

Open-Endedness: A New Grand Challenge for AI

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UBER AI

Why Is Machine Learning about Solving Problems?

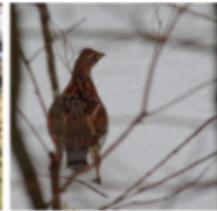
- Can the computer classify these images from ImageNet?



flamingo



cock



ruffed grouse



quail



partridge



pill bottle



beer bottle



wine bottle



water bottle



pop bottle



race car



wagon



minivan



jeep



cab

Open-Endedness

A Different Kind of Learning

- Not *how to learn something*
- But *how to learn everything*
- A human playing a video game is interesting
- But the history of human invention is *beyond interesting*
- Or: natural evolution – the ongoing creation of all the diversity of life on Earth

A Different Kind of Learning

- Not just a single positive result
- But an *ongoing cacophony of surprises*



A Different Kind of Learning

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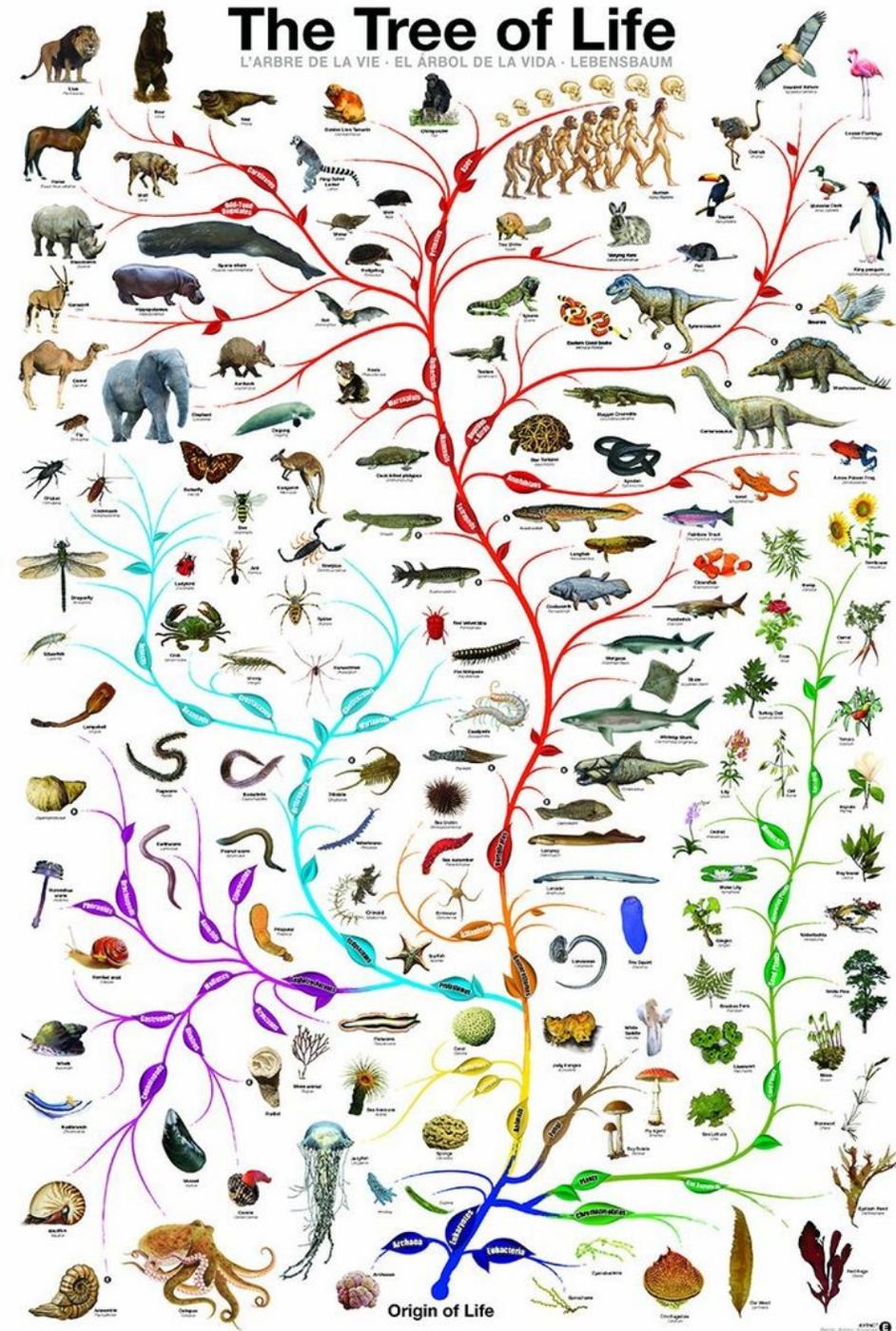


