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Jackson Pollock

Novel Algorithms Meetup

Andrew N. Sloss

Question?

For the end of the introduction

- If you take a **64-bit variable** as a **search space** - how many variables does it take to exceed the number of atoms in the universe (**est. 10^{80}**)?

Meetup is about

- Novel Algorithms is about exploring complex problem domains
- It is a catchall term
- Use unconventional methods to achieve a single goal or multiple objectives
- Either used to
  - Discover solutions from a complex landscape (i.e. enormous problem-domain)
  - Used as a first attempt to understand a complicated problem
- Quite frequently used as the "*algorithms of last-resort*"
- Attempt to contextualize around the semiconductor industry
- Warning slight bias towards *Evolutionary Algorithms*

Loosely-based

2019 Evolutionary Algorithms Review

Andrew N. Sloss[1] and Steven Gustafson[2]

[1]Arm Inc., Bellevue
[2]MAANA Inc., Bellevue

June 24, 2019

Abstract

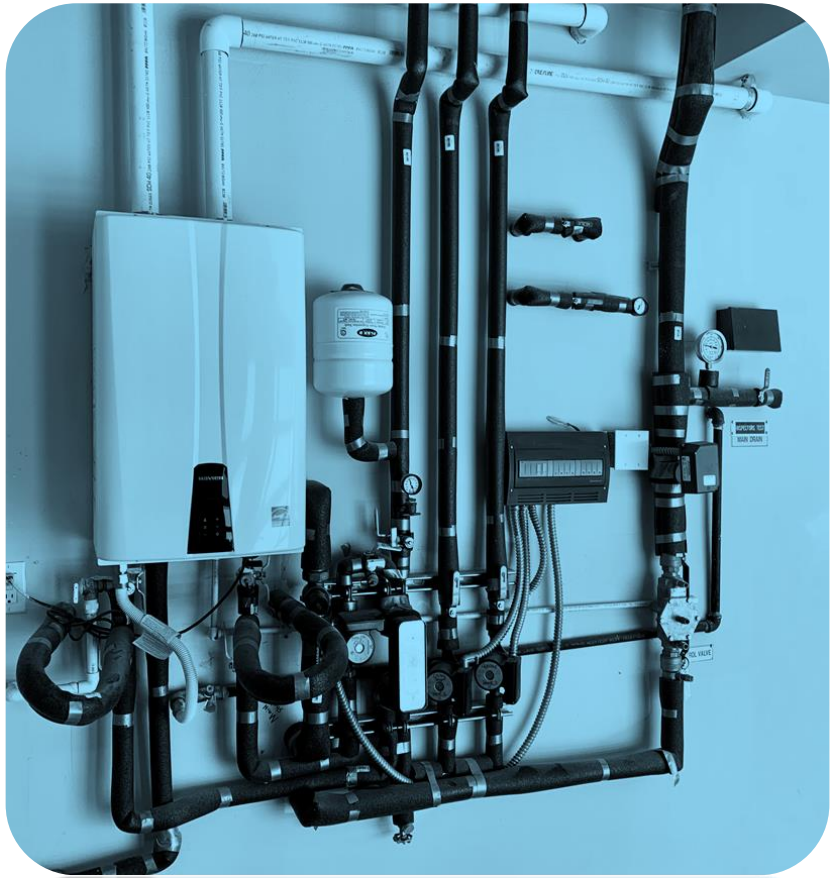
Evolutionary algorithm research and applications began over 50 years ago. Like other artificial intelligence techniques, evolutionary algorithms will likely see increased use and development due to the increased availability of computation, more robust and available open source software libraries, and the increasing demand for artificial intelligence techniques. As these techniques become more adopted and capable, it is the right time to take a perspective of their ability to integrate into society and the human processes they intend to augment. In this review, we explore a new taxonomy of evolutionary algorithms and resulting classifications that look at five main areas: the ability to manage the control of the environment with limiters, the ability to explain and repeat the search process, the ability to understand input and output causality within a solution, the ability to manage algorithm bias due to data or user design, and lastly, the ability to add corrective measures. These areas are motivated by today's pressures on industry to conform to both societies concerns and new government regulatory rules. As many reviews of evolutionary algorithms exist, after motivating this new taxonomy, we briefly classify a broad range of algorithms and identify areas of future research.

https://arxiv.org/abs/1906.08870

Driver – the why?

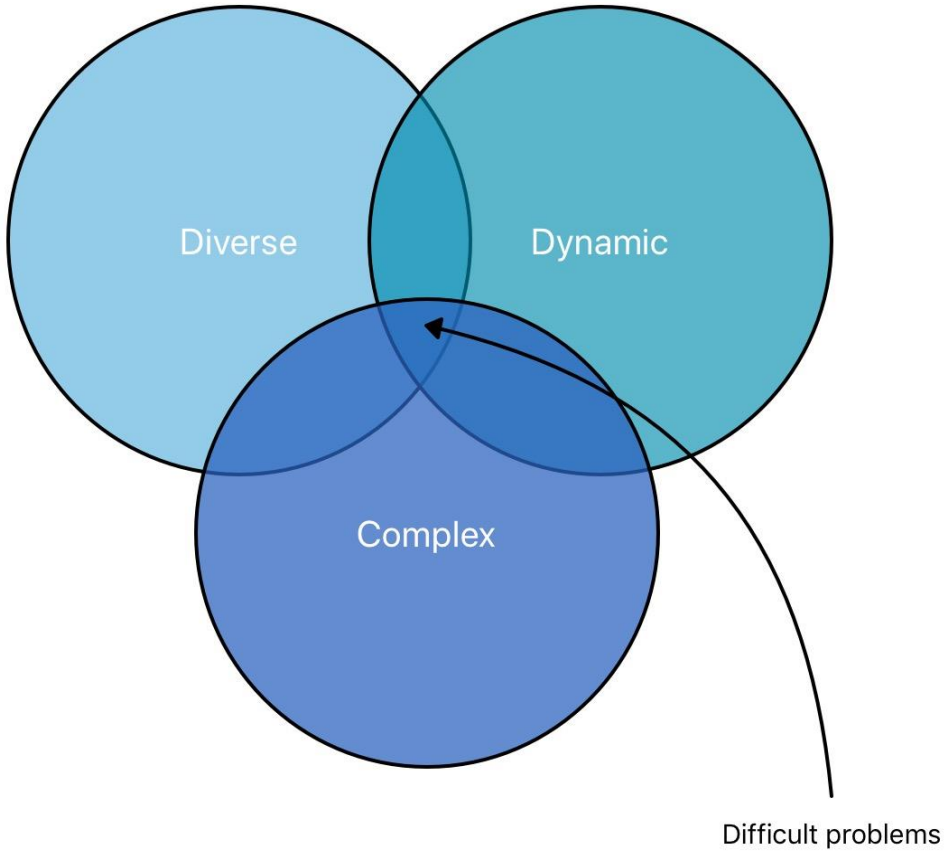
Continued desire to answer more complex questions

