Open-Endedness: A New Grand Challenge for AI

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Why Is Machine Learning about Solving Problems?

- Can the computer classify these images from ImageNet?
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

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

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

But you may need this to get human-level AI
One run of **evolution**, all life on Earth (no human intelligence!)
One run of evolution, all life on Earth (no human intelligence!)

Human-level Intelligence, a tiny moment in an endless saga
One run of **evolution**, all life on Earth (no human intelligence!)

**Endless Surprises!**
(and it keeps on going)
The Never-Ending Algorithm
The Never-Ending Algorithm

Open-Ended Evolution
The Never-Ending Algorithm

More Generally: Open-Endedness

bittbox.com
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
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

Transfer attempt
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


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
More Thoughts on Divergent Search
More information

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