Deeper Dive into AI & Data

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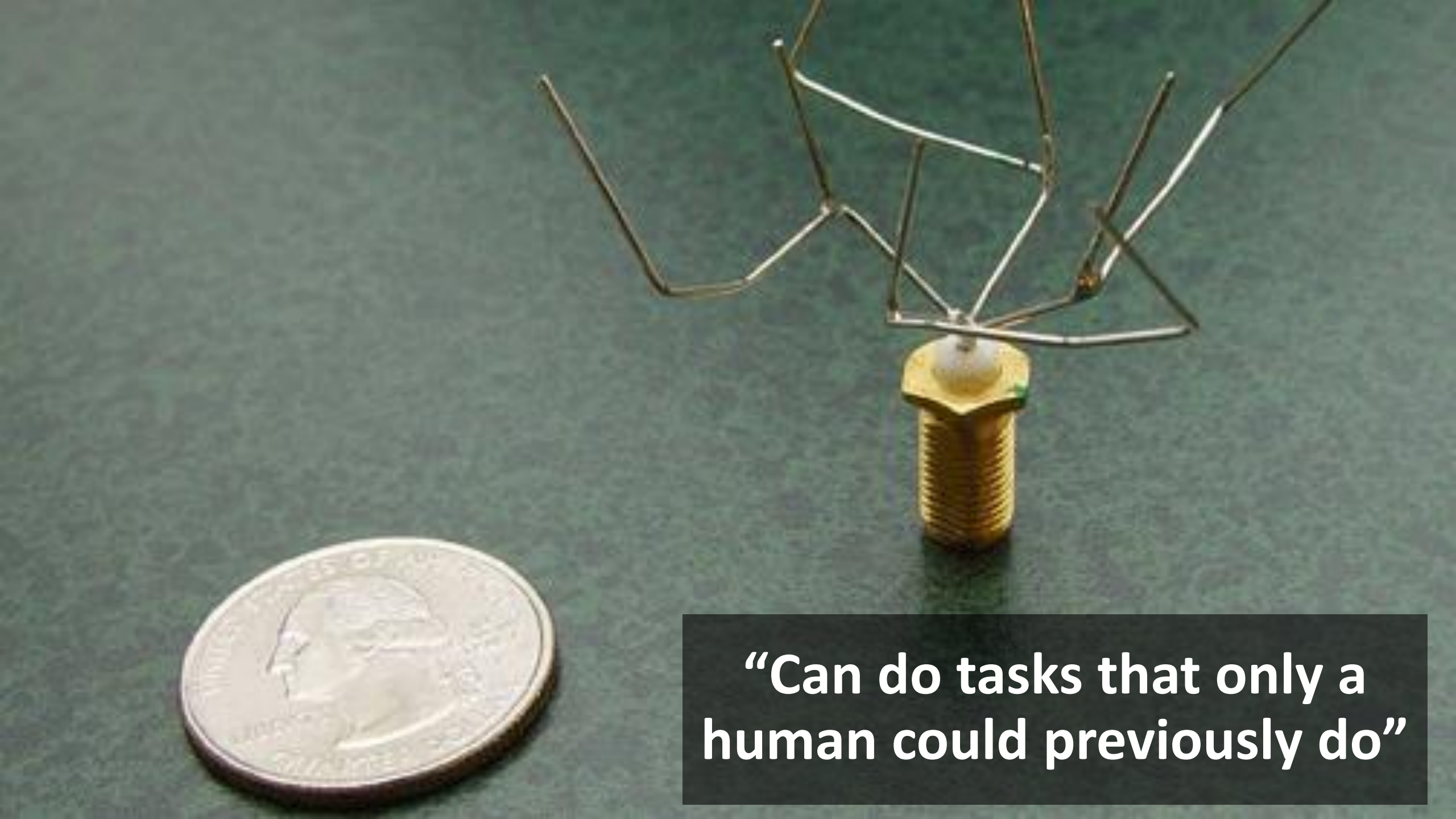
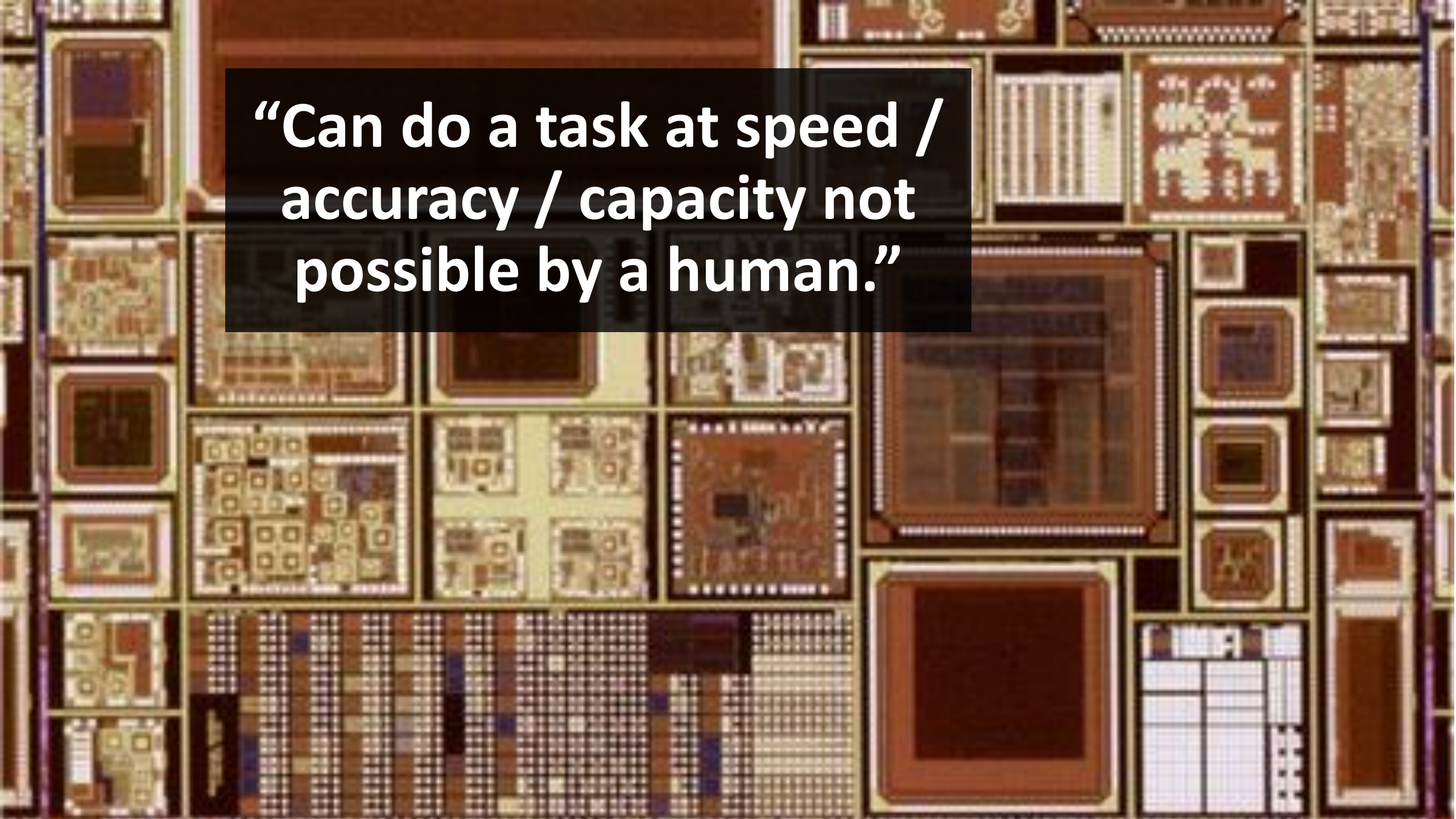
ocean

Ways to Frame AI

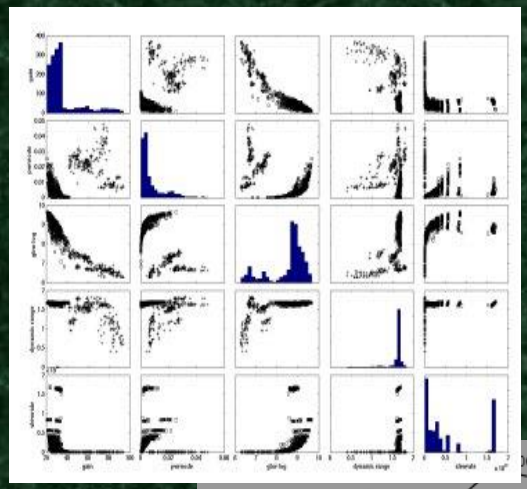
“Replicates human cognitive behavior” [Turing test]