(on-going)

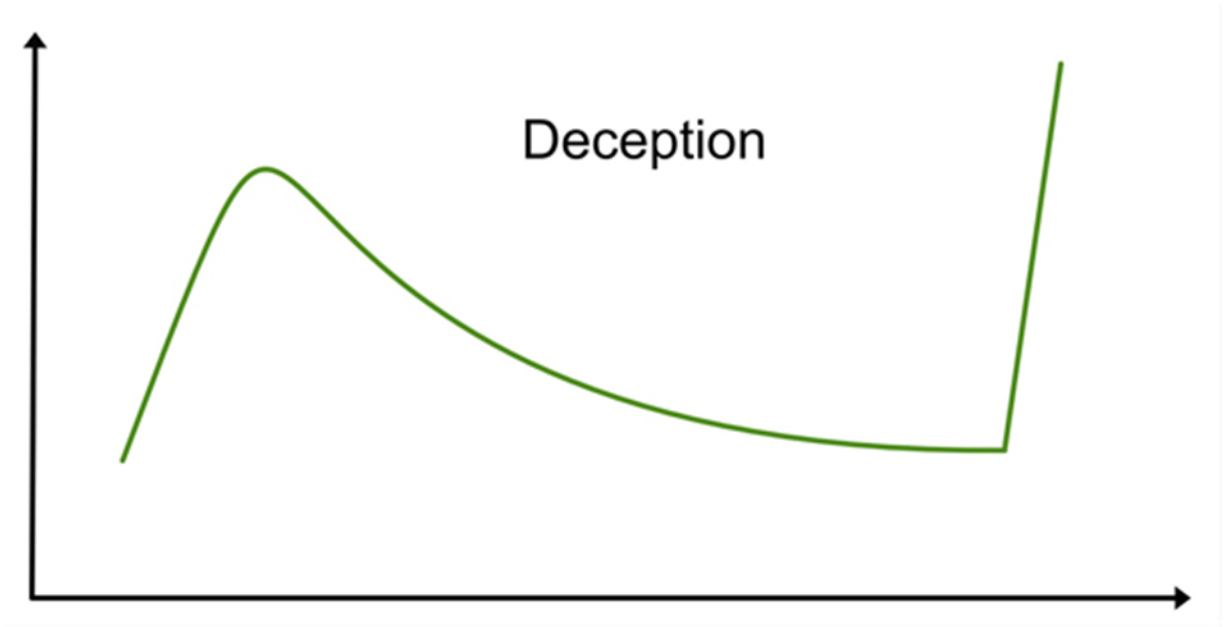


How do we solve the next problems?

Problem domains : Characteristics

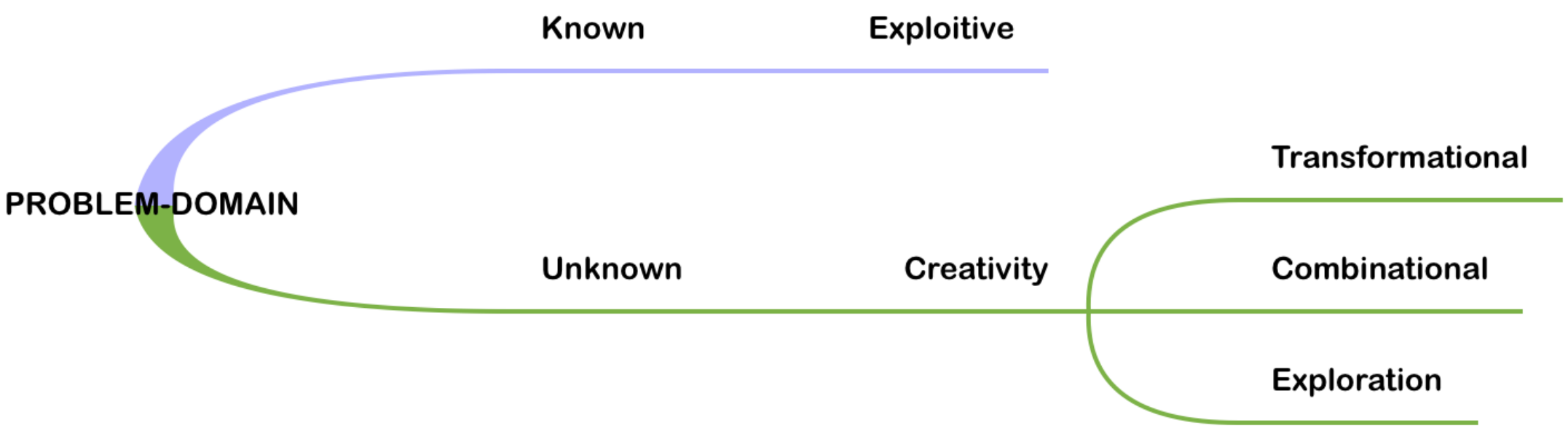


Data Landscapes[1]