Interestingly, you don't need human-level AI to do this

But you may need this to get human-level AI

The Tree of Life

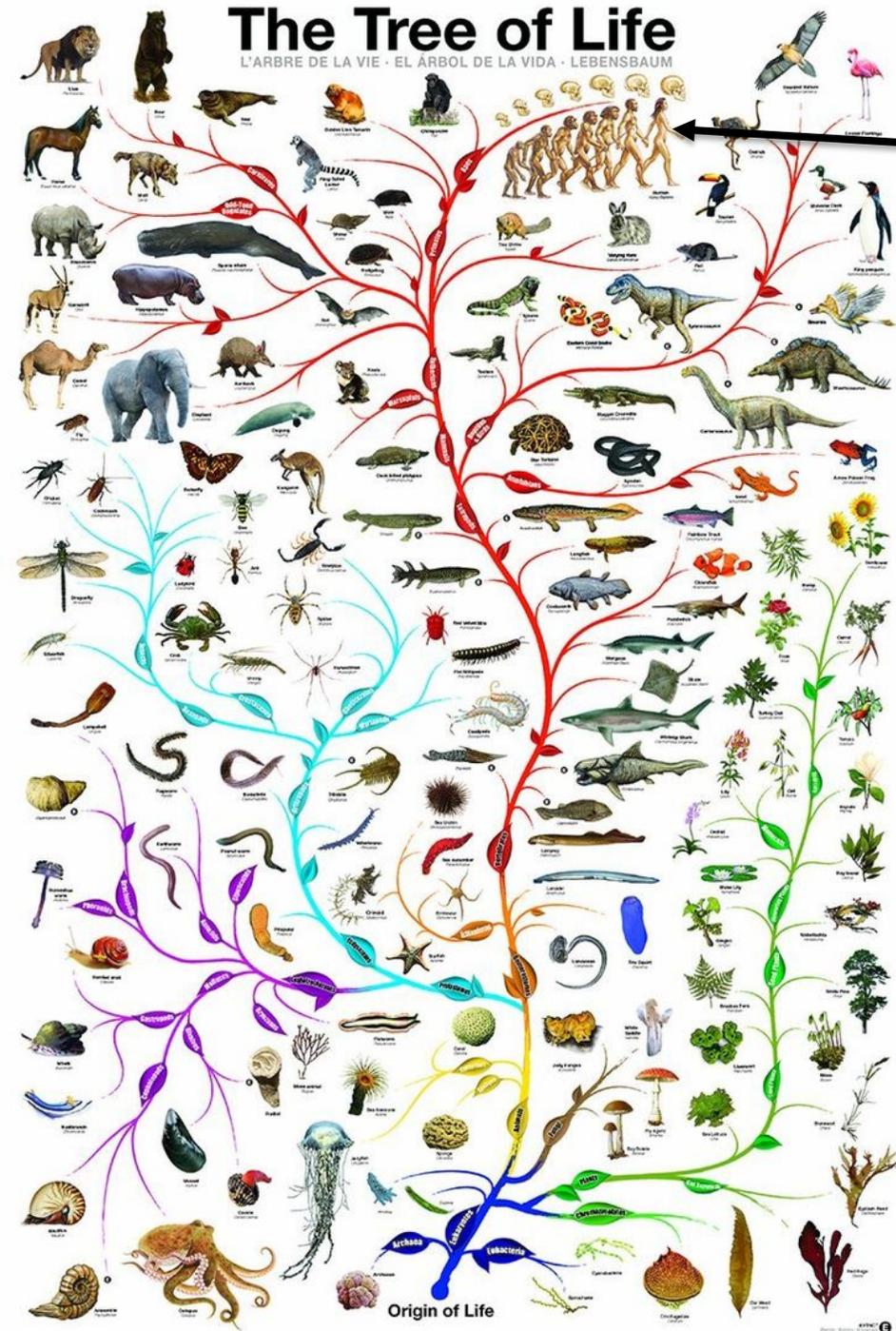
L'ARBRE DE LA VIE · EL ÁRBOL DE LA VIDA · LEBENSBAUM



One run of **evolution**,
all life on Earth
(no human
intelligence!)