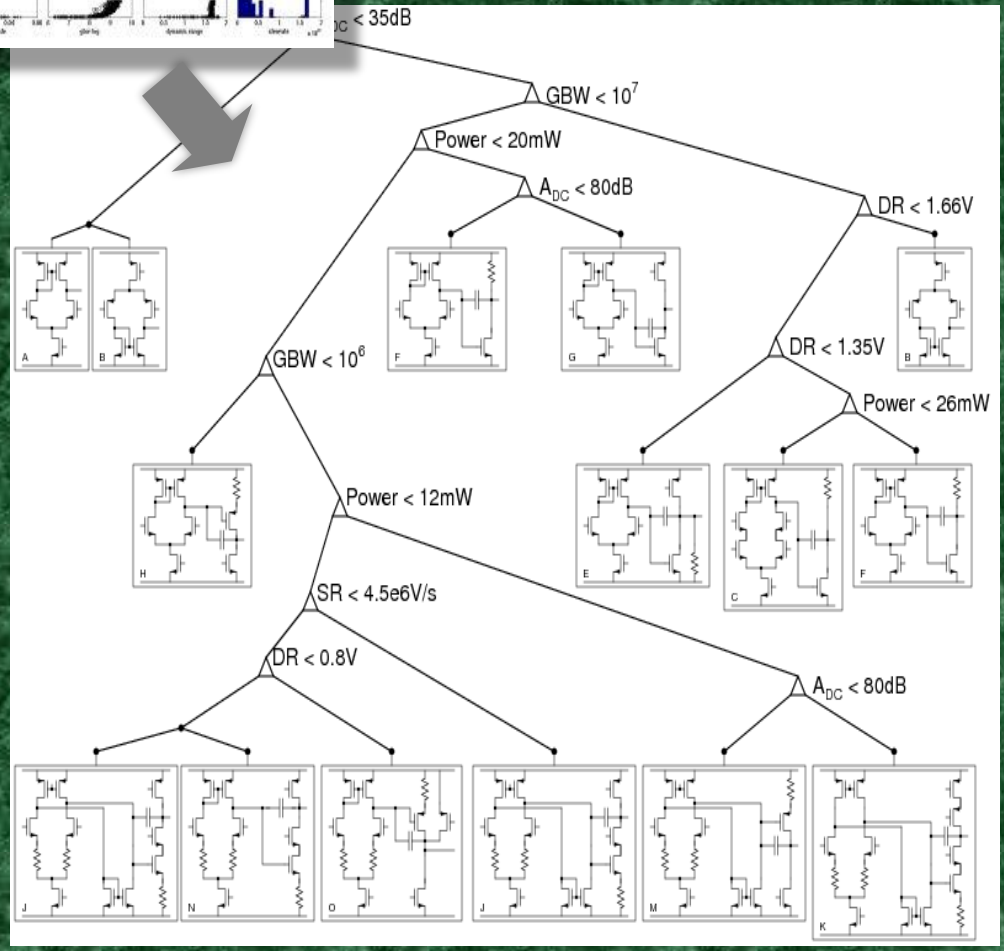

“Can do tasks that only a human could previously do”


“Can do a task at speed / accuracy / capacity not possible by a human.”

“A set of tools”

- Classification
- Regression
- Knowledge extraction
- Optimization
- Creative / Structural design
- …

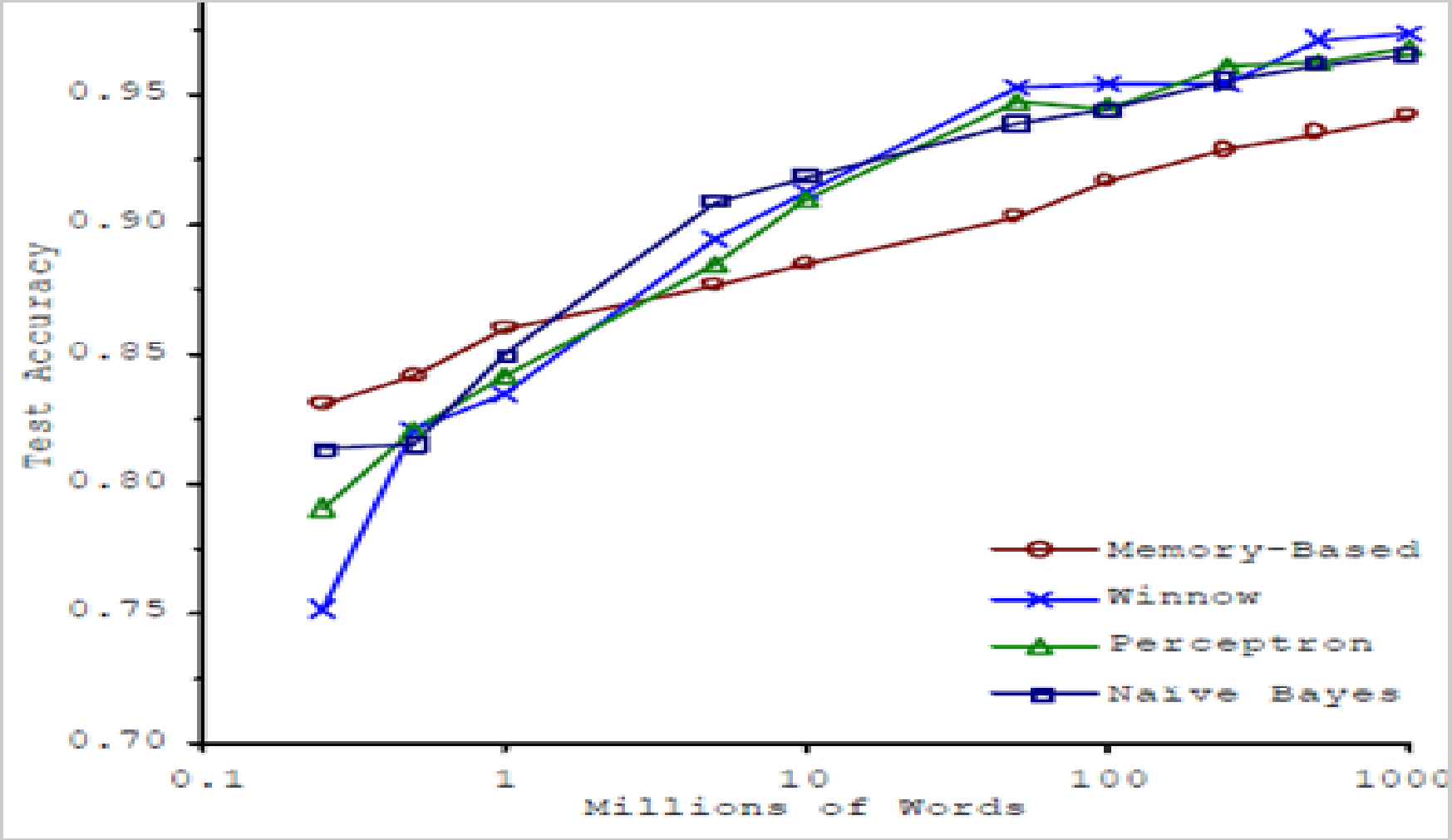





“Embodied agents” (AGI)


AI & data

The Unreasonable Effectiveness of Data

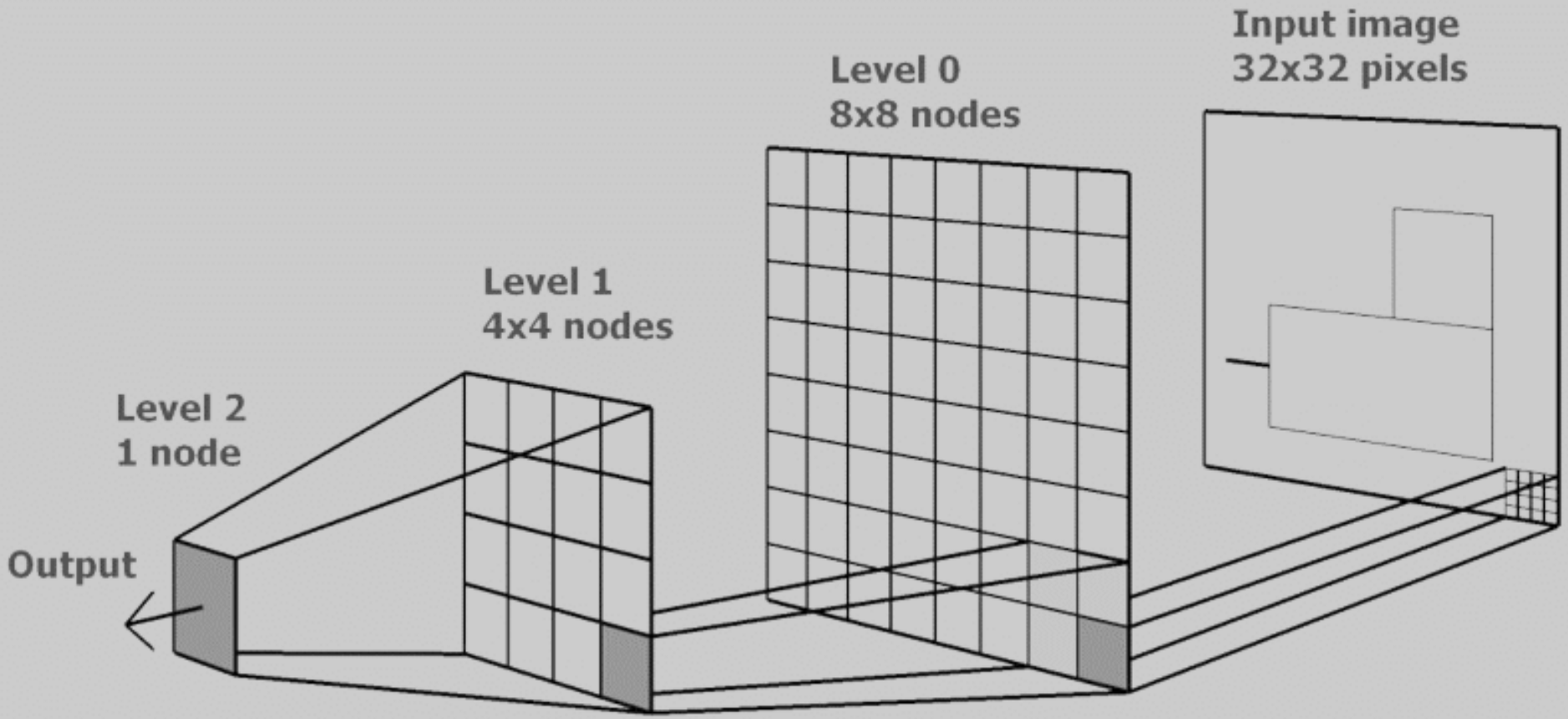


1000x *more* data

[Banko and Brill, 2001]