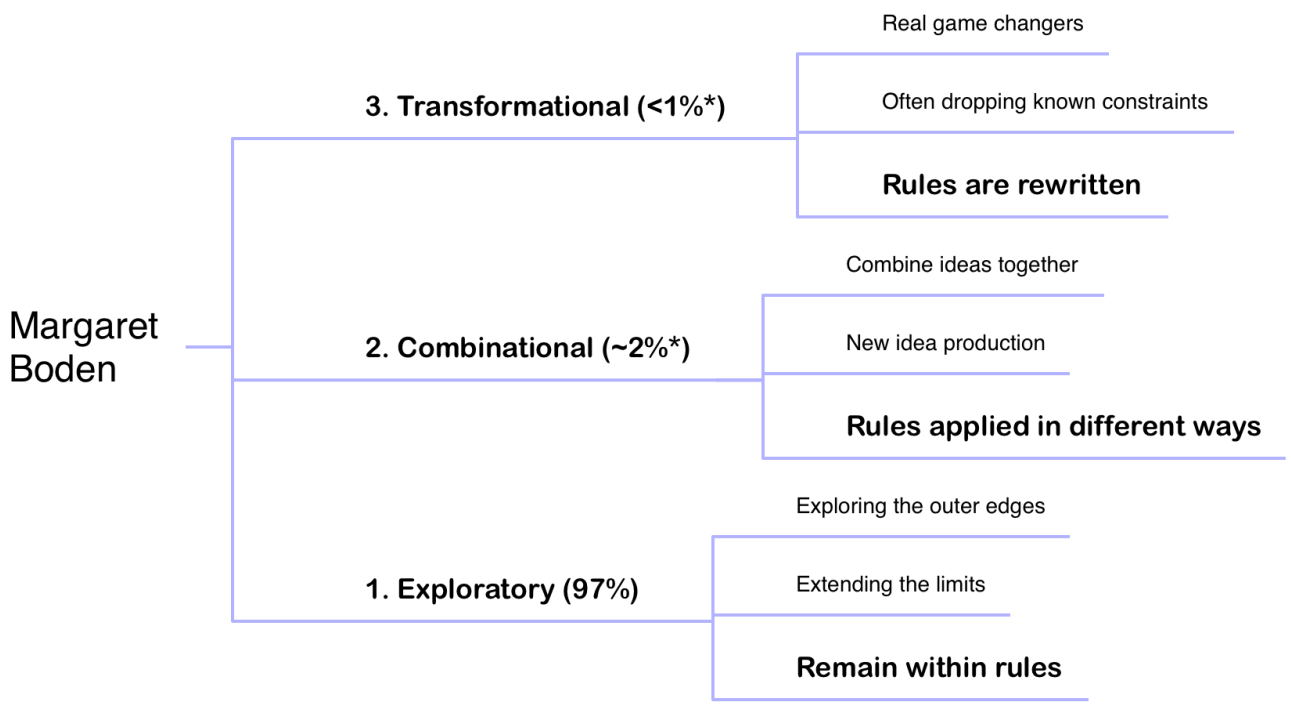
[1]*Inspired by "Essential of Metaheuristics", by Sean Luke*

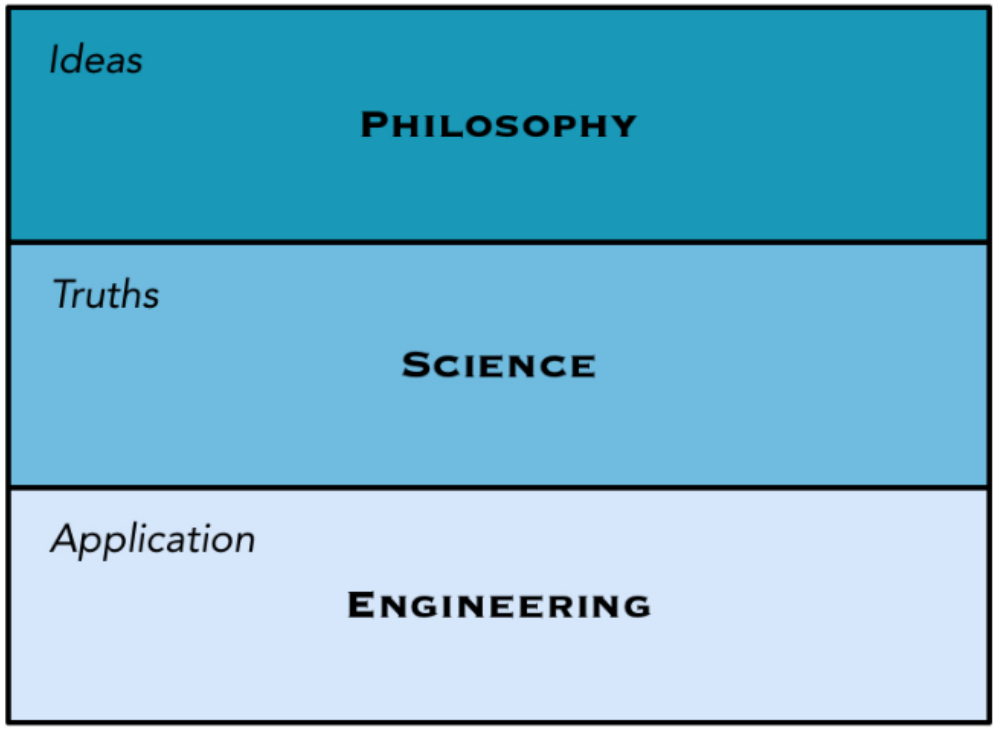
Solutions



Creativity

- Dangerous
- Uncomfortable





- Safe
- Comfortable

** Poetic license*

From *The Creativity Code: M. Boden is a* Research Professor of Cognitive Science in the Department of Informatics at the University of Sussex

Laws of Algorithms

- **Law of Conservation of Generalized Performance [Schaffer, 1994]**

An algorithm that achieves performance that is better than random search is a perpetual motion machine

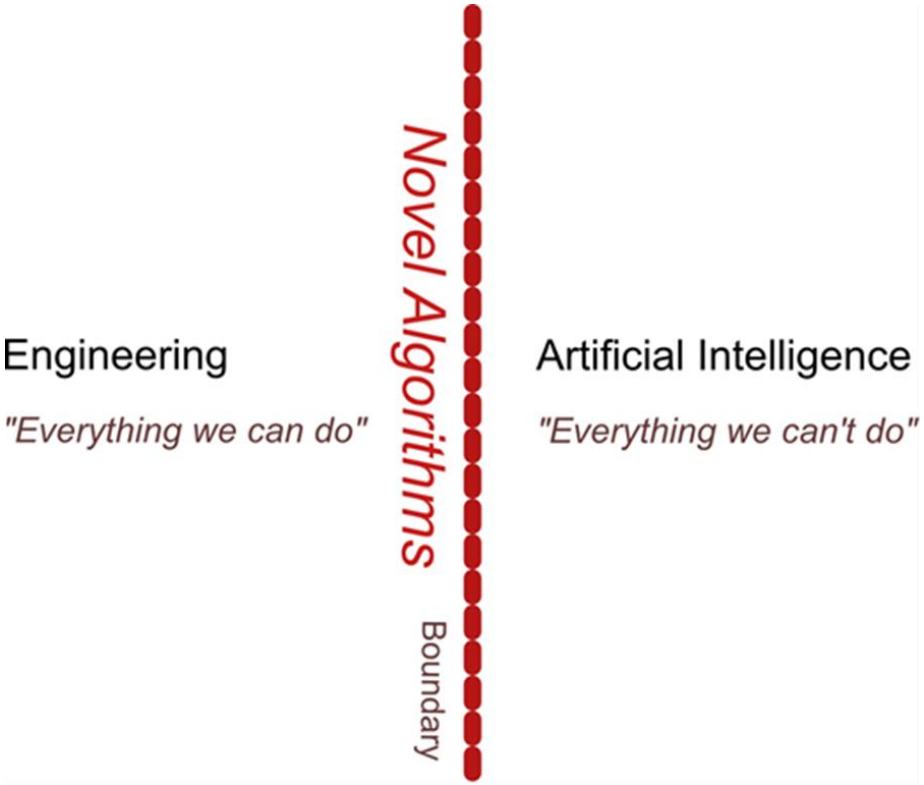
- **Law of Conservation of Information [English, 1999]**

