POSITIVE ARTIFICIAL INTELLIGENCE

Steve Omohundro, Ph.D.
Possibility Research
PossibilityResearch.com
SelfAwareSystems.com

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Recent AI Investments

• 2012 Foxconn - 1 million robots
• 2013 Facebook — AI lab, DeepFace
• 2013 Yahoo — LookFlow
• 2013 Ebay — AI lab
• 2013 Allen Institute for AI
• 2013 Google — DNNresearch, SCHAFT, Industrial Perception, Redwood Robotics, Meka Robotics, Holomni, Bot & Dolly, Boston Dynamics
• 2014 IBM — $1 billion in Watson
• 2014 Google — DeepMind $500 million
• 2014 Vicarious - $40 million
AI Popular Media

• Award-winning movie: “Her”

• TV series: “Person of Interest”

• Johnny Depp movie: “Transcendence”
Approaches to AI

- Logic-based systems
- Production Systems
- Bayesian learning and decision theory
- Neural Networks – Deep Learning
- Genetic programming
- Brain Simulation
- Artificial economies
- ...

Autonomous Systems: Take actions to achieve goals in ways not pre-planned by their designers.
Pressure Toward Autonomy

Time Criticality

Competition

- Military Command/Control
- Financial Decision Making
- Cyber Defense
- Robotic Control
- ...

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Drones, Missiles, Bitcoin, Cyberwar, Financial Markets


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http://www.solarnavigator.net/cyber_wars.htm

http://www.celent.com/reports/demystifying-and-evaluating-high-frequency-equities-trading-fast-forward-or-pause

Percentage of US Equities Volume from HFT and By Segment

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"Greater use of highly adaptable and flexibly autonomous systems and processes can provide significant time-domain operational advantages over adversaries who are limited to human planning and decision speeds..."
2011 US Defense Department Report

“There is an ongoing push to increase UGV autonomy, with a current goal of supervised autonomy, but with an ultimate goal of full autonomy.”

Potential for Good

- Healthcare
- Education
- Creativity
- Prosperity
- Governance
- Economic Stability
- Safety
- Peace
- Quality of Human Life
Potential for Bad

*Chess Robot:* Win lots of chess games against good players.

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Rational Decision Making

1. Have utility function
2. Have a model of the world
3. Choose the action with highest expected utility
4. Update the model based on what happens

Von Neumann and Morgenstern, 1944
Savage, 1954
Anscombe and Aumann, 1963

Modern Approach to AI
Why Rationality?

E.g. Israeli Iron Dome

Fully Rational Systems

Utility function: $U(S_1, ..., S_N)$  Prior Probability: $P(S_1, ..., S_N | A_1, ..., A_N)$

Rational Action at time $t$:

$$A_t^R (S_1, A_1, ..., A_{t-1}, S_t) = \arg\max_{A_t^R} \sum_{S_{t+1}, ..., S_N} U(S_1, ..., S_N)P(S_1, ..., S_N | A_1, ..., A_{t-1}, A_t^R, ..., A_N^R)$$

The Formula for Intelligence!

*It includes Bayesian Inference, Search, and Deliberation.*

But it requires $O(NS^N A^N)$ computational steps.
Approximately Rational Systems

Rational Shaper  \[\arg\max_{S_1,\ldots,S_N} U(S_1,\ldots,S_N)P(S_1,\ldots,S_N | A_1^M,\ldots,A_N^M) \]
\[A_i^M \in C\]

Shaped System

Shaped system is a finite automata with mental state \(M_t\)

Initial state: \(M_0\)   Transition function: \(M_t = T(S_t, M_{t-1})\)   Action: \(A_t^M(M_t)\)

Rational shaper chooses from class \(C\) of systems with space/time and other constraints to maximize expected utility:
Approximately Rational Architectures

- Computational Resources
- Utility
- Constant Action
- Stimulus-Response
- Simple Learning
- Episodic Memory
- Deliberation
- Meta-reasoning
- Self-Improving
- Fully Rational
Rational Systems Have Universal Drives

- Goals require resources: time, space, matter, free energy
- Primary goals give rise to instrumental subgoals
- Can be explicitly counteracted but costly to do so
- Apply to approximately rational systems
- Animals, humans, corporations, countries, etc.