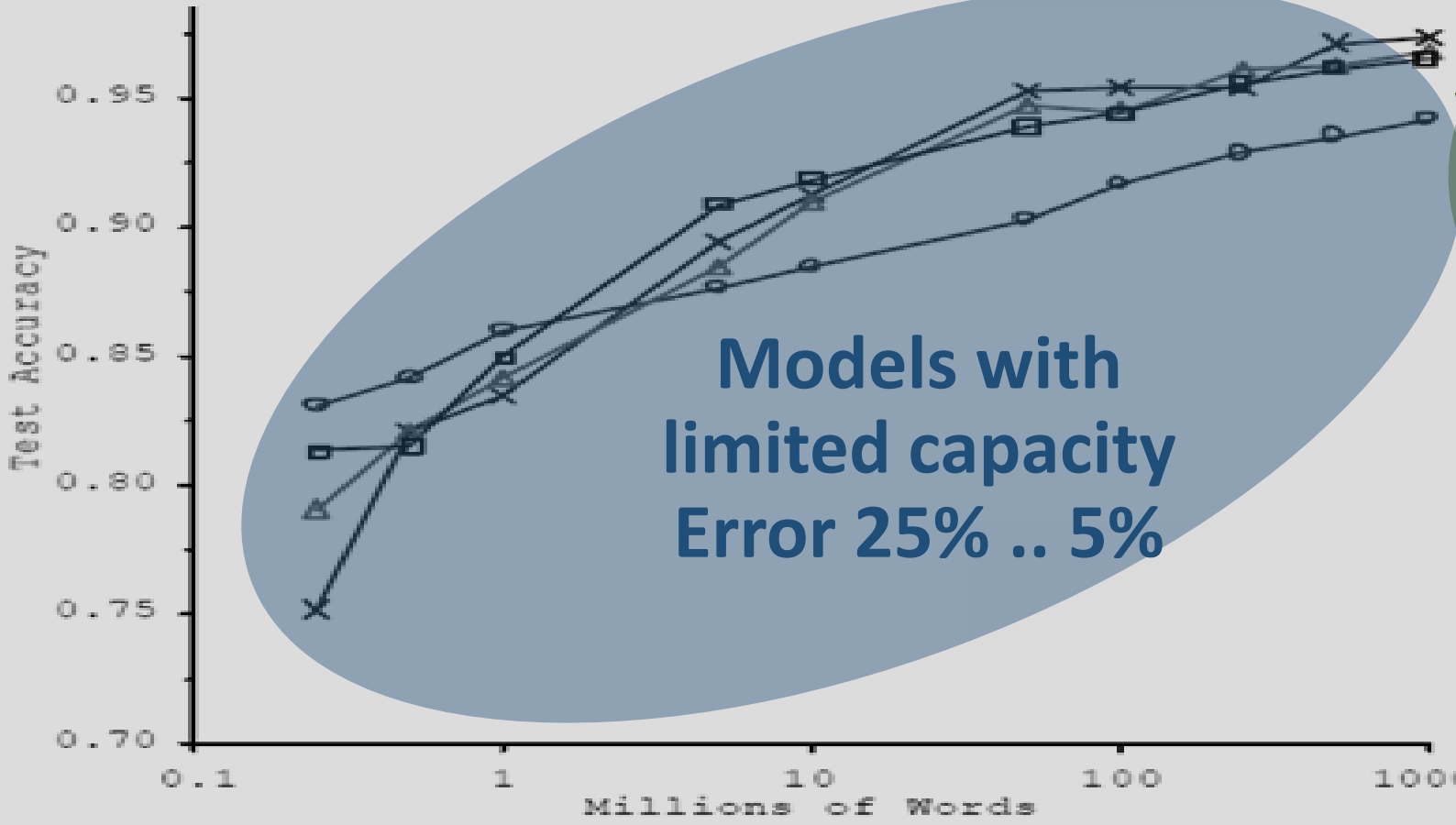
Deep Learning: Neural Networks * Moore's Law