Futile to attempt to design an optimization algorithm that is better than random search, unless you can incorporate problem-specific information in the algorithm

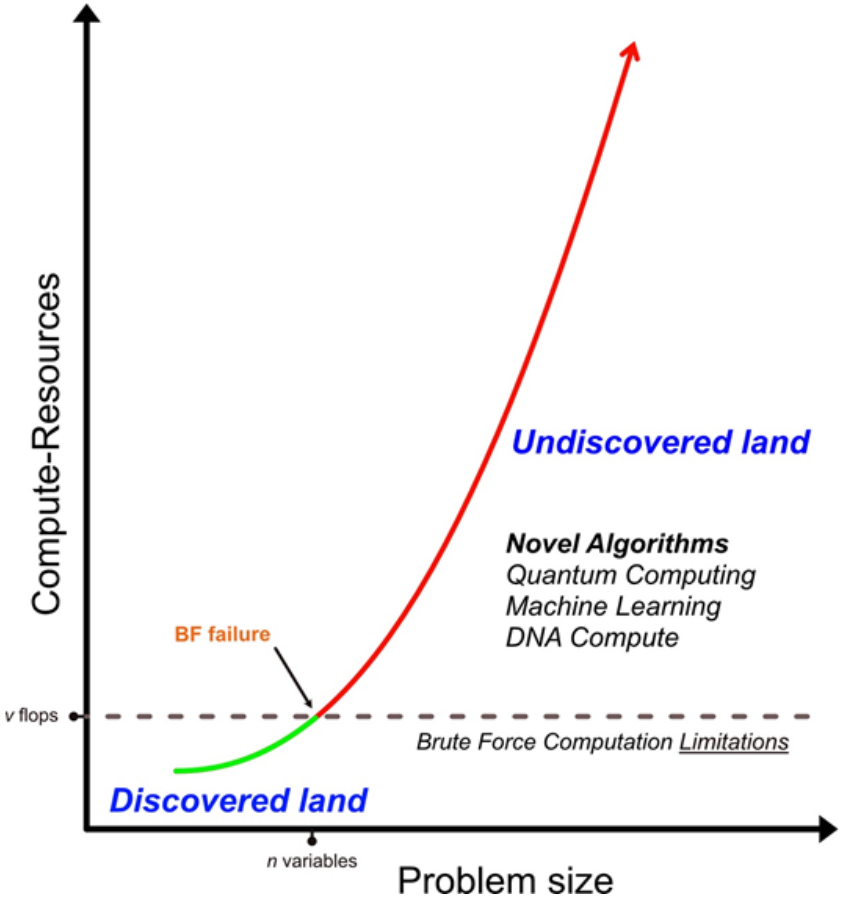
- **Bernoulli's Principle of Insufficient Reason [Dembski & Marks 2009]**

Absence of problem-specific information, we must assume that all possible solutions are equally likely

