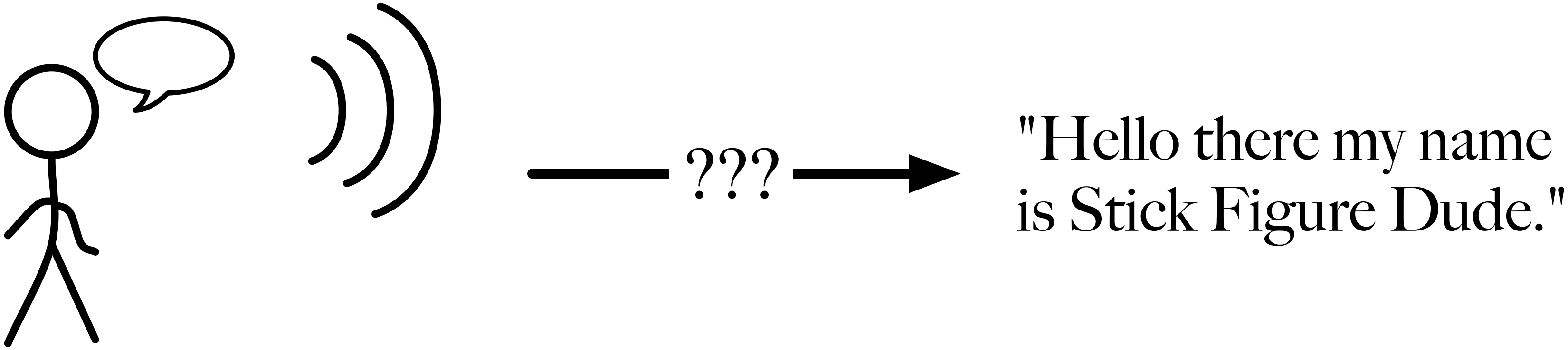
In AI and machine learning, a *feature* is a numeric representation of something that we would like to work with. It is a distillation of a complex, possibly noisy input signal like human speech, a visual scene, or raw sensor data.

`StickFigureDude says something...`

`The AI recognizes what was said.`



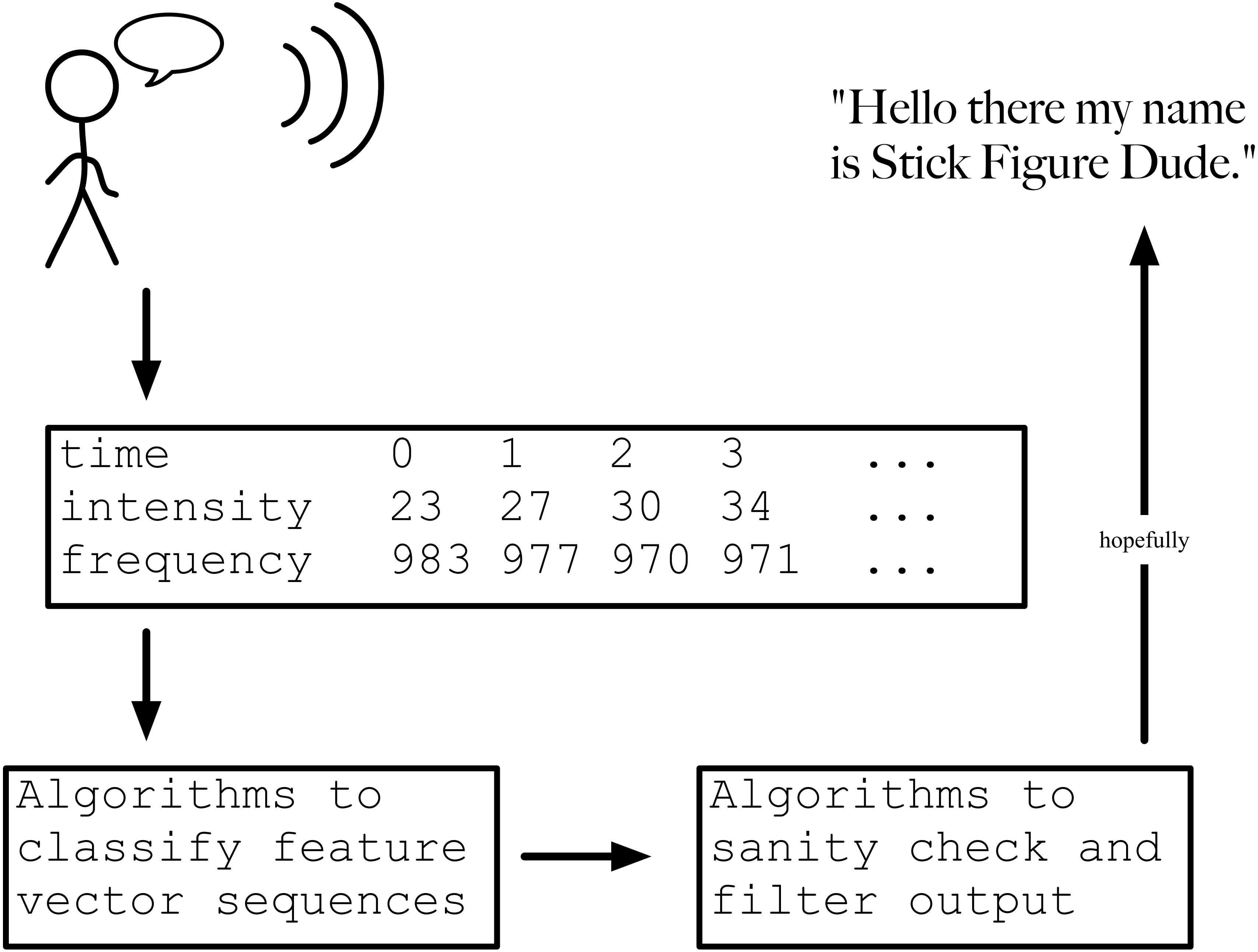
"Hello there my name is Stick Figure Dude."