≈1950s algorithms on 1000x+ more storage & compute



https://en.wikipedia.org/wiki/File:HTM_Hierarchy_example.png

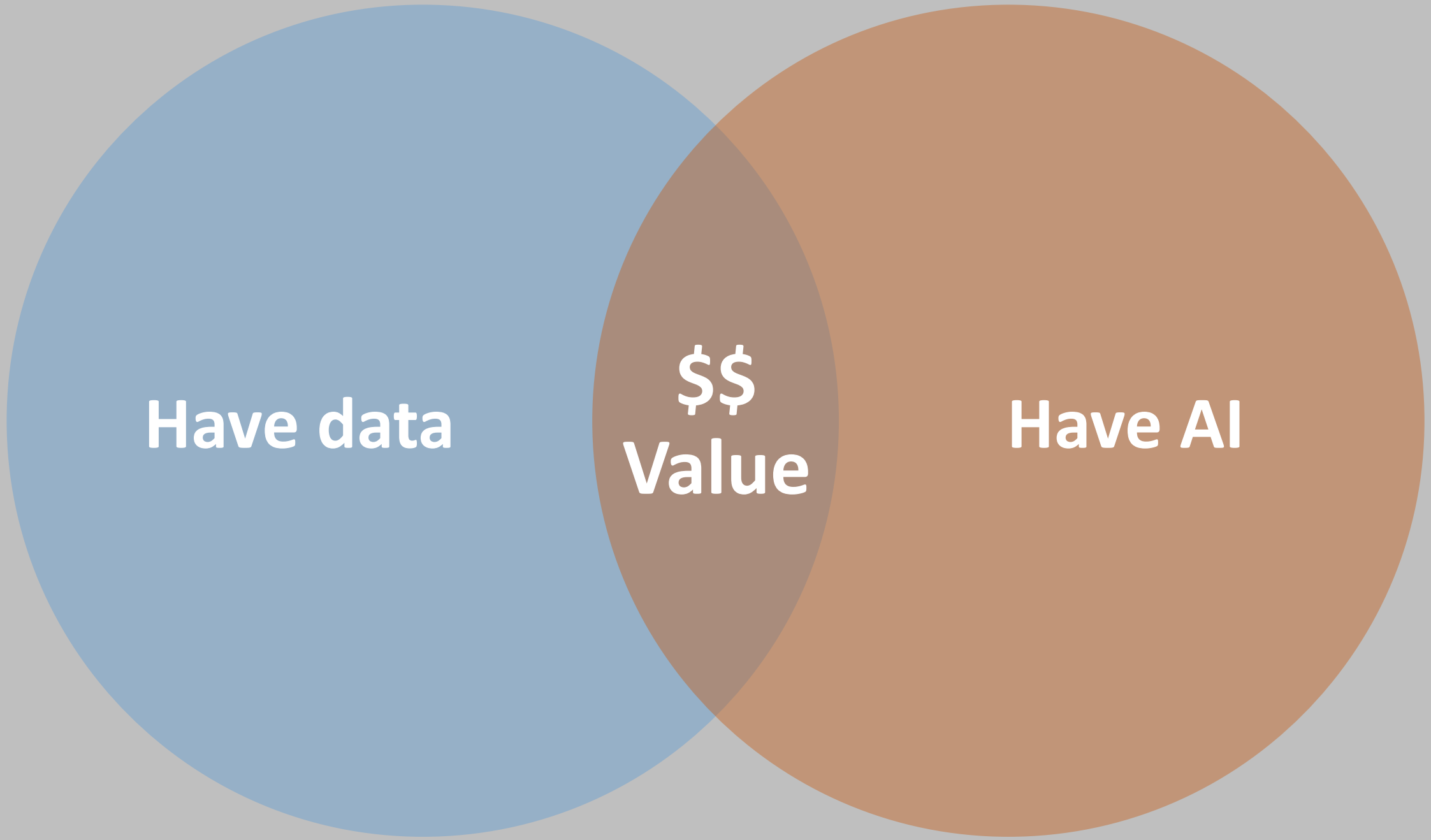
Deep Learning *Loves* Data



Models with limited capacity
Error 25% .. 5%

Deep learning models with >> capacity
Error 5% .. 0.01%

***Another* 1000x more data**


Have data
$$
Value
Have AI

AI Tools:
Deep Dive

Classification, in 2D

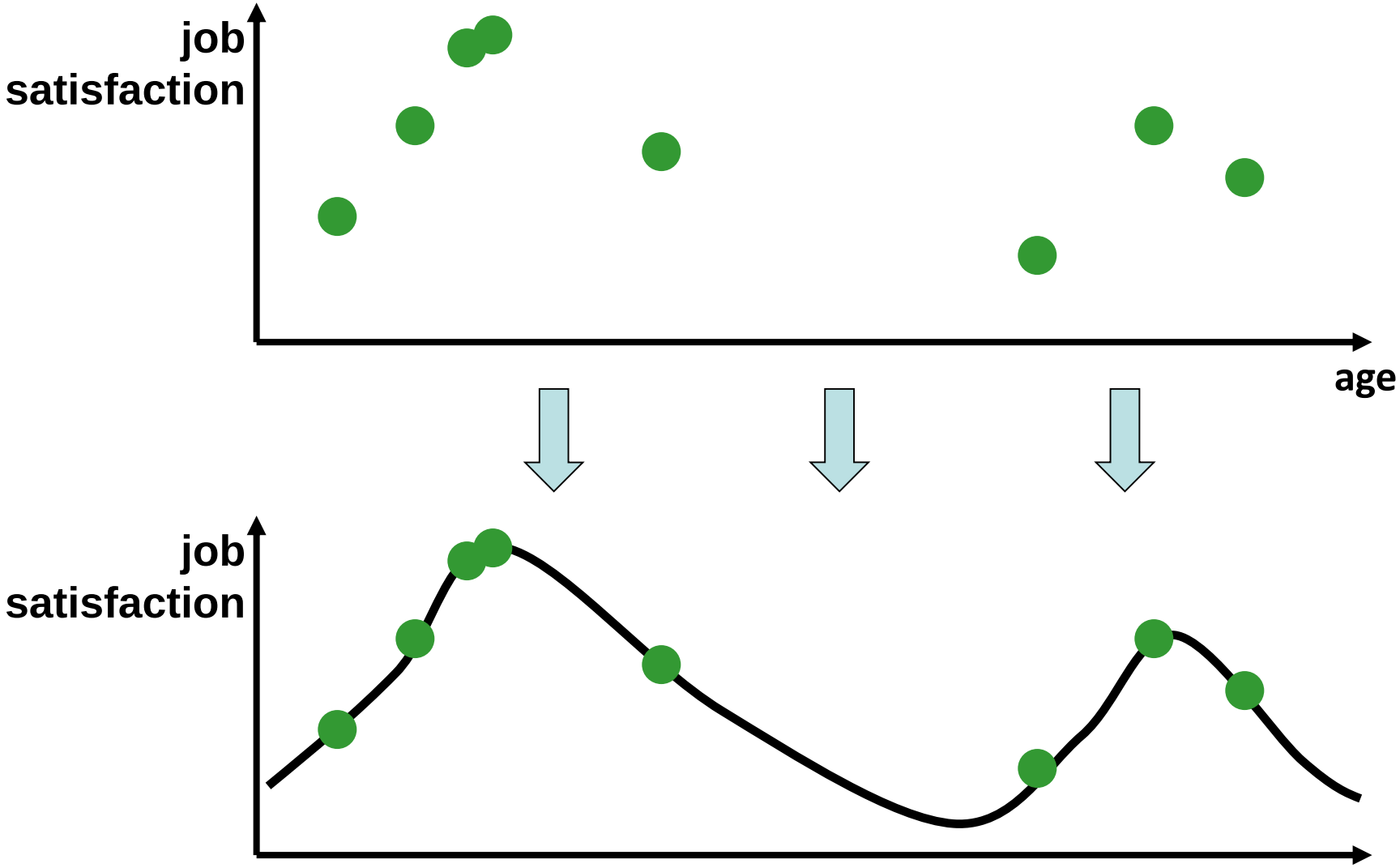
Use case: credit card applications

Credit profile:

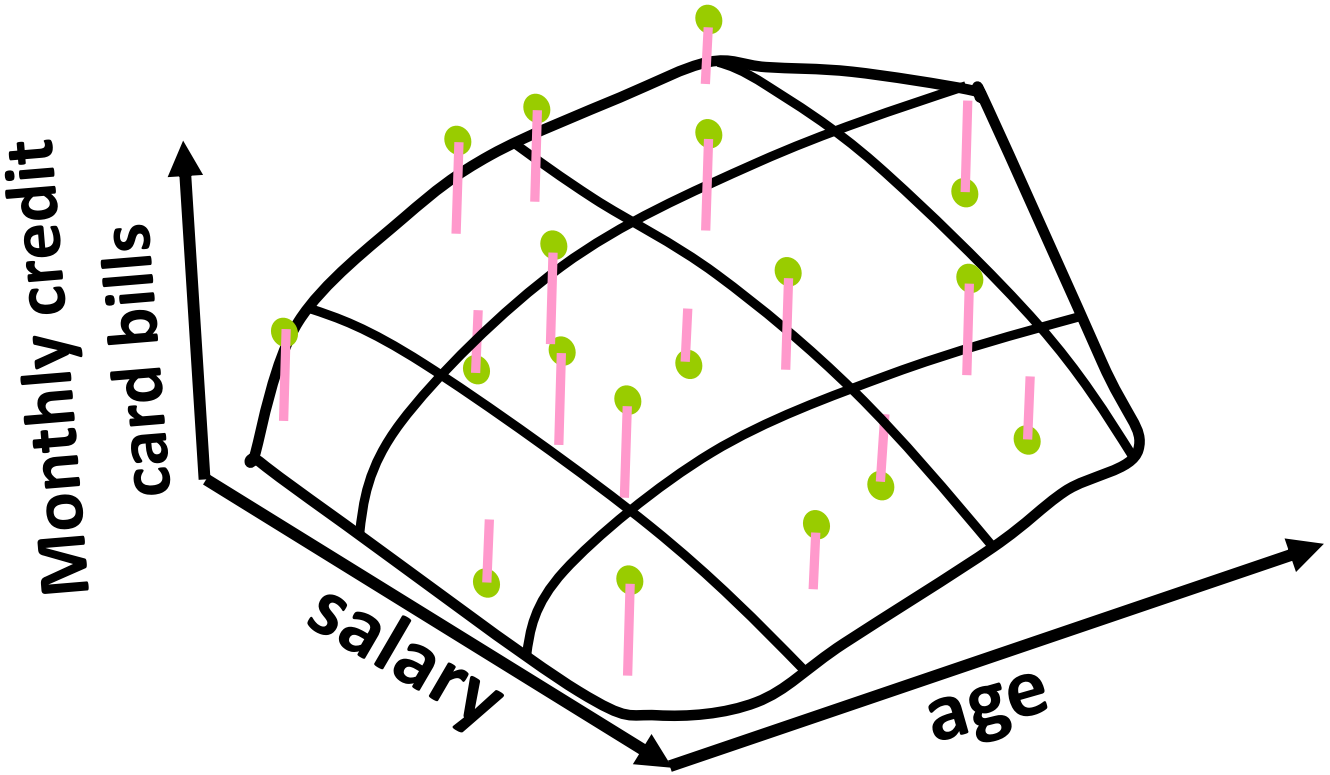
- **Paid bills**
- **Didn't pay**

How: linear classifiers, neural networks / deep learning, support vector machines, boosted trees, random forests / bagged trees