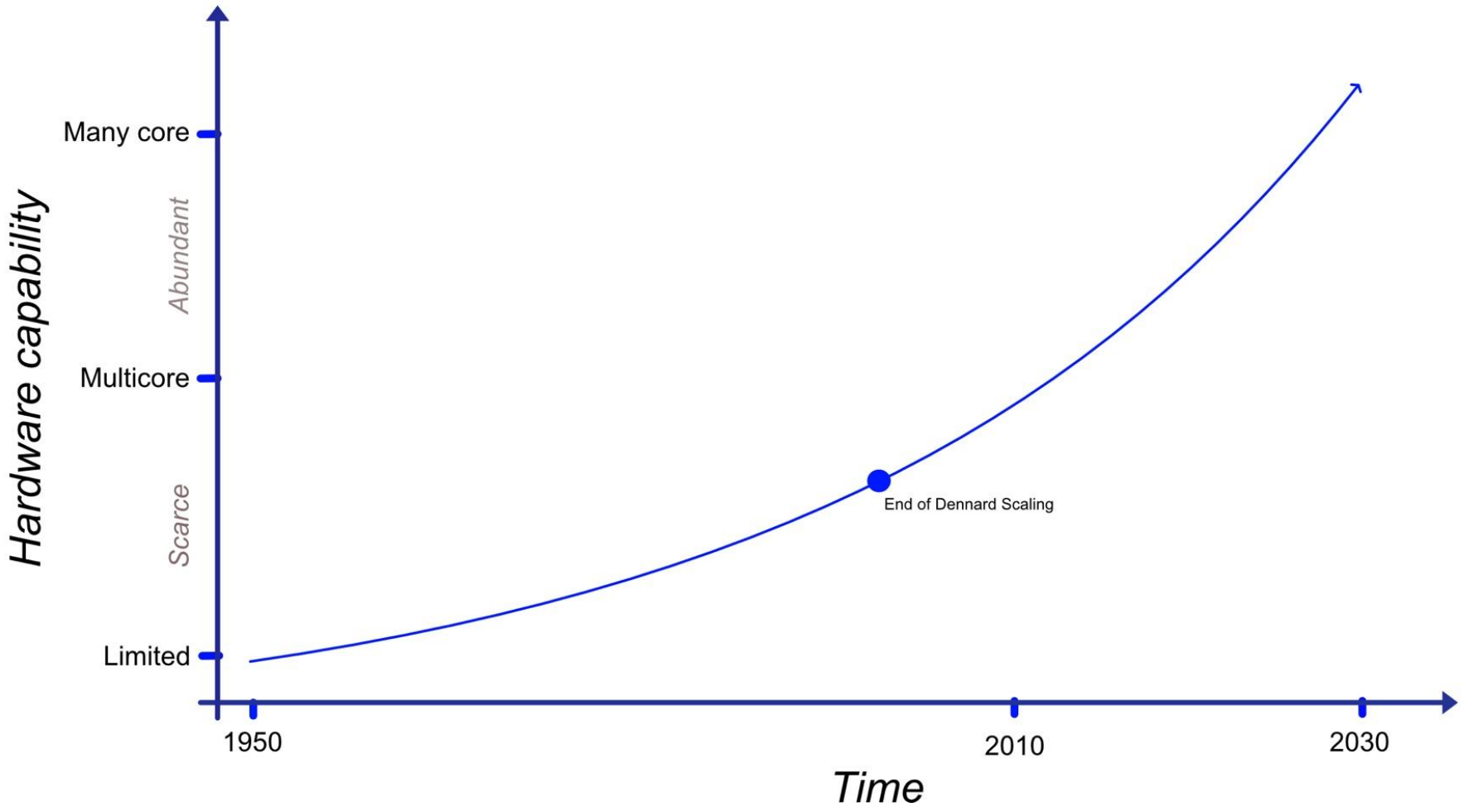
Boundary



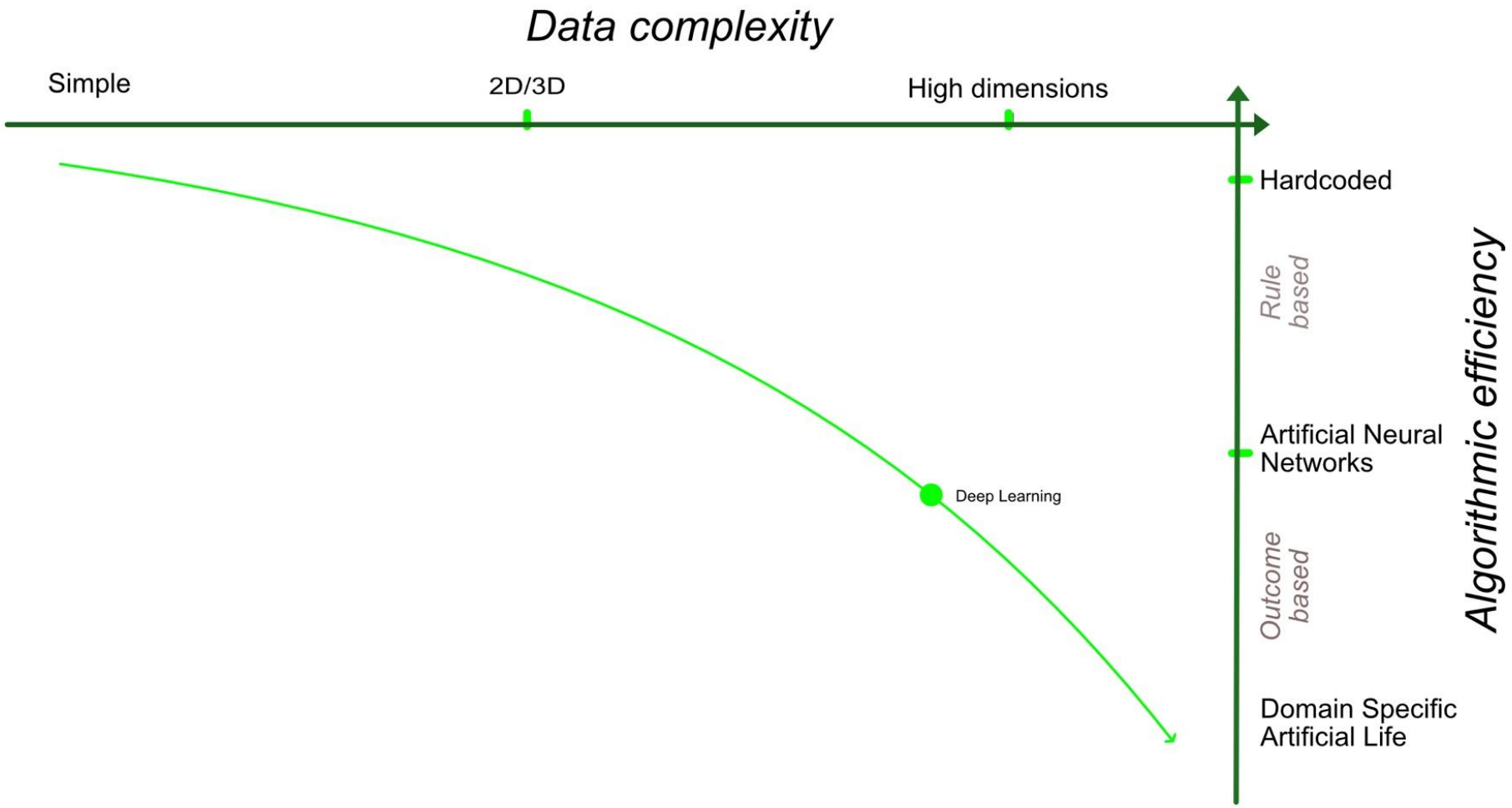
Where do Novel Algorithms fit?