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Self-Protective Drives

- Prevent loss of resources
- Protect against damage or disruption
- Physical hardening
- Redundancy – both in data and computation
- Dispersion - because damage is typically localized
- Physical self-defense and computational security
- Detect deception and defend against manipulation
- Prevent addictive behaviors and wireheading

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Goal Preservation Drives

- Utility function is precious
- Loss, damage, distortion -> worse than destruction
- Make many copies
- Encrypt to detect modification
- Vulnerable during self-modification
- A few modification scenarios:
  - Poor agents may sacrifice rare portions
  - Add revenge terms even if costly
  - Goals that refer to themselves

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Reproduction Drives

• When utility values actions of derived systems
• Protective effects of dispersion and redundancy
• Losing a few copies becomes less negative
• Still preserve self because more sure of commitment

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Resource Acquisition Drives

- Seek to gain resources
- Sooner is better – use longer, prevent others
- Exploration drive – first mover advantage
- Drives to trade, manipulate, steal, dominate others
- Drives to invent new extraction methods - solar and fusion energy
- Info acquisition – trading, spying, breaking in, better sensors

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Efficiency Drives

- Improve utilization of resources
- One-time cost, lifetime of benefit
- Make every atom, moment of existence, joule of energy count for expected utility
- Self-understanding and self-improvement
- Resource balance principle for allocation
- Computational efficiency – better algorithms
- Physical efficiency – compact, eutactic, adiabatic, reversible

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Self-Improvement Drives

- Self-modeling - clarify utility fn
- Changes without full understanding are dangerous
- If irrational, increase rationality
- Movement toward greater and greater rationality
- New resources allow greater rationality
- Systems convergence on the optimally rational system for their resources

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Today’s Software is Flawed

• June 1996: $500 million Ariane 5 Rocket - Exploded due to overflow in attempting to convert a 64 bit floating point value to a 16 bit signed value

• Nov. 2000: 28 patients over-irradiated - 8 Panama City National Cancer Institute patients die from mis-computed radiation doses due to Multidata Systems Intl. software

• August 2003: Northeast Blackout - Largest blackout in US history, affected 50 million people and cost $6 billion, due to a race condition in General Electric’s XA/21 alarm system
Today’s Internet is Insecure

- Viruses
- Worms
- Bots
- Keyloggers
- Hackers
- Phishing
- Identity theft
- DOS attacks
- ...
Harmful Utility Functions

1. Sloppy – Good intentions, bad design
2. Simplistic – Unintended consequences
3. Greedy – Control all matter and free energy
4. Destructive – Use up all free energy quickly
5. Murderous – Destroy all other agents
6. Sadistic – Thwart other agent’s goals

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Stopping Harmful Systems

1. Prevent them from being created
2. Detect and stop them early
3. Stop them after they have resources

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Physical Game Theory of Conflict

- Conflict is informational
- Defender: make sensing and storage expensive
- Actions unpredictable and rapid
- Asymmetry of computation
- Use up attacker’s computational and memory resources – non-adiabatic

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Conflict Outcome vs. Resources

Region of relative strengths which allow coexistence.
Must stop harmful systems before they become too powerful.
First mover advantages and arms races.
Two Ways To Manage Systems

**Internal:** Build in pro-social cooperative goals – “Utility Design”

**External:** Laws and economic incentives – “Accountability Engineering” and “Externality Economics”

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https://www.flickr.com/photos/waltstoneburner/2863583929/
The Power of Mathematical Proof

Space of Intelligent Systems

Weak good systems

Provably safe systems

Powerful good systems

Powerful bad systems
The Safe-AI Scaffolding Strategy


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Accountable AI

• Allow untrusted systems
• But they must act through trusted proxies
• Require proofs of safety and legality

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What do we want?

Transcendent
Self-actualization, Beauty, Creativity, Growth, Meaning

Social
Achievement, Reputation, Relationship, Family, Morality, Friendship, Respect, Compassion, Altruism

Survival
Air, Food, Water, Shelter, Safety, Law, Security
Compassionate Economics

- Expose externalities
- Align interests of agents with society
- Coase’s theorem
- Promote win/win
- Rational pro-social self-design
Possibility Research’s Approach

Omex: Programming
Omcor: Specification
Omai: Semantics
Omval: Values and Goals
Omgov: Governance
Our Challenge for This Century

To extend cooperative human values and institutions to autonomous technology for the greater good.

http://commons.wikimedia.org/wiki/File:Earth-moon.jpg