That arrow in the middle is the little tricky part. Usually how this works is:

(1) Convert the audio waves into a digital form via a sensor.
(2) Analyze the waveform to provide *features* for time steps:
- — intensity level
- — segmentation into syllables
- — identification of segments into possible phonemes
- — prosodic qualities (rhythm, timbre, inflection, pauses, etc)

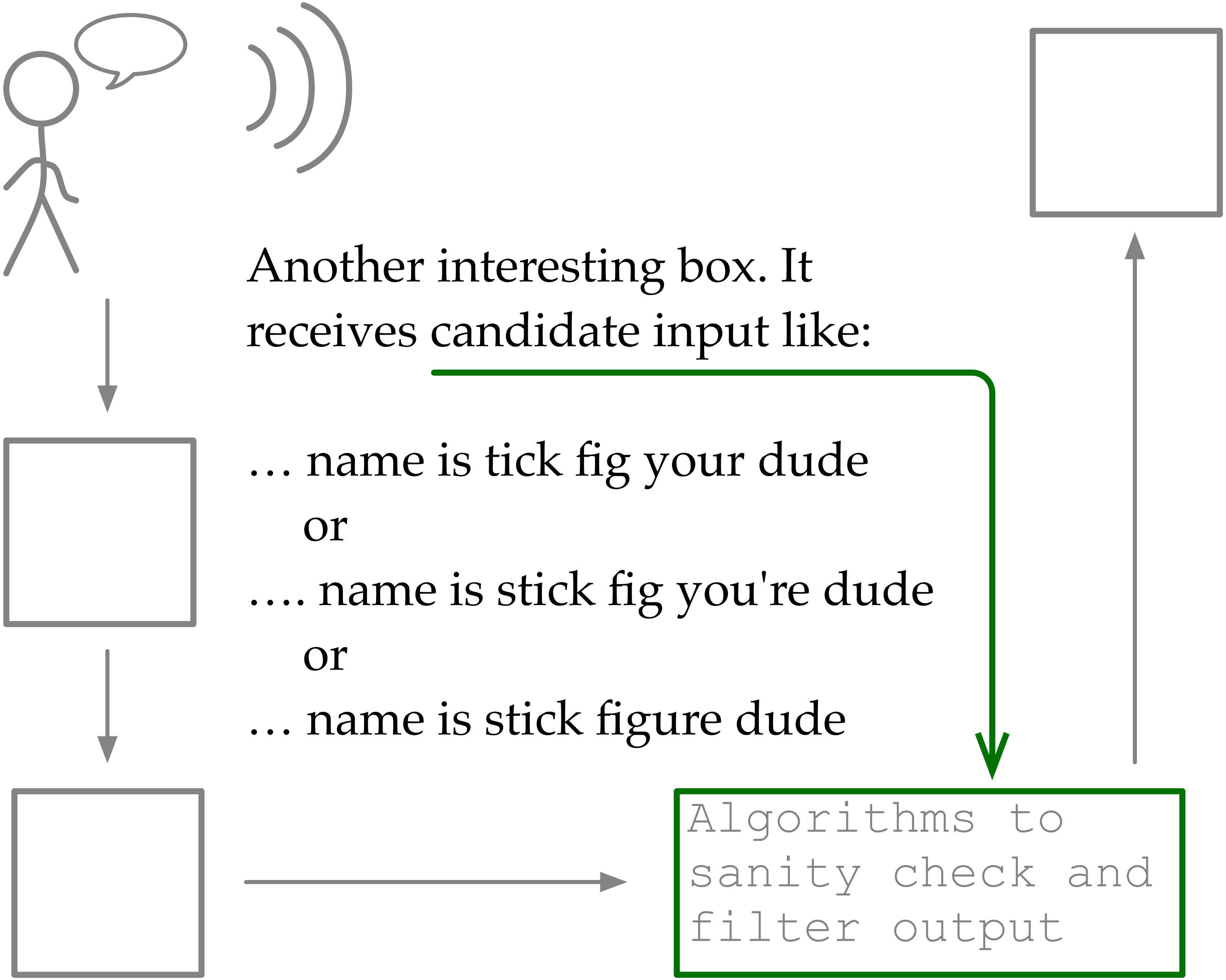
(3) Doing math on that collection of features