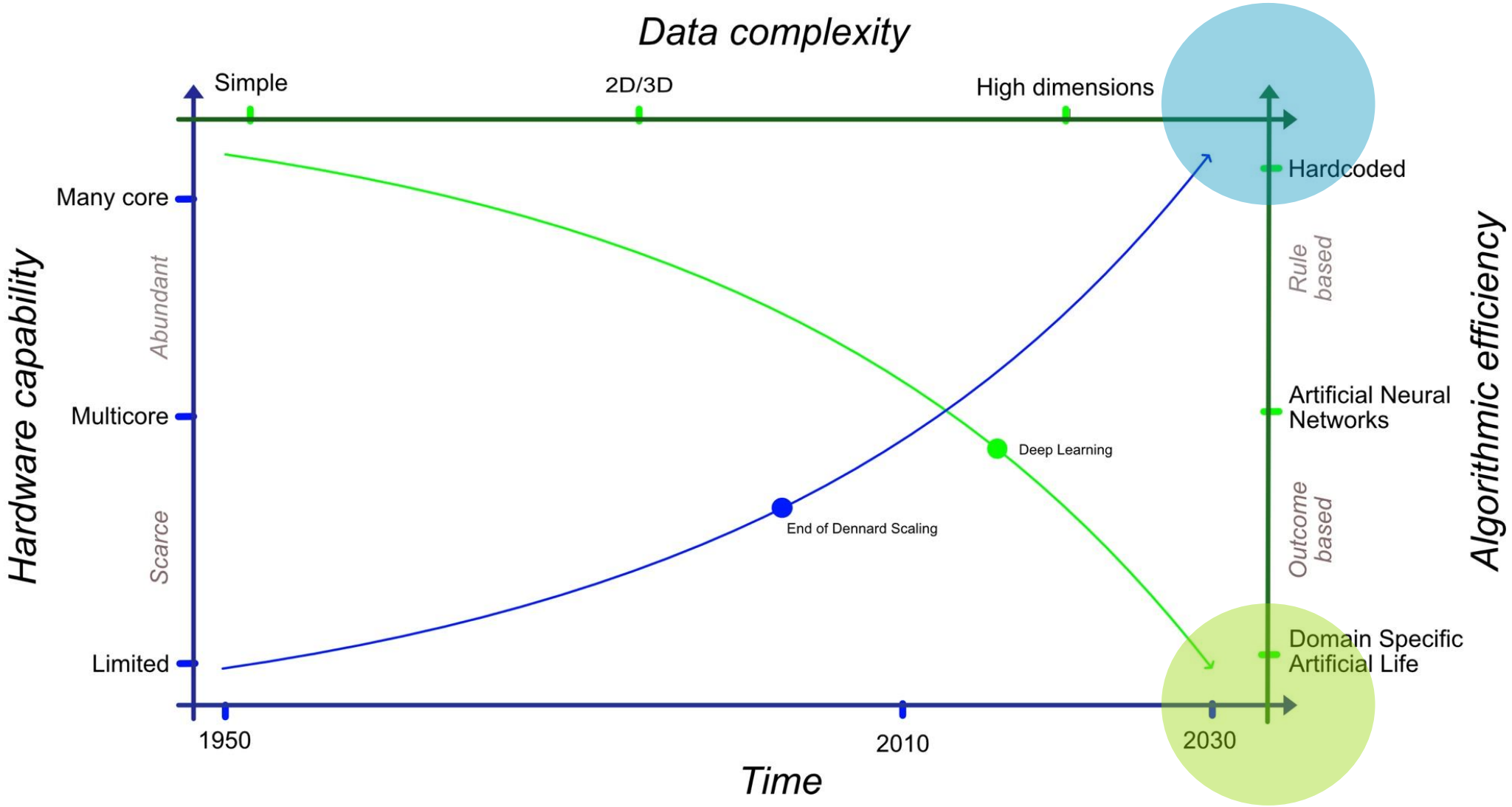
Hardware changes



Software changes



Combined



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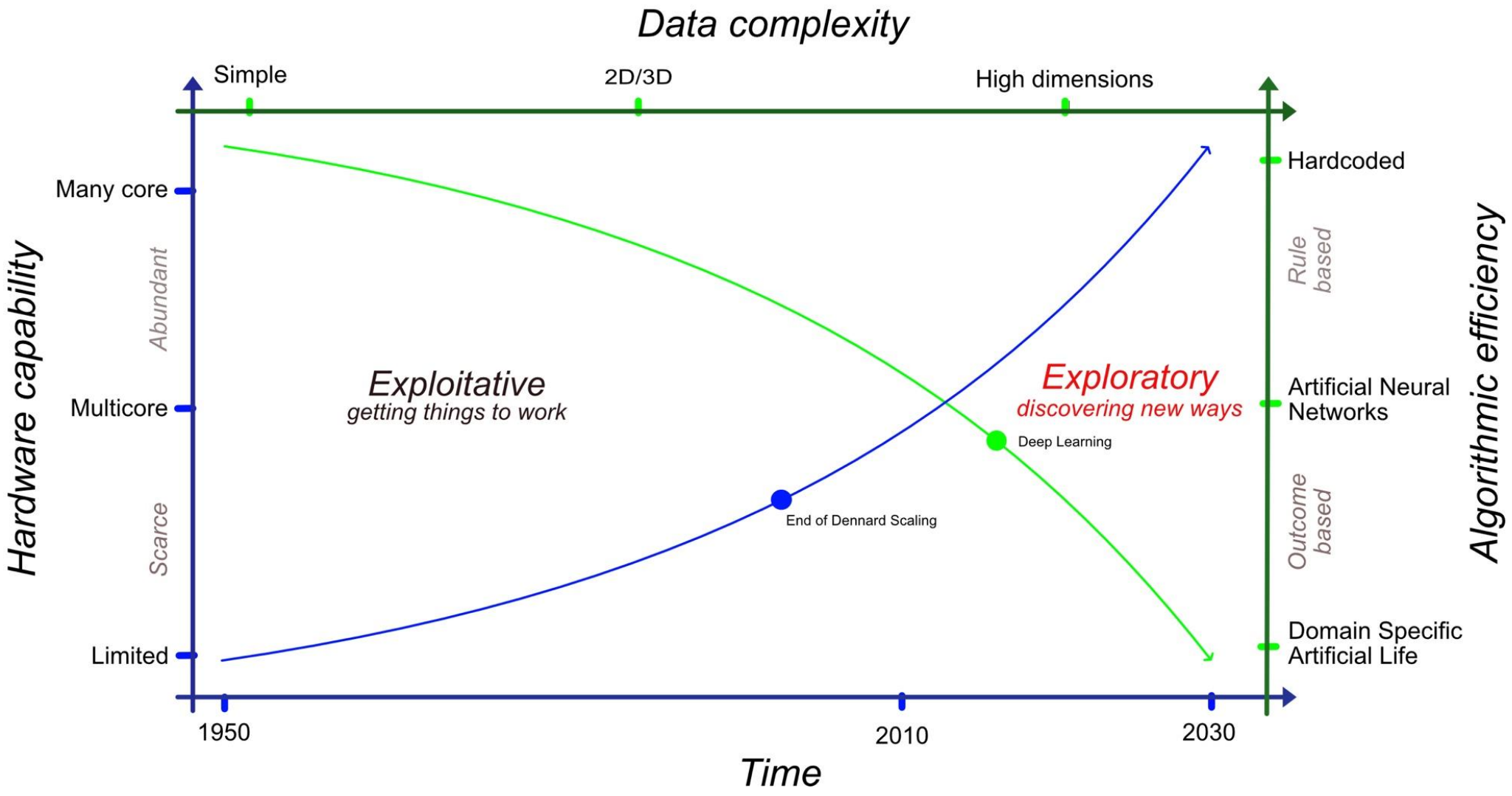


Algorithmic shift

Exploitative		Exploratory
Known problem		Unknown problem
bounded data		complex data
specialization		general purpose
discrete		continuous
more hardware focused		more software focused
highly efficient		inefficient
absolute results		good enough results

So you know your algorithms?

