Big Picture

Thomas Graf

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LIN 220
Lecture 1

Two lessons

Two lessons

Lesson 1

Pogo sticks don't fly.

Two lessons

Lesson 1

Pogo sticks don't fly.

Lesson 2

Wasps are strangely stupid.

An alternate history of flight

- It is the 19th century, and airplanes aren't a thing yet.
- Three competitors at the first national flight competition:

Icarus Inc

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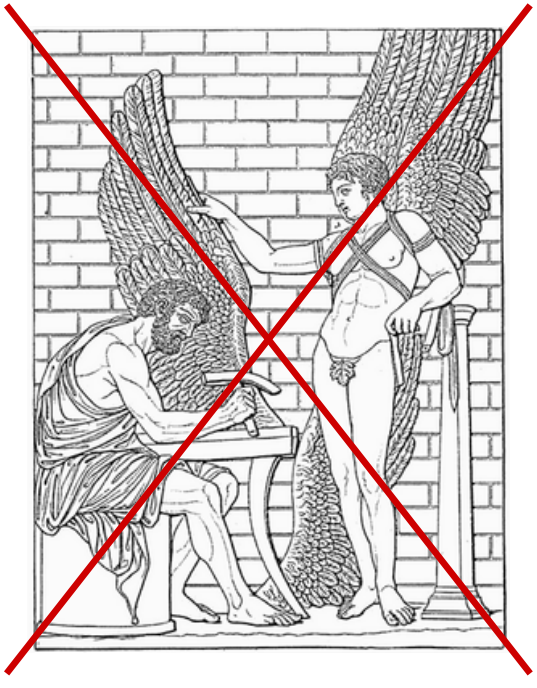

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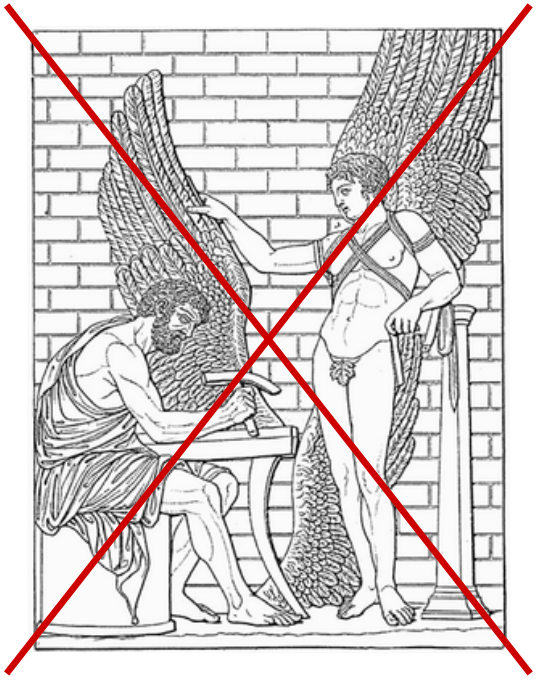

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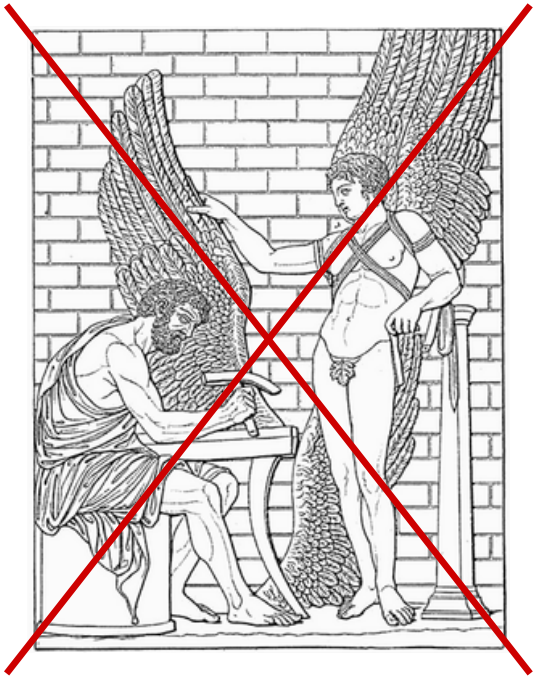