The Tree of Life

L'ARBRE DE LA VIE · EL ÁRBOL DE LA VIDA · LEBENSBAUM

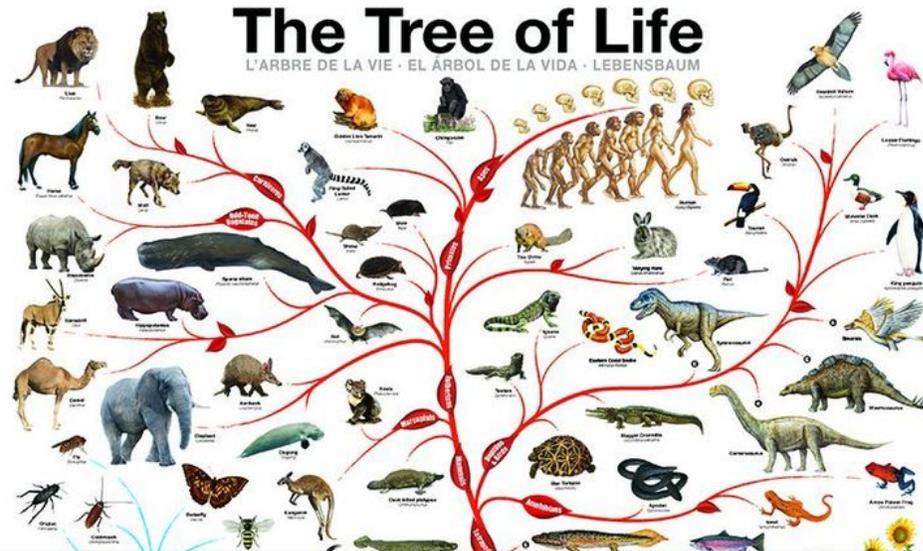


Human-level Intelligence, a tiny moment in an endless saga

One run of **evolution**, all life on Earth (no human intelligence!)

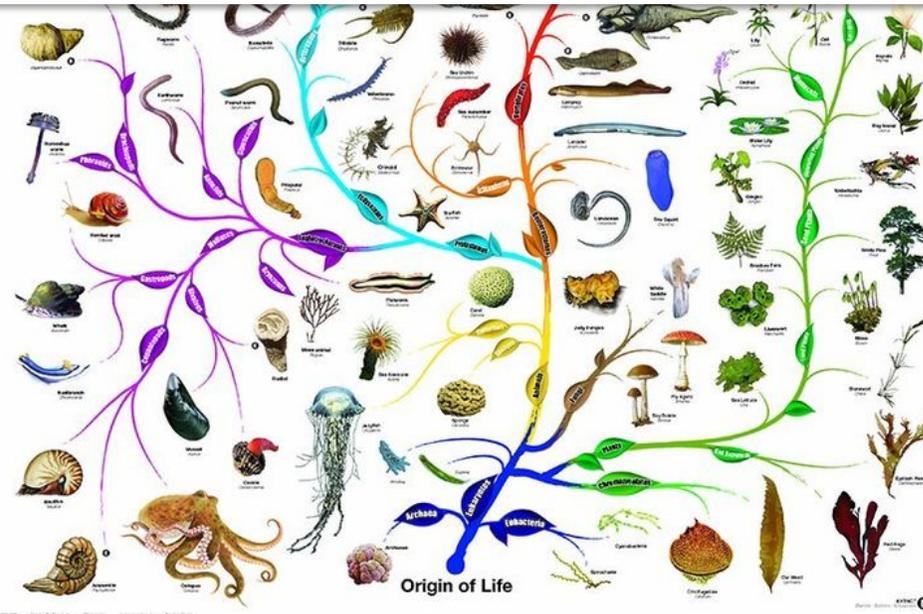
Origin of Life

Thinglink.com



Endless Surprises!
(and it keeps on going)

← One run of **evolution**,
all life on Earth
(no human
intelligence!)