"Hello there my name is Stick Figure Dude."
hopefully
time 0 1 2 3 ...
intensity 23 27 30 34 ...
frequency 983 977 970 971 ...
Algorithms to classify feature vector sequences
Algorithms to sanity check and filter output

Each column here is a feature vector. This has 2 dimensions, but a real one might have dozens or hundreds. That might sound scary to humans, but computers do not care how scary a vector is.

time	0	1	2	3	...
intensity	23	27	30	34	...
frequency	983	977	970	971	...

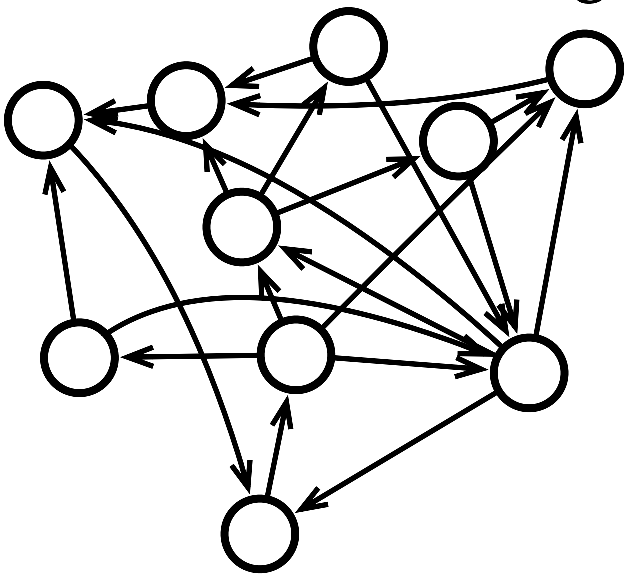
Now that you have feature vectors rather than raw compression wave data, you can do math. You can do stuff like take the angle between two vectors, or measure the distance between their endpoints. This is Calc 2 stuff. You can also do matrix math (that's linear algebra stuff).