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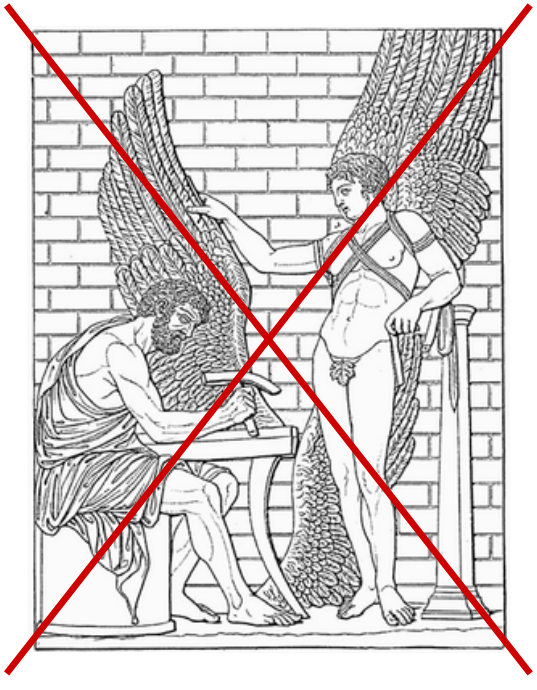

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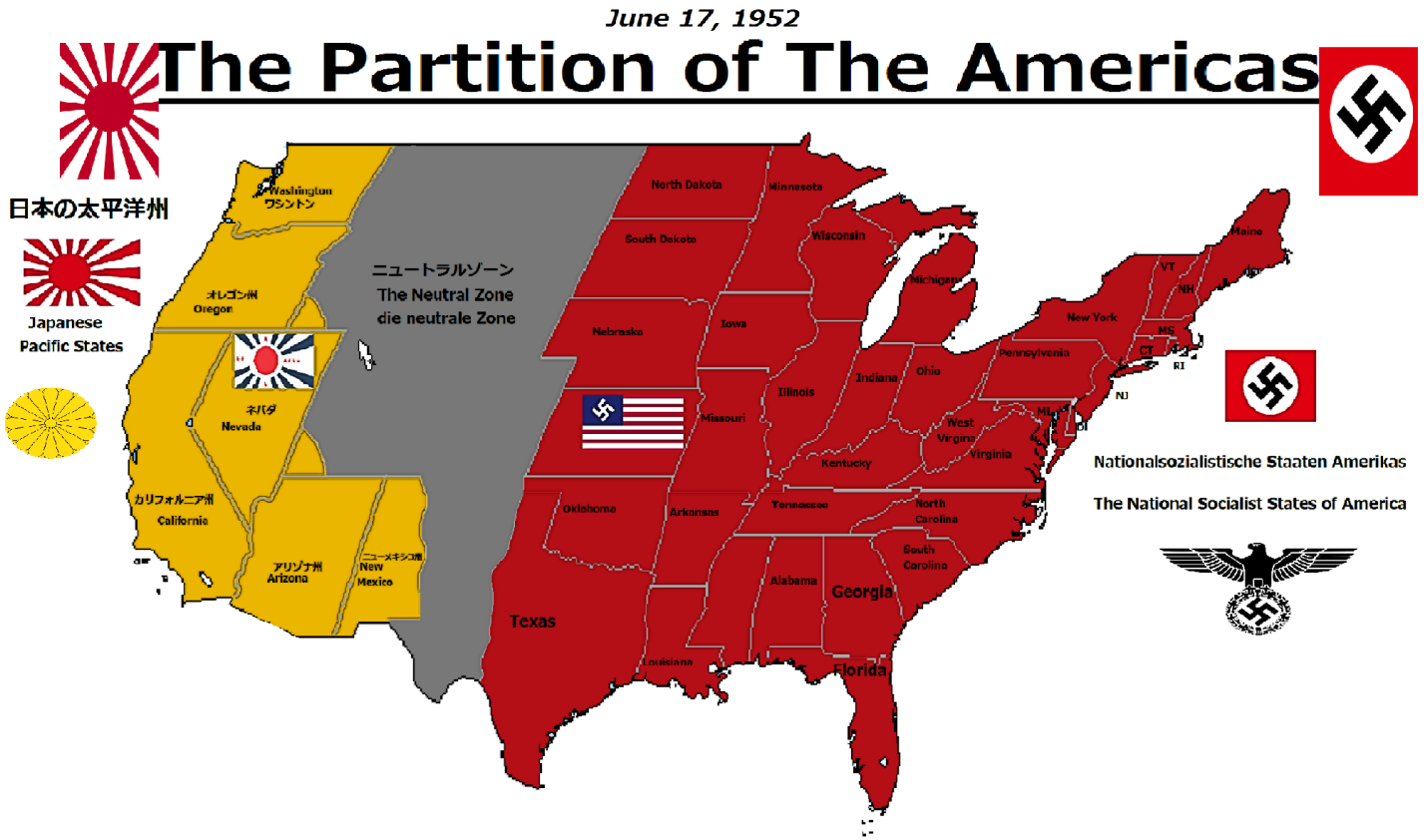
Timmy

An alternate history of flight [cont.]