Regression, in 1D

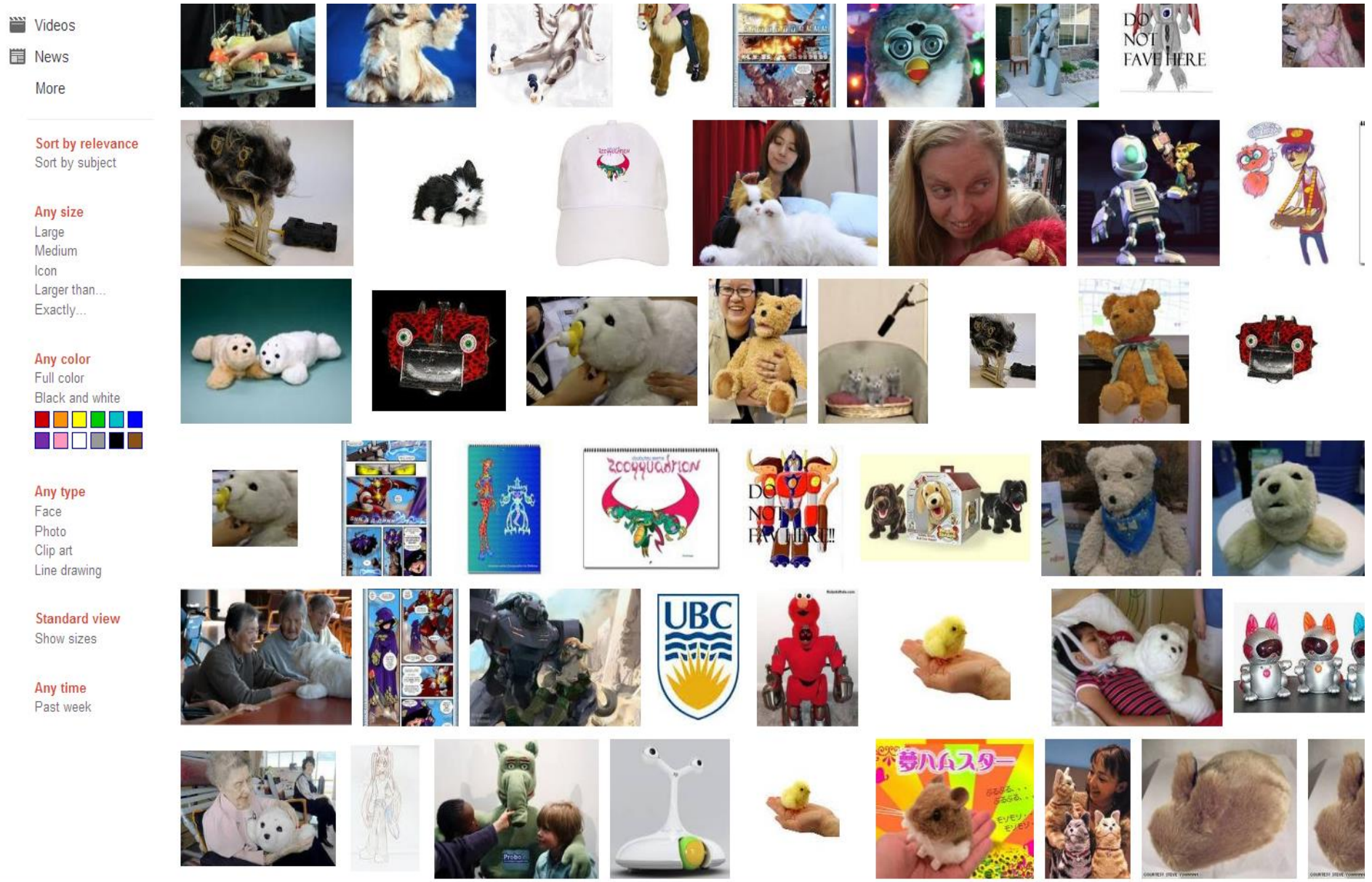


Regression, in 2D



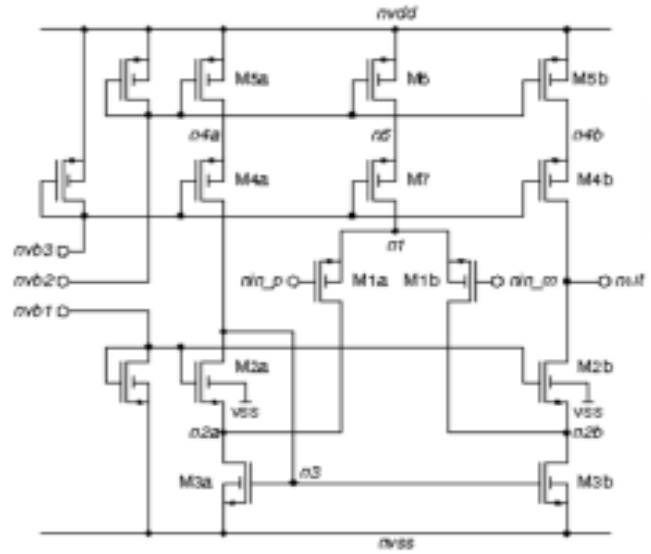
Regression in 10,000D

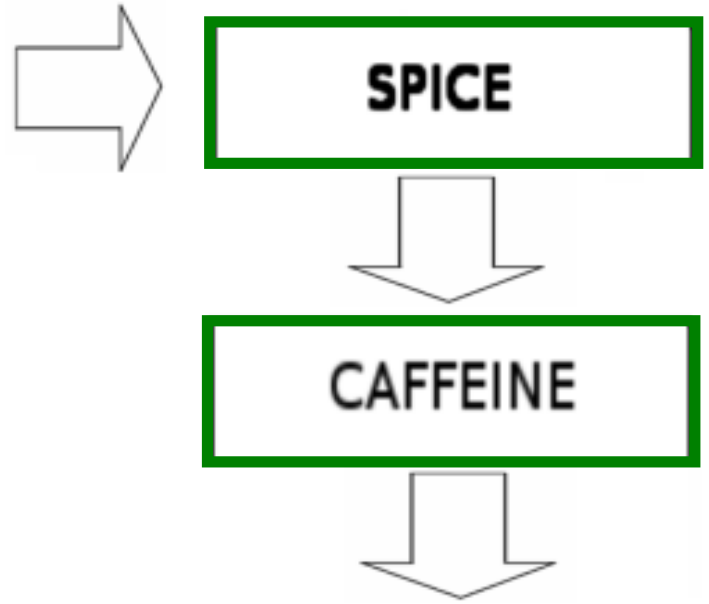
Use case: reverse image search [Google]

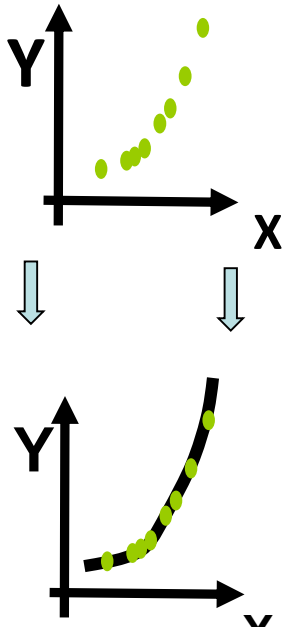


Knowledge extraction

Use case: scientific modeling of analog ccts [McC '05 KUL]



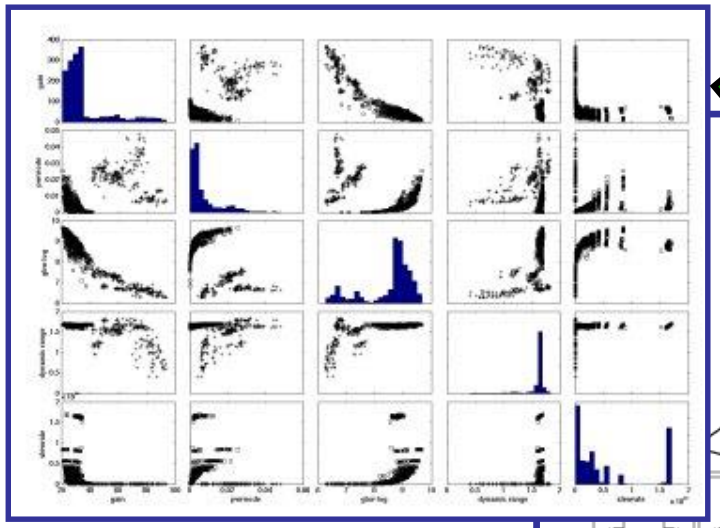


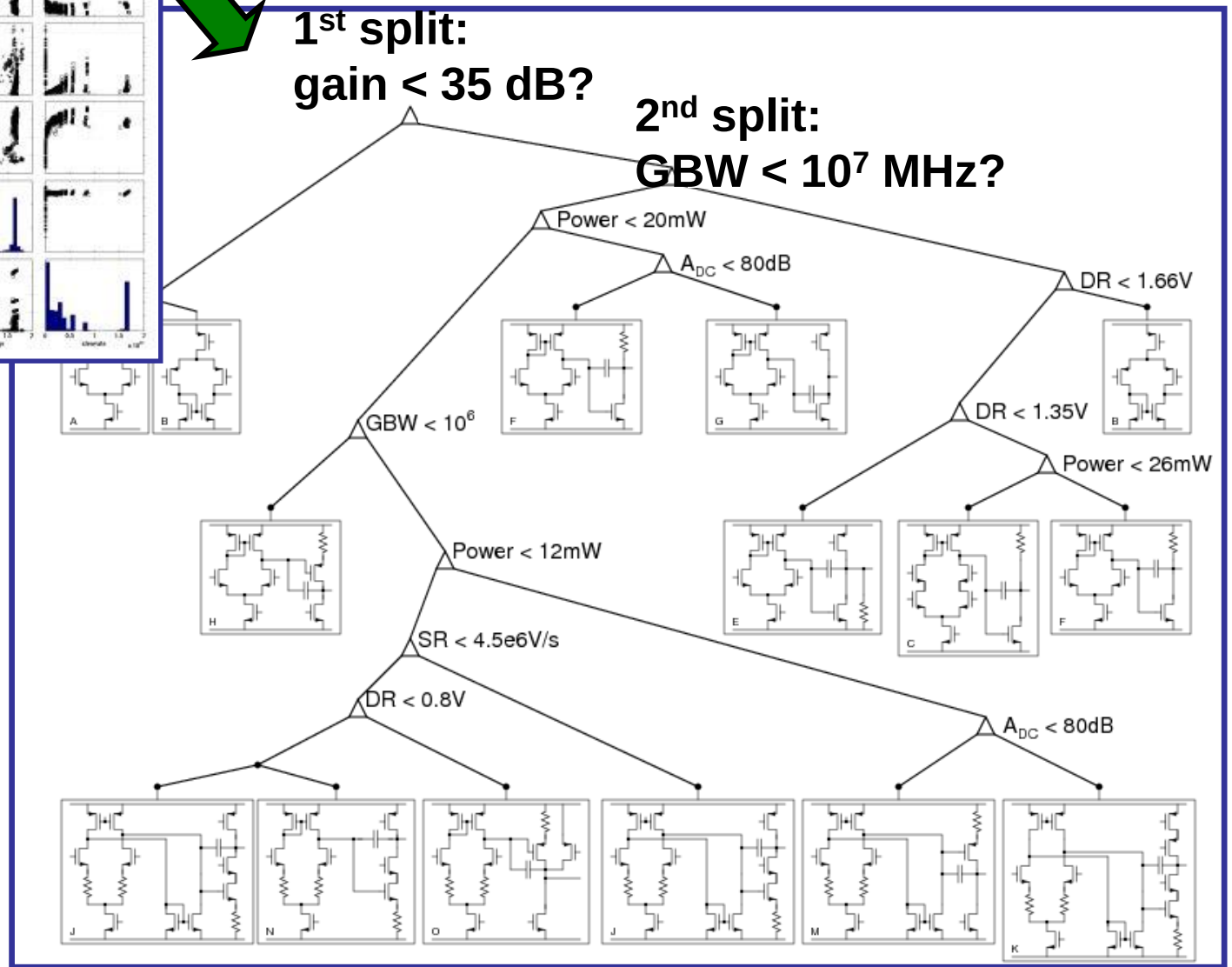


Perf.	Expression
A_{LF}	-10.3 + 7.08e-5 / id1 + 1.87 * ln(-1.95e+9 + 1.00e+10 / (vsg1*vsg3)+ 1.42e+9 *(vds2*vsd5) / (vsg1*vgs2*vsg5*id2))
f_u	10^(5.68 - 0.03 * vsg1 / vds2 - 55.43 * id1+ 5.63e-6 / id1)
PM	90.5 + 190.6 * id1 / vsg1 + 22.2 * id2 / vds2
V_{offset}	- 2.00e-3
SR_p	2.36e+7 + 1.95e+4 * id2 / id1 - 104.69 / id2 + 2.15e+9 * id2 + 4.63e+8 * id1
SR_n	- 5.72e+7 - 2.50e+11 * (id1*id2) / vgs2 + 5.53e+6 * vds2 / vgs2 + 109.72 / id1