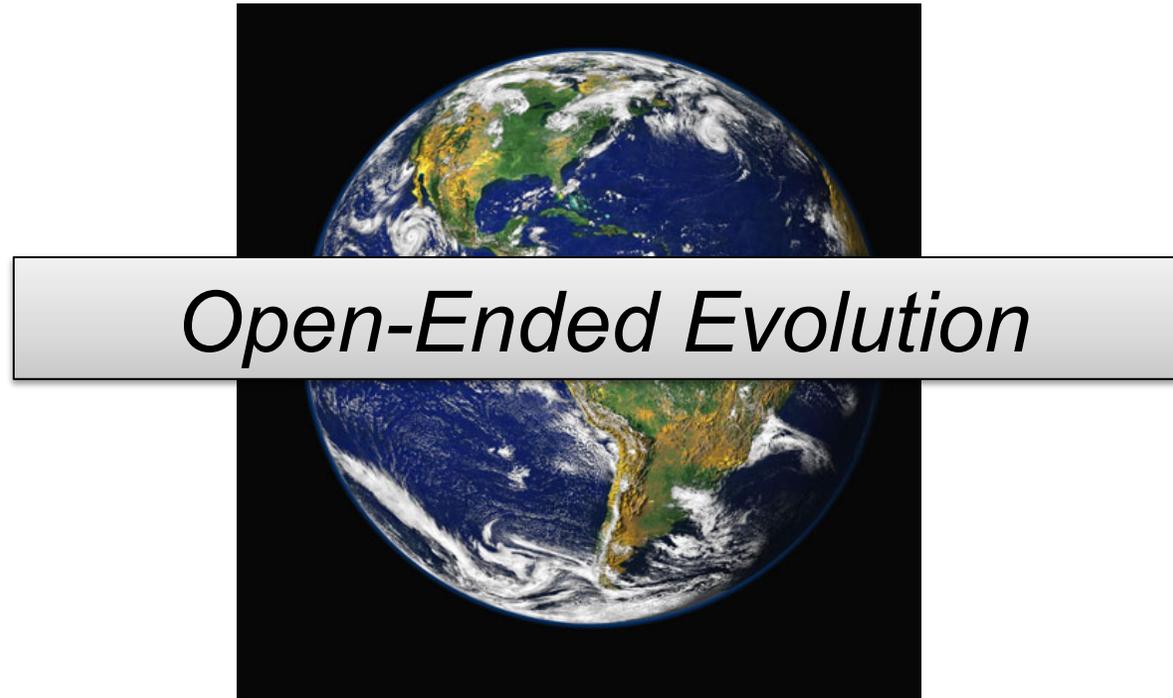


The Never-Ending Algorithm



bittbox.com

The Never-Ending Algorithm



bittbox.com

The Never-Ending Algorithm



*More Generally:
Open-Endedness*

The Never-Ending Algorithm



Open-Endedness:

The history of human innovation

...of art

...of science

...of architecture

etc...

*Why don't we create
open-ended algorithms?*

*Why don't we create
open-ended algorithms?*

Why only solve problems?

Exception: The OEE Community

- Open-ended evolution (OEE) is a traditional topic of artificial life
- OEE is the *power of creation*
 - Potentially transformative
 - Boundless creativity on demand
 - Discoveries beyond the scope of optimization
- A grand challenge on the scale of AI; maybe the path to AI itself
 - Why so little attention?

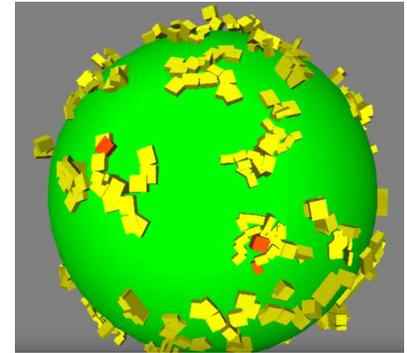


The Promise of Open-Endedness

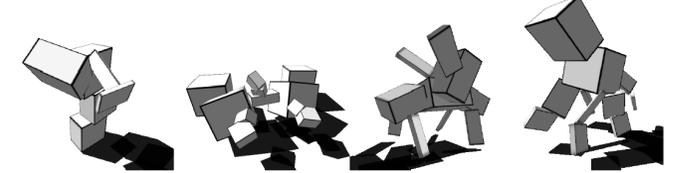
- Design of buildings, vehicles, furniture, clothing, equipment, etc.
- Repertoires of controllers for vehicles, robots, UAVs, spaceships, etc.
- Endless generators of art and music
- Open-ended video game worlds with the granularity and originality of ecologies on Earth
- Renewed understanding and acceleration of the process of human invention
- Human-coupled open-ended systems
- Intelligence itself?