- After Timmy's victory, **pogo sticks are all the rage**.
- Better and better pogo sticks hit the market.
- By 1930, the US is the world's leading pogo stick nation.

An alternate history of flight [cont.]

- By 1952, the US is occupied by Japan and Nazi Germany.
- Its pogo sticks were **no match for airplanes**.
- Nobody knows what happened to Timmy.



Language technology = pogo sticks

- Like flight, language technology is the future.
- Like pogo sticks, **hyped solutions** are not the final answer:
  - Deep Learning
  - Big Data
  - embeddings
  - RNNs, LSTMs
  - seq2seq
- Let's talk about them...

The current hype: Deep Learning

- One learning model is all over the media right now: **Deep Learning**
- Deep learning = very large and complex neural networks
- Neural networks imitate the human brain.

Standard model of the human brain

- connected network of neurons
- input activates neurons, which start "firing" (= emitting electrical current)
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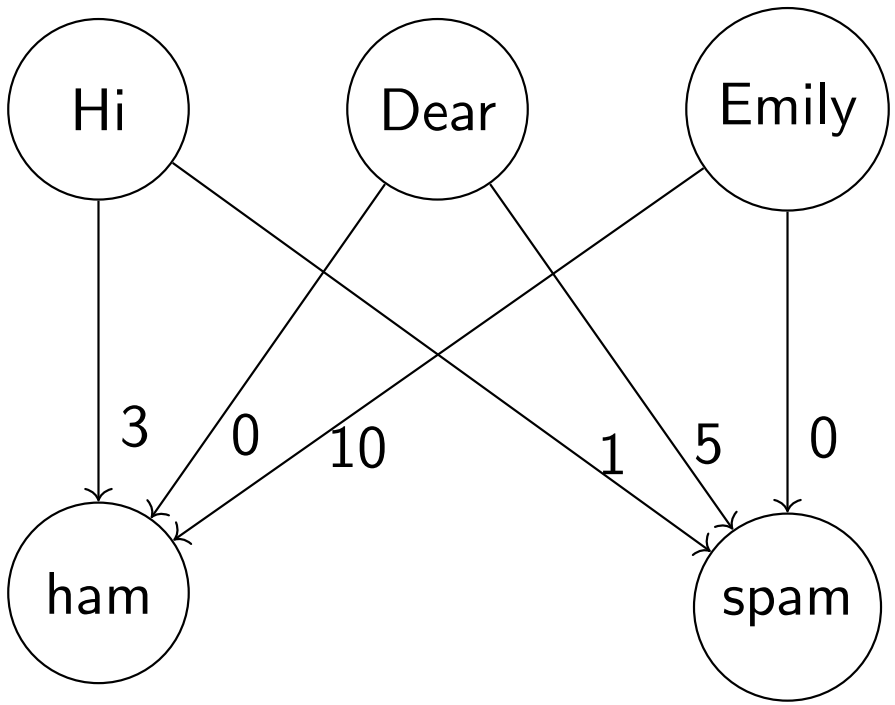
The perceptron

- **input layer:** neurons that are sensitive to input
- **output layer:** neurons that represent output values
- **connections:** weighted links between input and output layer
- most activated output neuron represents decision