- Society and civilization algorithms
- Charged system search
- Invasive weed optimization
- Cuckoo Search
- Intelligent water drops
- River formation dynamic
- Stochastic diffusion search
- Gaussian adaptation
- Big bang big crunch algorithm
- Imperialist competitive algorithms
- Squeaky wheel optimization

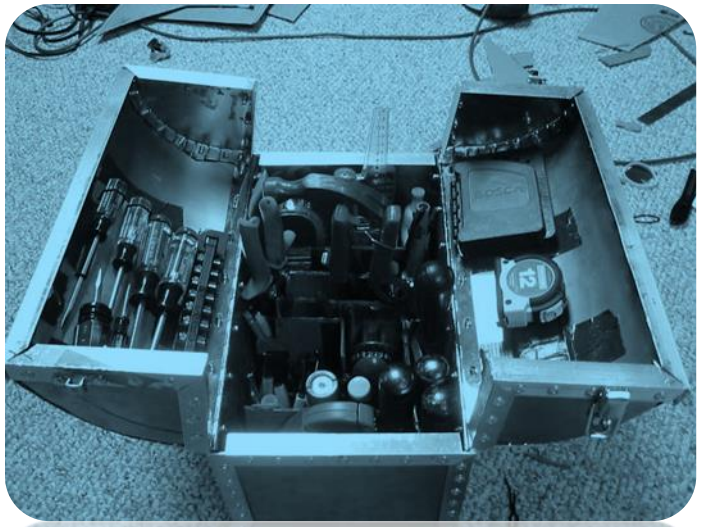
- Grammatical evolution
- Glowworm swarm optimization
- Bat-inspired algorithm
- Bacterial chemotaxis
- Several artificial bee algorithms
- Gravity-based search algorithm
- Harmony search
- Chemical reaction optimization
- Frog algorithm
- Fish algorithm
- Tangled graph program
- …

<1%

Area of interests/trends

New Tools for the Algorithmic Toolbox

- Meta-learning
- AutoML
- Metaheuristics
- **Evolutionary Algorithms**
- Reinforcement Learning
- Neuroevolution
- Neuromorphic Computing
- Self-assembly / Self-healing / Self-organization
- …



Principles

- **Induction**; **regularities** in past data to determine future events
- **Causality**; a **model** on the how the data was created
- **Stochastic**; taking either **educated** or uneducated guesses
- …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Complexity

Complexity – John Holland Perspective

Physical

- Partial Differential Equations
- Newtonian Physics
- Maxwell's Equations
- Boundaries

Agent

- Chaos
- Discovery
- Self adaption
- Interaction

Semiconductor complexity 1950’s-1990’s

1-4 Transistors

Isolated Dwelling

1950’s

2,300 Transistors

Town

1970’s

100,000 Transistors

City

1980’s

1,000,000 Transistors

Metropolis

1990’s

Semiconductor complexity 2000’s-2019

100,000,000 Transistors

Country

2000’s

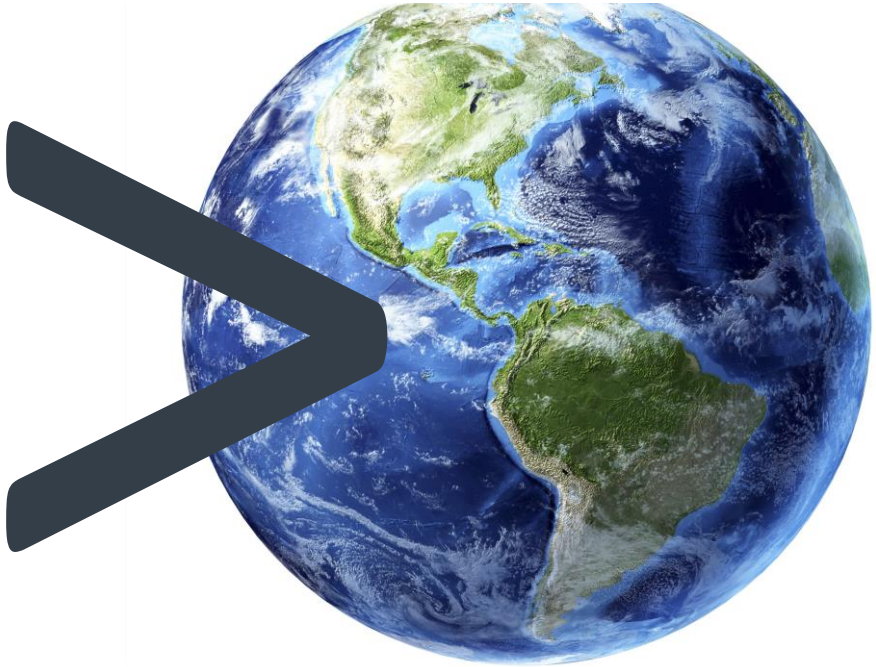
1,000,000,000 Transistors

Continent

2010’s

1,200,000,000,000 Transistors

(Wafer Level)