A Brief History of Open-Endedness

- Artificial life worlds
- Novelty search (Stanley and Lehman 2008, 2011)
- Quality Diversity (QD) algorithms (NSLC, MAP-Elites)
- Minimal Criterion Coevolution (Brant and Stanley 2017)
- More recently
 - POET (2019): The Paired Open-Ended Trailblazer



Evosphere (Thomas Miconi 2008)



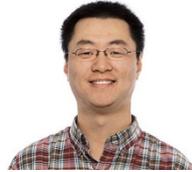
NSLC (Lehman and Stanley 2011)



MAP-Elites: Cully, Clune, Tarapore, and Mouret (2015)

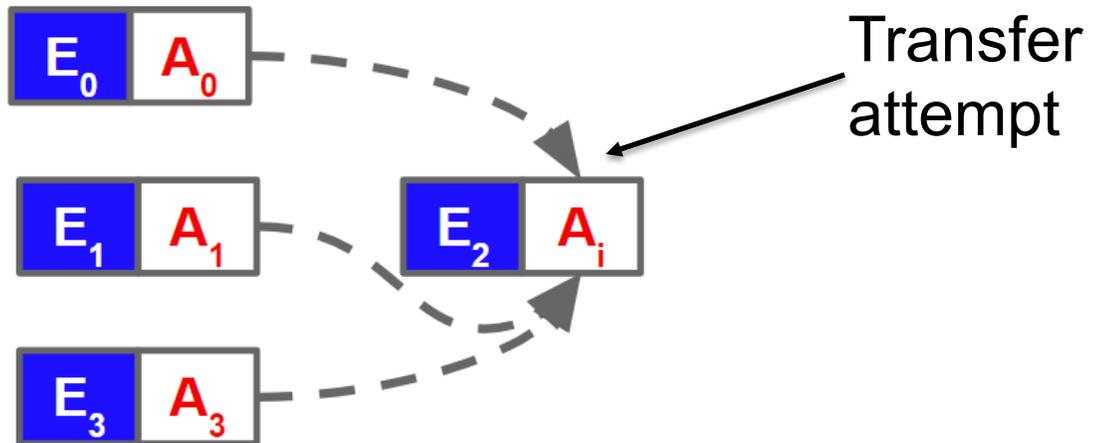
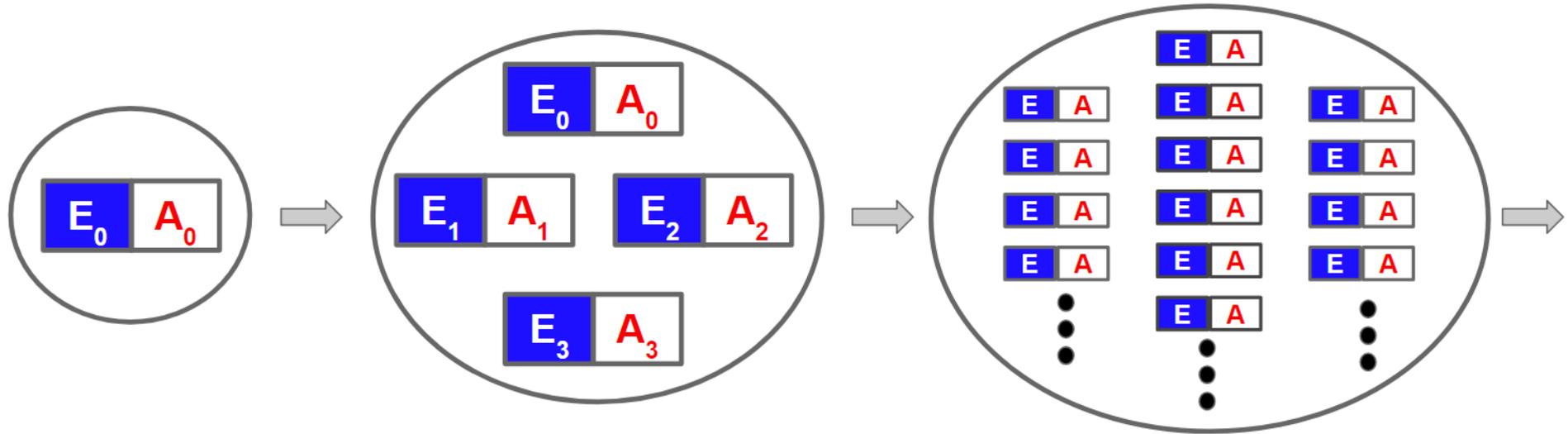
Recently Uber AI: POET (Paired Open-Ended Trailblazer)