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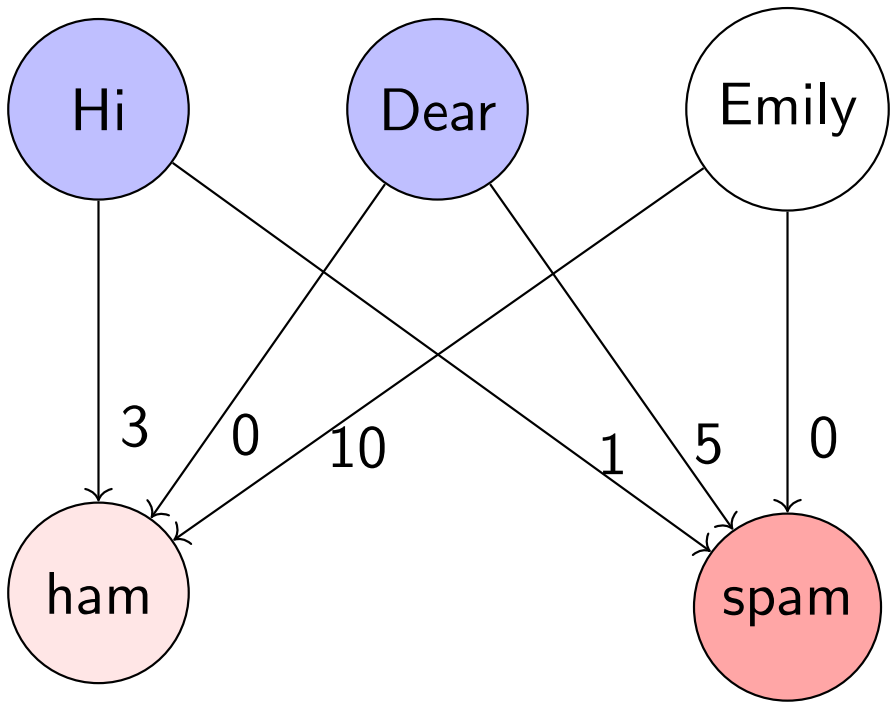

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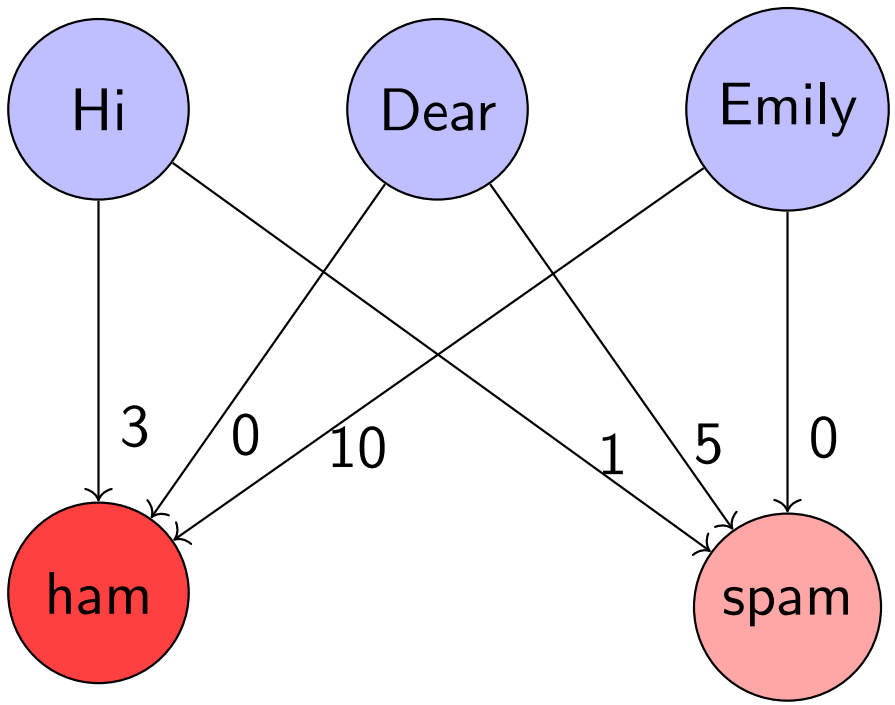

For the friendly neighborhood mathematician

- Perceptrons are linear functions (matrix multiplication).

Example (Computing *Hi Dear*)

$$\begin{pmatrix} 1 & 1 & 0 \end{pmatrix} \otimes \begin{pmatrix} 3 & 1 \\ 0 & 5 \\ 10 & 0 \end{pmatrix} = \begin{pmatrix} 3 & 6 \end{pmatrix}$$

- Since matrix multiplication is associative,
  every **multi-layer perceptron can be reduced to one layer**.

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Example (Adding more weight to spam score)

$$\begin{pmatrix} 3 & 6 \end{pmatrix} \otimes \begin{pmatrix} 3 & 0 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 9 & 6 \end{pmatrix} = \begin{pmatrix} 1 & 1 & 0 \end{pmatrix} \times \begin{pmatrix} 9 & 1 \\ 0 & 5 \\ 30 & 0 \end{pmatrix}$$

Neural networks: The big picture

- Modern neural networks are just the perceptron on steroids.
- There's a lot of jargon:
  - RNNs
  - LSTMs
  - embeddings
  - encoder/decoder
  - seq2seq
- Mathematically, modern neural networks intersperse linear functions (= perceptron layers) with non-linear functions.
- And **that's it**.