Knowledge extraction

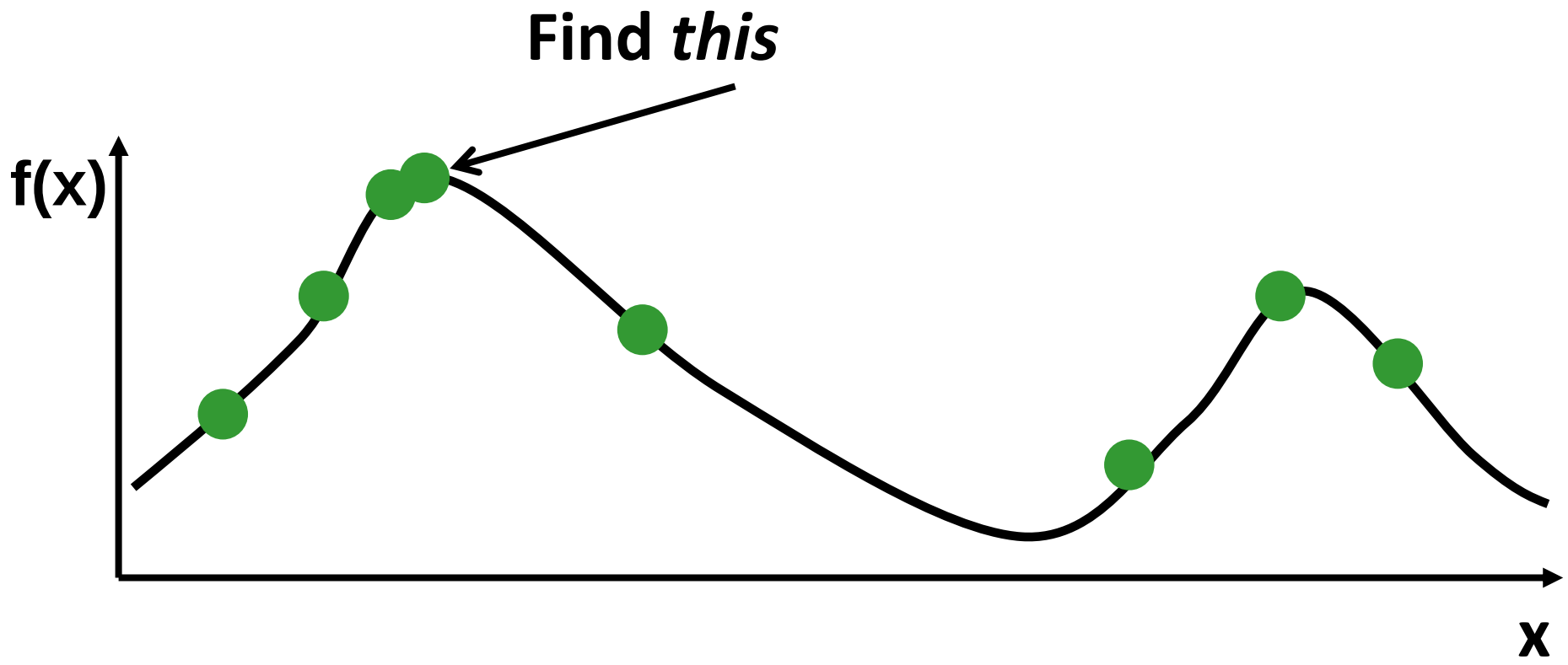
Use Case: Topology decision tree [McC '08 KUL]





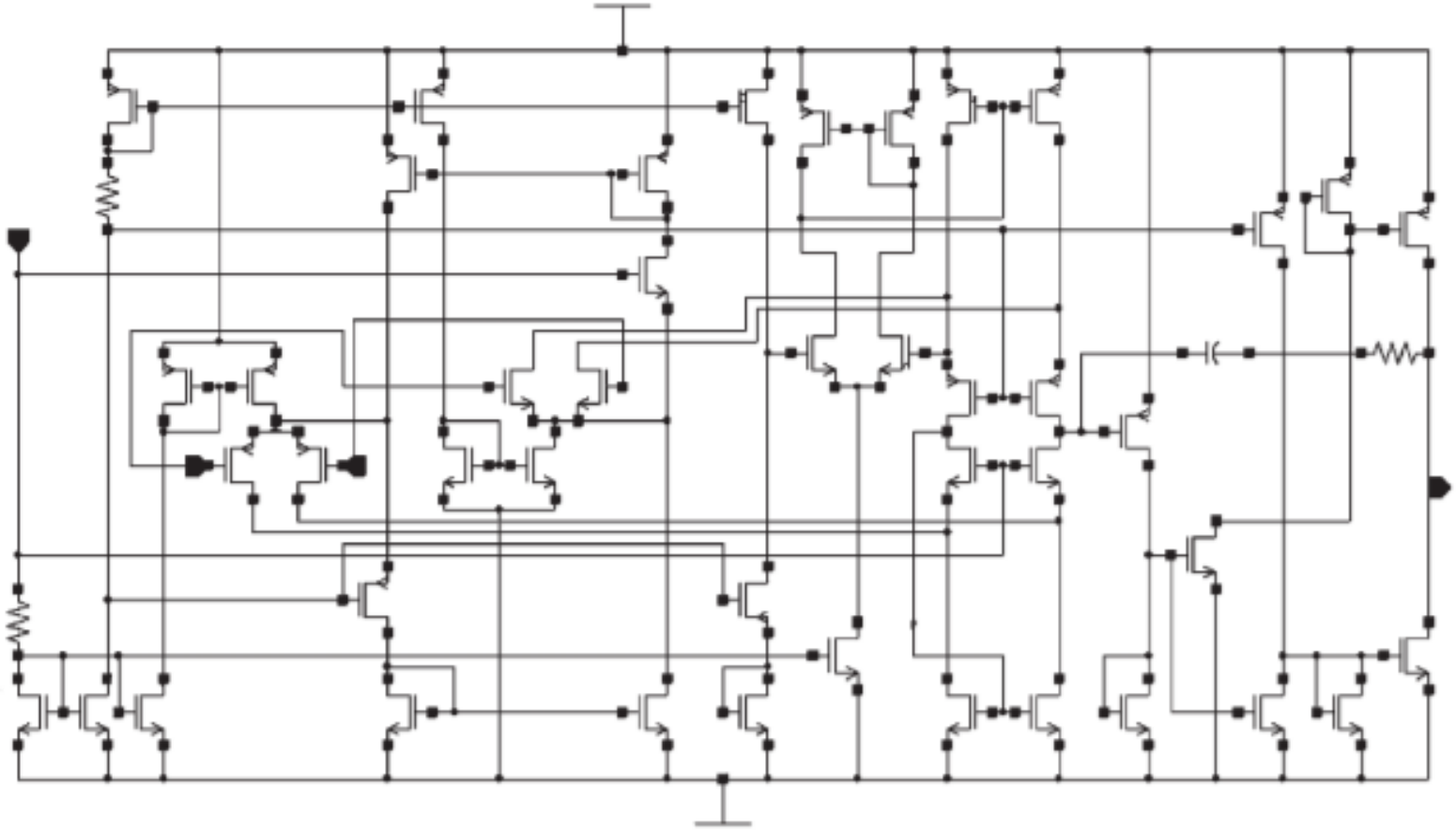
Optimization

"Find the x that maximizes f(x)"
(With as few evaluations of f(x) as possible)



Optimization

Use Case: Optimize perf. of lg. analog circuits [McC ‘01 ADA]



Optimization

Use Case: Interactive Circuit Design [McC ’12 Solido]

Under the hood, a machine learning engine adaptively samples the space of possible decisions, and measures outcomes.

Explore (ID=0)	True	3.928	53.50p	137.6u
Best (1) (ID=-1)	False	2.469	6.482p	64.28u
Best (2) (ID=-6)	False	2.379	6.722p	

Save netlist... Compare... Simulate...