Planet

2019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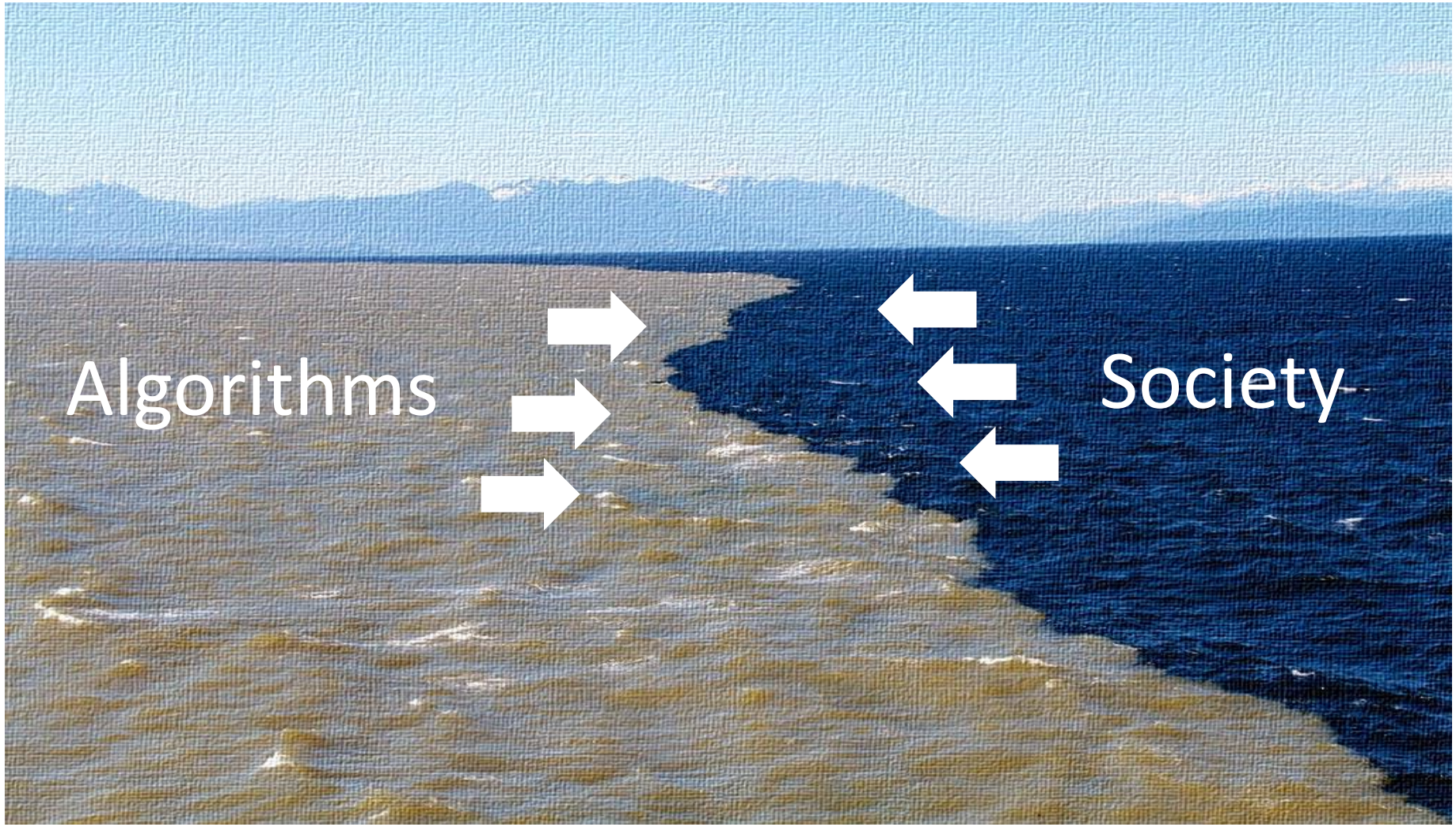
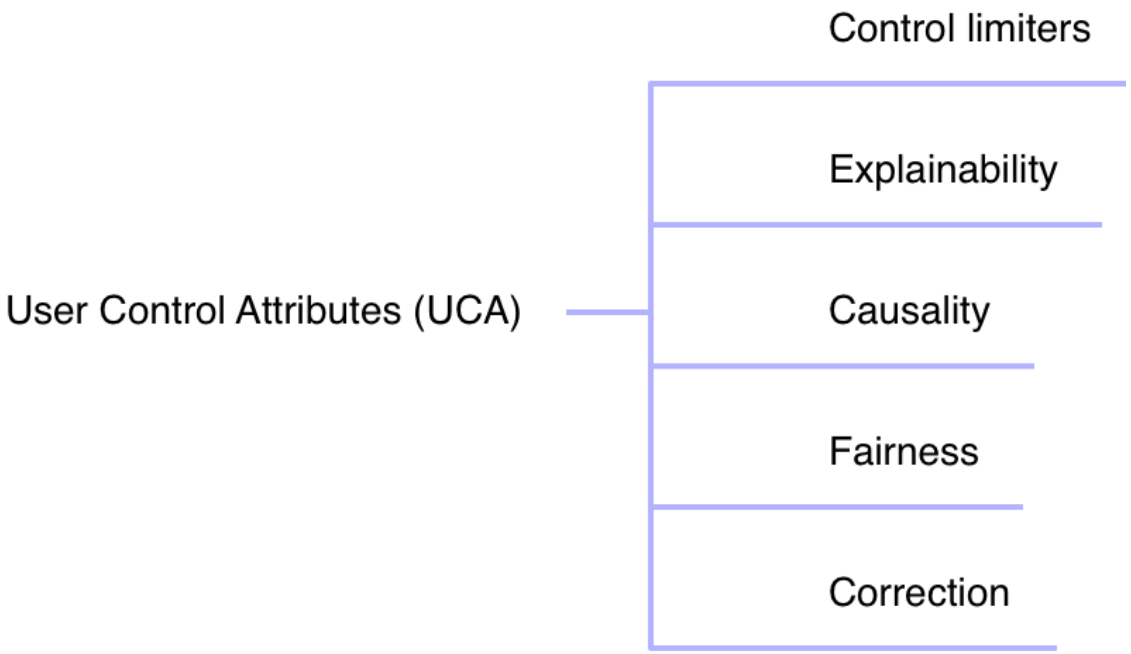
Society

Society pressure



Society requirement



Question?

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Physicist

ber of atoms estimated in our

10^{80}

nber of 64 bit words n re

to count all the atoms

$10^{80} = 2^{n*64}$

Solve for n by taking $\log_2$

Recall $\log x^y = y \log x$

$n = \frac{80}{64} \log_2 10$

$= 1.25 \cdot 3.32193$

$\cong 4.15241$

rounding up to whole word

$n = 5$

Mathematician

10 = 2^(3.32)

so 10^80 = (2^3.32)^80 = 2^(3.32*80) = 2^265.6

Five 64-bit registers have 64*5=320 bits and so 2^320 states which is greater than 2^265.6

So there are more possible states of five 64 bit registers then there are number of atoms in obervable? universe - assuming that this 10^80 estimate is correct.

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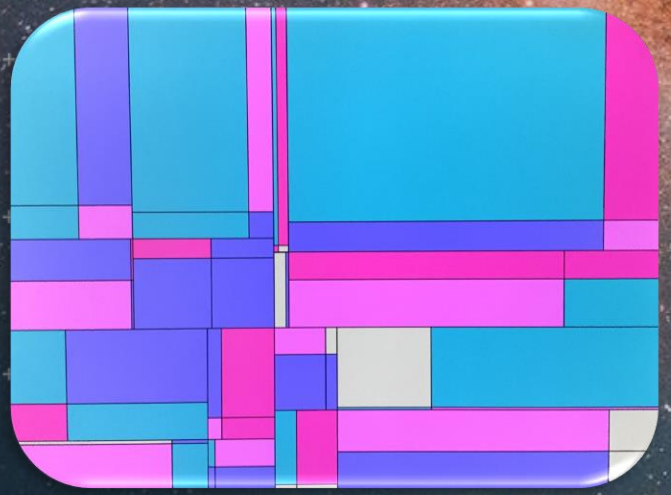

~~Jackson Pollock~~

Mondrian-inspired

(Computer Generated)

Questions?

Network/Questions/Discussions

- What are the next important algorithms?
- What are the next problem-sets and domains?
- What are the next architectures to solve these problems?