Neural networks aren't a magic bullet

Neural networks are not perfect:

- **Data hungry**
  If you don't have tons of data, don't even try.
- **Resource hungry**
  Large networks take forever to train.
- **Black boxes**
  Nobody knows what they do. It's **trial and error**.
- **Do not scale**
  If your objectives change, you're back to square 1.
- **No safeties**
  If something goes wrong, it often goes really wrong.

Neural networks in one picture

A common reply

We're not aiming for perfection,
it just has to be good enough.

Every engineer ever

My reply

1. It's still a bad choice for engineering:
   - expensive (resources, time, labor)
   - scales badly
   - not modular
2. Your notions of "good enough" are too limited:
   - precision
   - recall
   - F-score

   They all ignore **error quality**.

Let's go to wasp school

Lesson 2

Wasps are strangely stupid.

Let's go to wasp school

Lesson 2

Wasps are strangely stupid.

Volunteer needed!

What we learned from wasp school

- Users endow systems with human-like qualities.
- When human biases are violated, the illusion breaks down.
- Breaking the illusion is jarring.

The true task of language technology

- Trick humans into considering you human-like.
- Minimize errors that violate human biases.

Biases in human cognition: a quick experiment

blip	not *blip*	*blip*	not *blip*
not *gnok*	not *gnok*	*gnok*	*gnok*
not *bnik*	not *bnik*	*bnik*	not *bnik*
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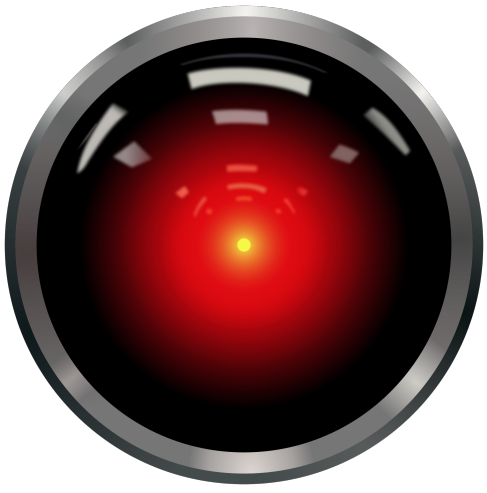
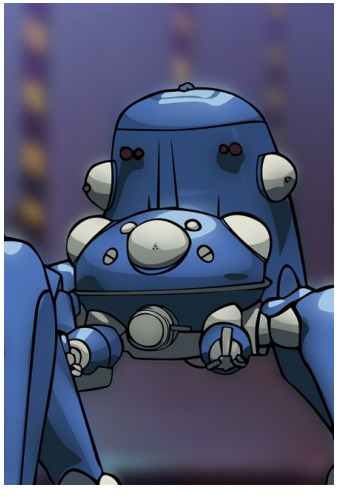
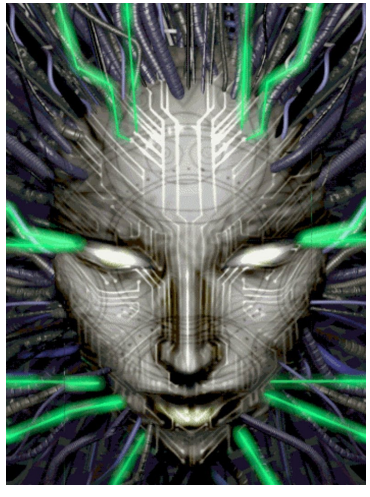
Human language bias and unreasonable expectations

Human bias is a much bigger issue for language than for, say, cars.

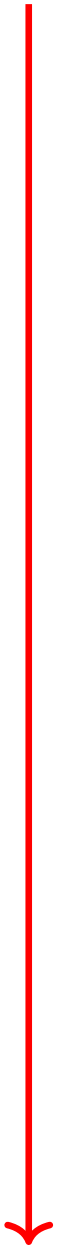






Robots' Narrow Range of Language Competence



Robots' Narrow Range of Language Competence

completely human

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completely human

perfect but weird voice

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Arnold

Fake it till you make it!

- Language technology is still largely smokes and mirrors.
- User-facing software has to fool the user.
- Current methods can't do that, they will trip up in weird ways.

Be wrong, not weird

- 90% performance can be better than 99%.
- It depends on how unnatural the errors are.

Wrapping up

- Don't get me wrong, NLP has achieved amazing things.
- Neural networks have revolutionized the field.
- But NNs are no magic fix.
- For long-term success,
  language technology needs language science.

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