Another interesting box. It receives candidate input like:
… name is tick fig your dude
or
…. name is stick fig you're dude
or
… name is stick figure dude
Algorithms to sanity check and filter output

Network Models:
Making, editing, and exploring graph structures

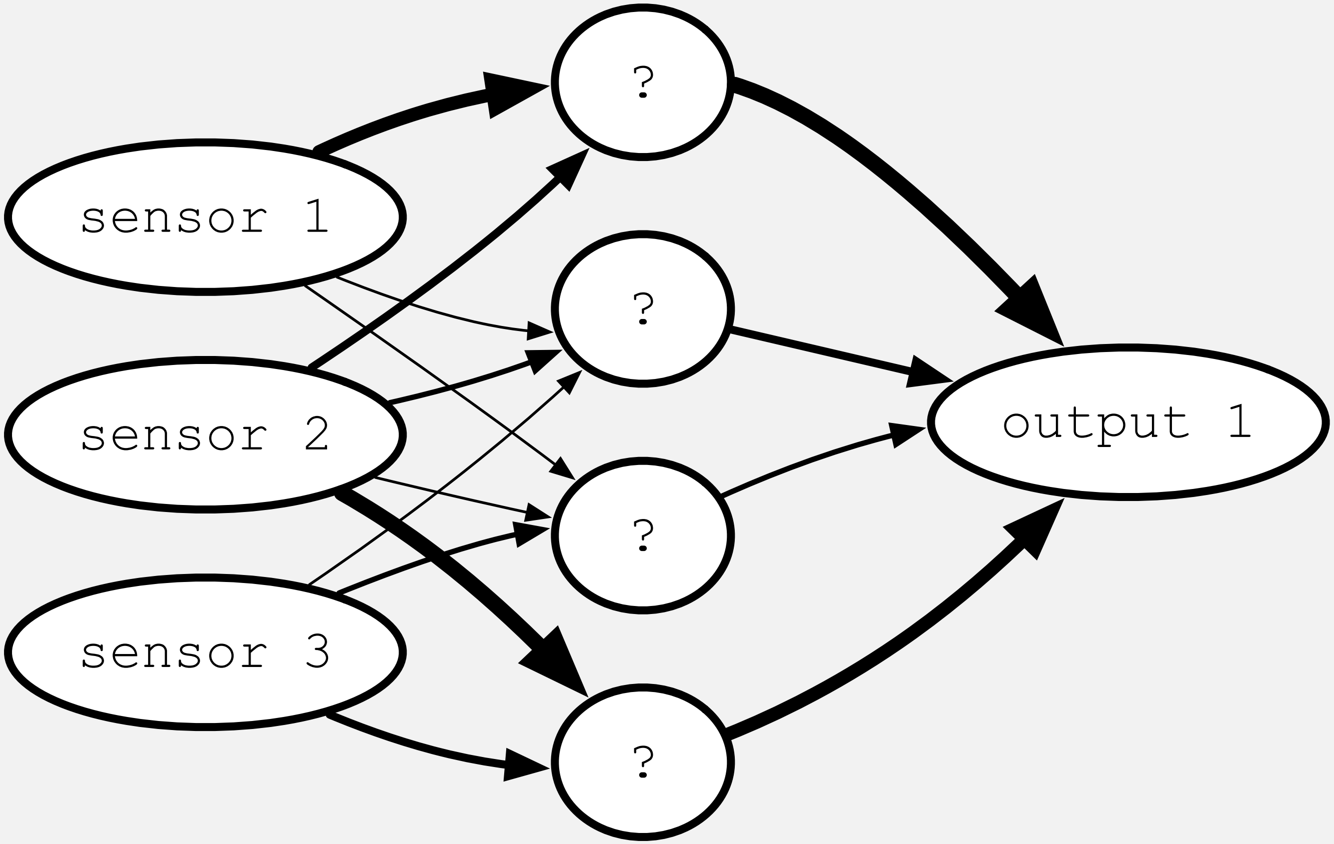
Logical	Web of concepts and truth statements
Statistical	Assign probabilities of how likely items are with relation to one another