- With Rui Wang, Joel Lehman, Jeff Clune

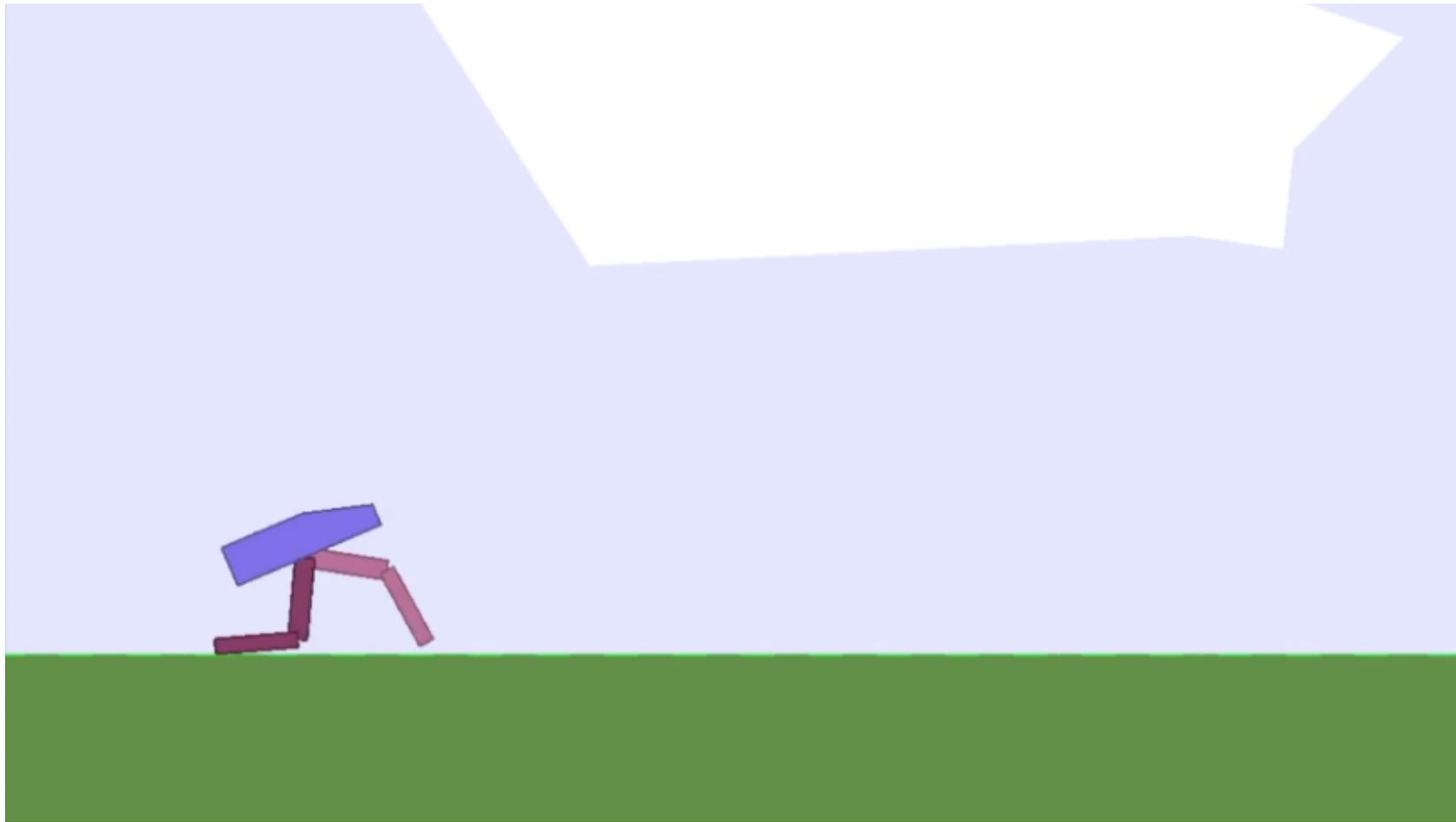


- Can we open-endedly invent new problems and optimize solutions to those problems indefinitely?
 - Combines previous ideas in field
- Idea: Continually optimize within generated environments and attempt solution *transfer* between them
- Hypothesis: *Only way some solutions can ever be found*