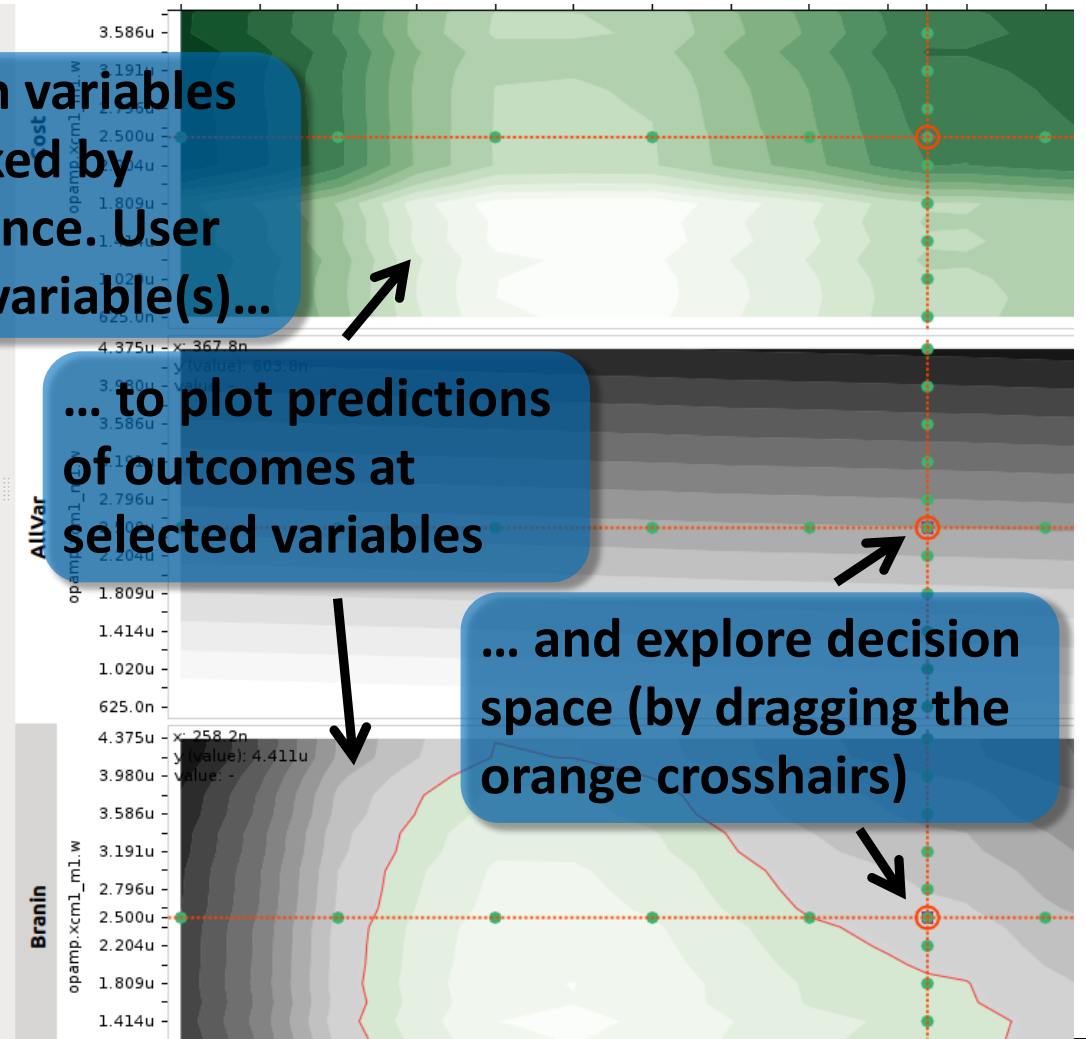
Impacts on: Branin

Impact	Variables	Value (Explore)
58.48%	opamp.xcm1_m1.l	300.0n
28.79%	opamp.xcm1_m1.w	2.500u
12.74%	opamp.xcm1_m1.l, opamp.xcm1_m1.w	300.0n, 2.500u

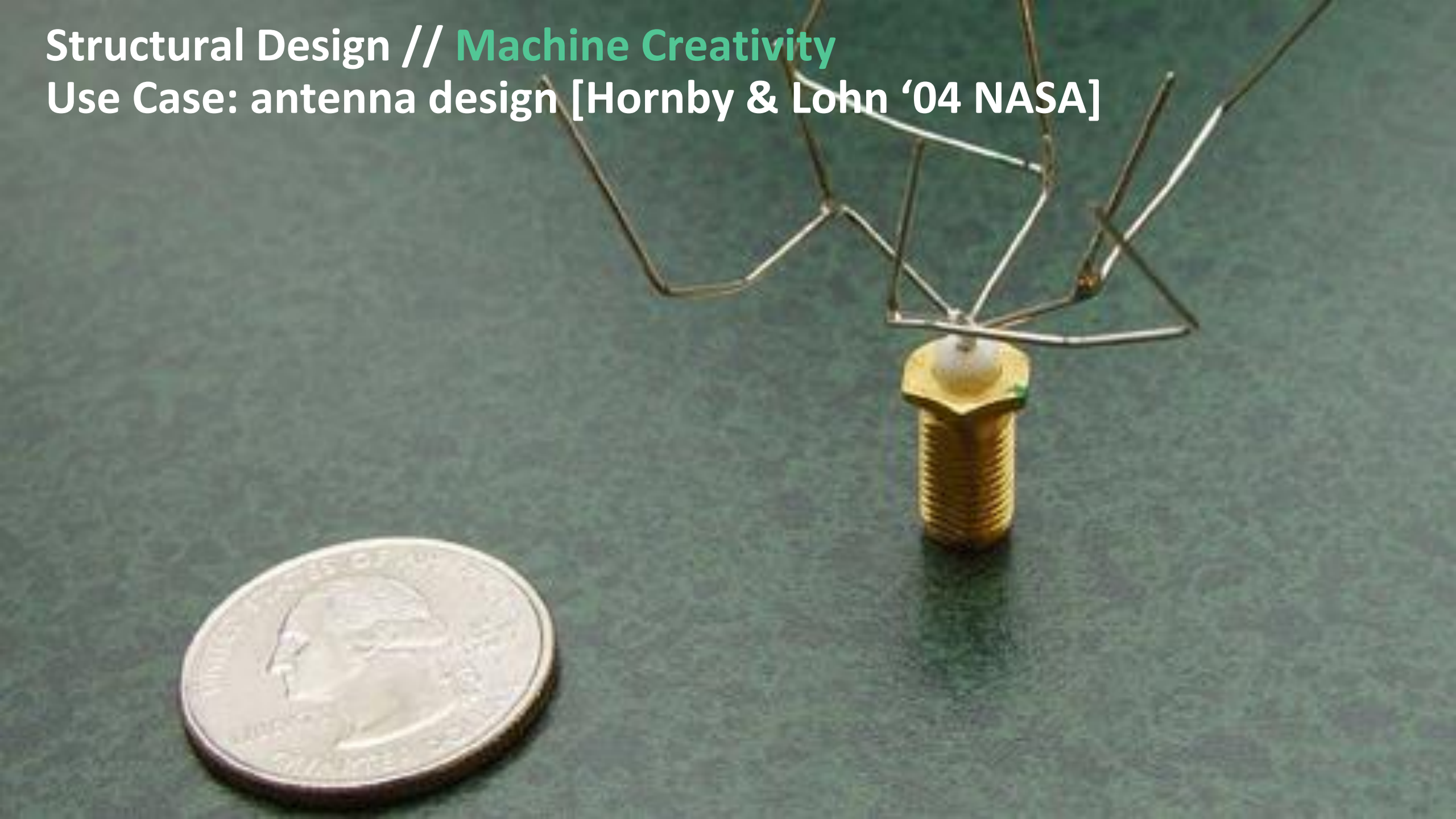
Decision variables are ranked by importance. User selects variable(s)…

… to plot predictions of outcomes at selected variables

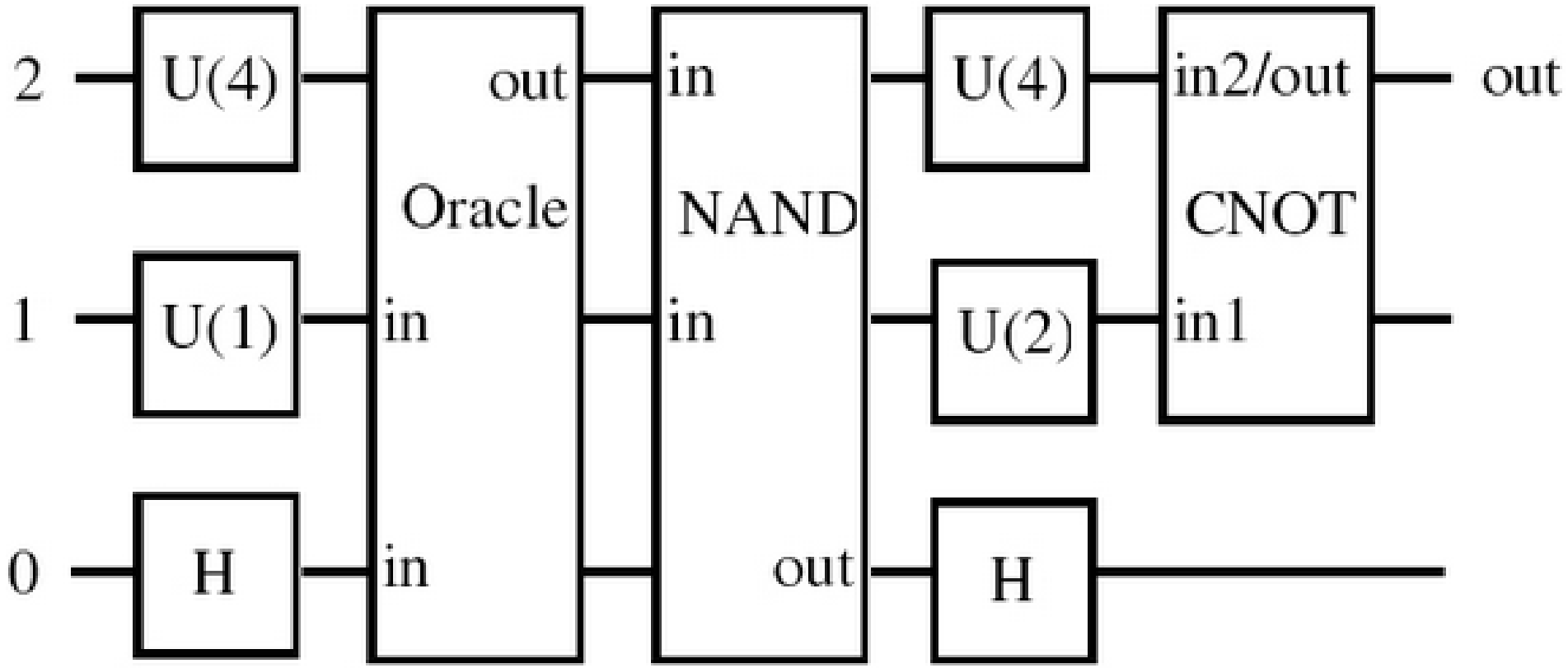
… and explore decision space (by dragging the orange crosshairs)