Biologically-inspired



Simulate brain physiology with hardware or software

Neural Networks

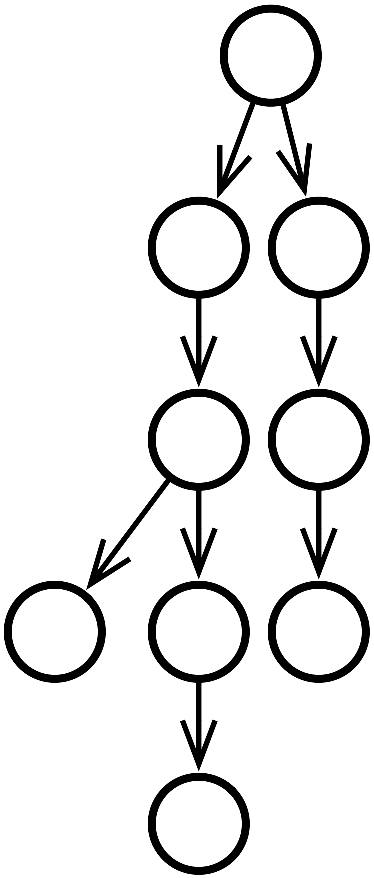


Each sensor sends a weighted signal to some number of *hidden* intermediate nodes. They combine their inputs to provided a weighted result that contributes to the output layer. These require **training** to work, and will 'notice' things that you don't want them to.

Possibly untrue legend of Neural Nets

Military trained a NN to find camouflaged tanks but trained all positive matches on a sunny day, all negative matches on cloudy day. Resulting NN could tell you if it is sunny or not regardless of presence of tank (or not).

Decision Trees



A decision tree models a series of yes/no questions that we might ask of a feature vector. Inner nodes are questions, and leaf nodes represent the predicted classification.

Questions!

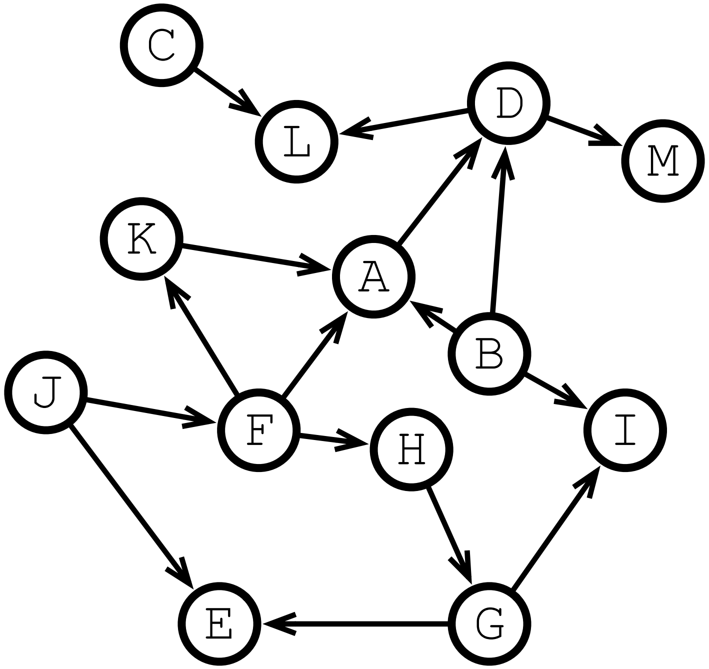
(1) Are you younger than 30?
(2) Are you planning on taking CS 2400?
(3) Do you enjoy programming?

If the answer was 'yes' to all of these questions, my decision tree leads us to the leaf node that says *you must be a computer science major.*

Intelligence as Search

Exhaustive

An exhaustive search tries *every reachable or possible solution* to evaluate how well it satisfies some question. This was the Rubik Cube thing. *See also: Big Data.* Can take days or years, but will give you a definite answer. Usually.



Heuristic

An heuristic search explores the solution space by using rules, statistics, or contextual information. Usually designed to be fast, with polynomial computational complexity. Finding and improving heuristics is a main activity of AI research.

Some AI tools:

Depth-first search! Can use this to exhaustively search a problem space that is modeled as a graph.

Principle components analysis: Convert a high-dimensional space into something smaller (e.g. 720 dimensions into 12). Often used as preprocessing step for other algorithms. Uses matrix data structures.

Bayesian Networks: use statistical data about previous situations to model relative likelihood of current or future situations. Uses a graph data structure.

Some more AI tools:

Calculus optimization! I know how much you love calculus. Remember Newton's method for root-finding? *Perfect* for finding optima and minima, which often represent locally or globally best solutions to a reasoning process.

Spit and chewing gum: Many of the coolest hacks in AI are built quickly based on programmer intuition. They may not be long-lasting, but they are often good starting points until a more solid basis can be found.