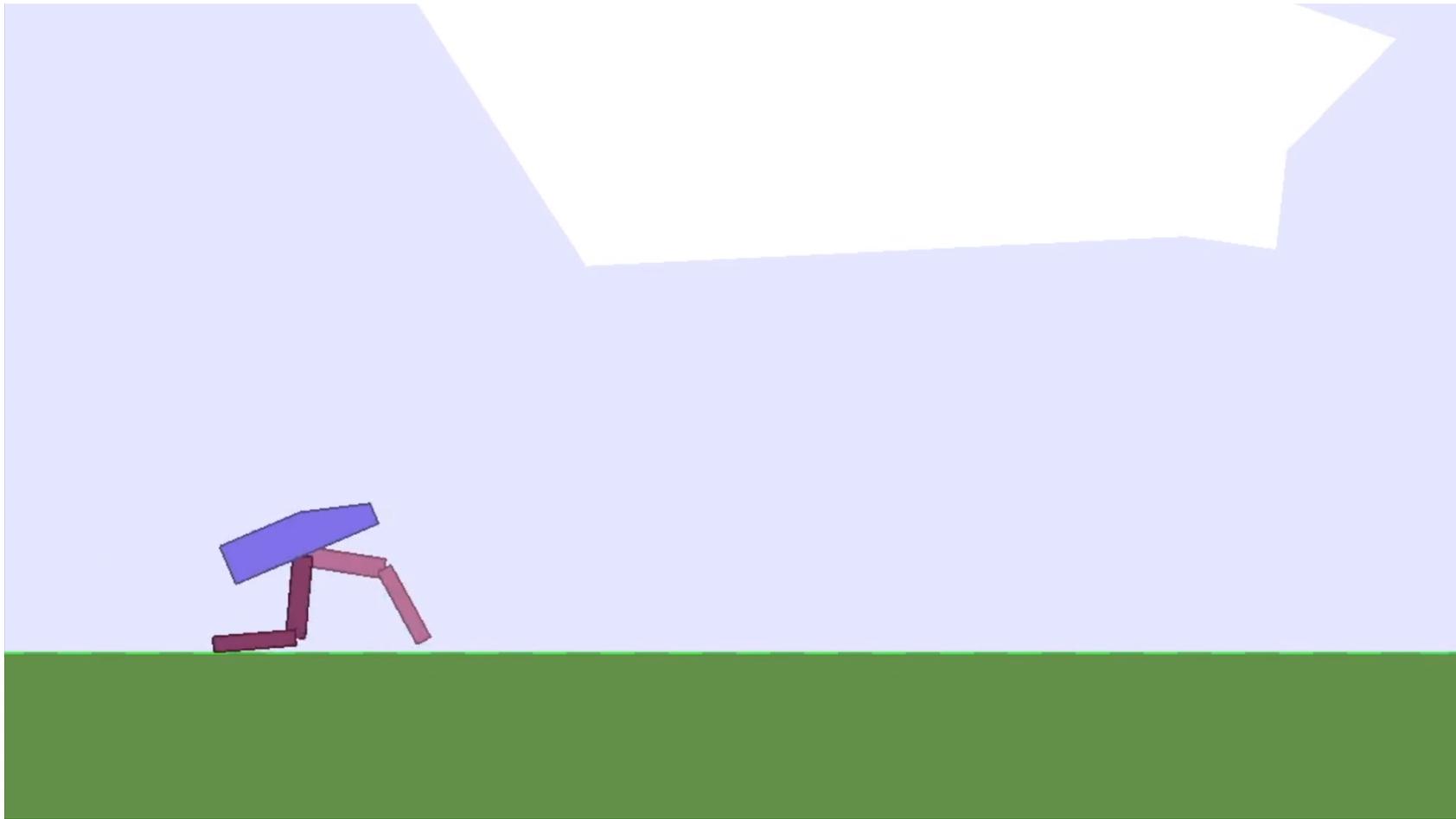
Transfer in POET



POET Video



POET Video



Open-Endedness: We're not Finished

- Field is just beginning; many challenges remain
 - Generating endless high-quality, diverse, and *interesting* artifacts remains a challenge
 - Killer applications remain critical for motivation
 - The measurement of success remains controversial and open
- *Open-endedness is the power of creation*
 - All of living nature is its product in a single run
 - When will we harness this power?