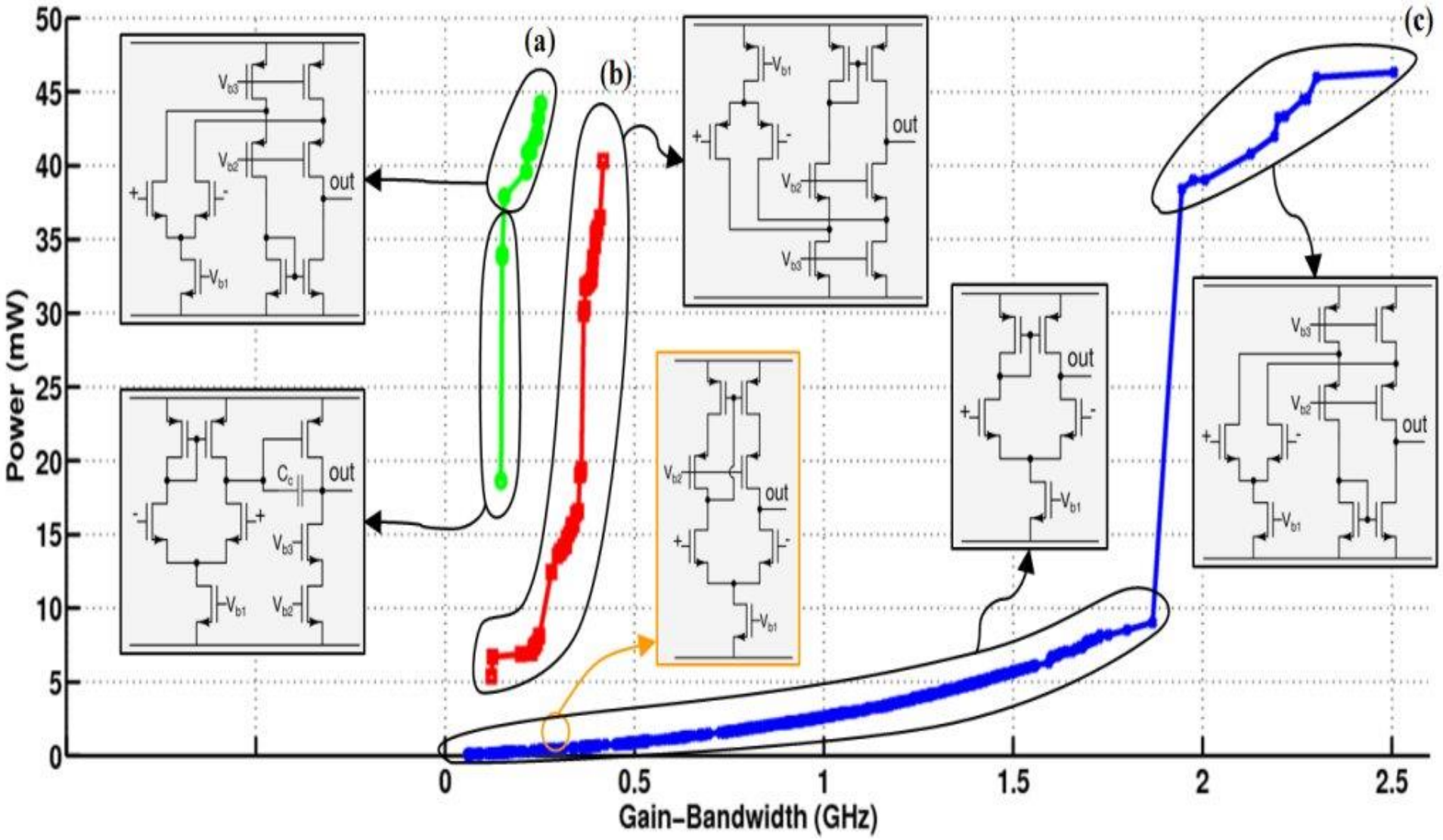
Structural Design // Machine Creativity
Use Case: antenna design [Hornby & Lohn ‘04 NASA]



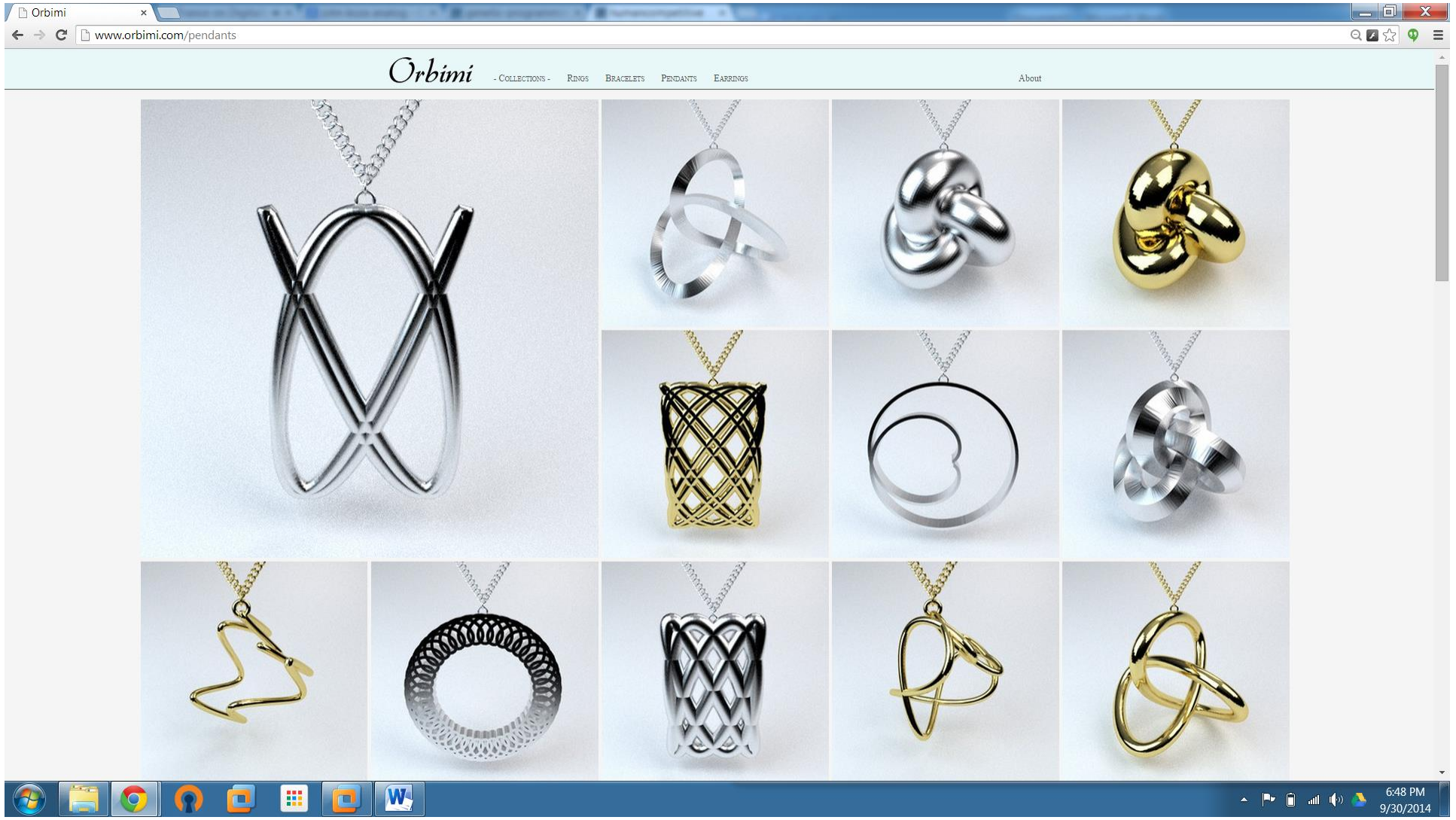
Structural Design // Machine Creativity
Use Case: quantum computing algorithm design [Spector ’04]



Structural Design // Machine Creativity
Use Case: circuit topology design [McC '06 KUL]



Structural Design // Machine Creativity
Use Case: jewelry design [Hornby ‘11 Orbimi]



Machine Creativity:
Art via genetic programming

Machine Creativity:
Art via deep learning – deep dreams

Machine Creativity:

Art via deep learning - style transfer

AI Sub-Fields

- machine learning
- neural networks / deep learning
- evolutionary computation (GAs, GP, ES, ..)
- swarm algorithms (ACO, PSO, ..)
- artificial general intelligence (AGI)

Strong relations to:

- statistics ("ML *is* modern statistics"), probability
- linear algebra ("flow of tensors" – TensorFlow)
- nonlinear programming, optimization
- control systems / cybernetics
- Monte Carlo methods
- philosophy, ethics (friendly AIs, AI rights, ..)