A Place to Start

- Non-technical intro to field (2017):
<https://www.oreilly.com/ideas/open-endedness-the-last-grand-challenge-youve-never-heard-of>



AI

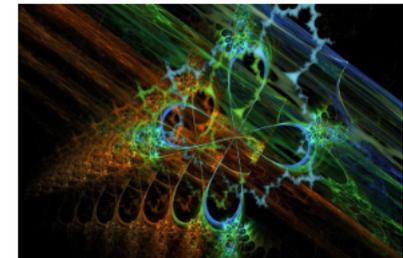
Open-endedness: The last grand challenge you've never heard of

While open-endedness could be a force for discovering intelligence, it could also be a component of AI itself.

By Kenneth O. Stanley, Joel Lehman, and Lisa Soros. December 19, 2017

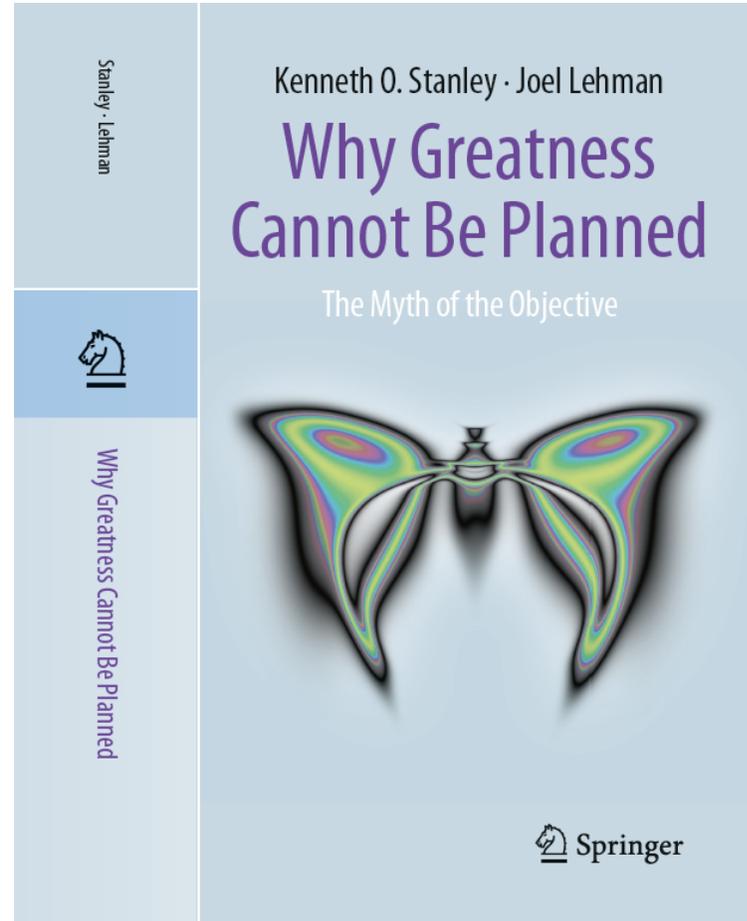
Check out the "Impact of AI on Business and Society" sessions at the AI Conference in San Francisco, September 4-7, 2018. Hurry—best price ends June 8.

Artificial intelligence (AI) is a grand challenge for computer science. Lifetimes of effort and billions of dollars have powered its pursuit. Yet, today its most ambitious vision remains unmet: though progress continues, no human-competitive general digital intelligence is within our reach. However, such an elusive



Fractal (source: Pixabay)

More Thoughts on Divergent Search



More information

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zero
- Open-Endedness O'Reilly article: <https://www.oreilly.com/ideas/open-endedness-the-last-grand-challenge-youve-never-heard-of>