Open and Closed Worlds: A New Framework for Comparing Complex Social Systems

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DARPA Seedling 2020

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FYI…

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Big Picture Issue

- How do we prepare for known knowns, known unknowns and unknown unknowns?

Big Picture Issue

- Solutions include wargaming, training,

Wargaming

Training

Big Picture Issue

- Solutions include wargaming, training, simulation

Wargaming

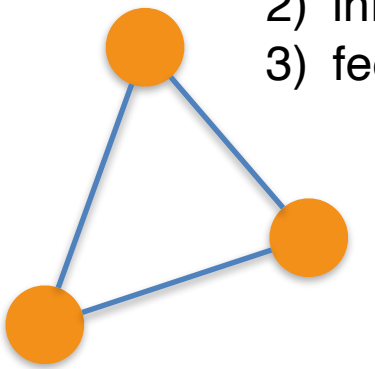
Training

Soccer Simulation

Specific Problem to Overcome

- Simulations/games are closed by design
- Real-world systems are open by nature

Relationships
1) information
2) influence
3) feedbacks



Actors
1) state
2) action space
3) decision policy

Closed

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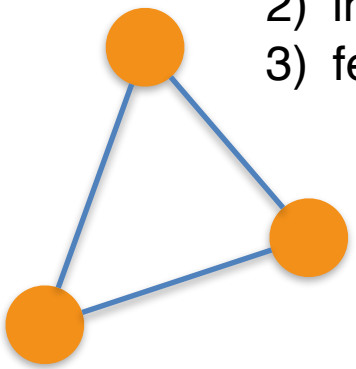

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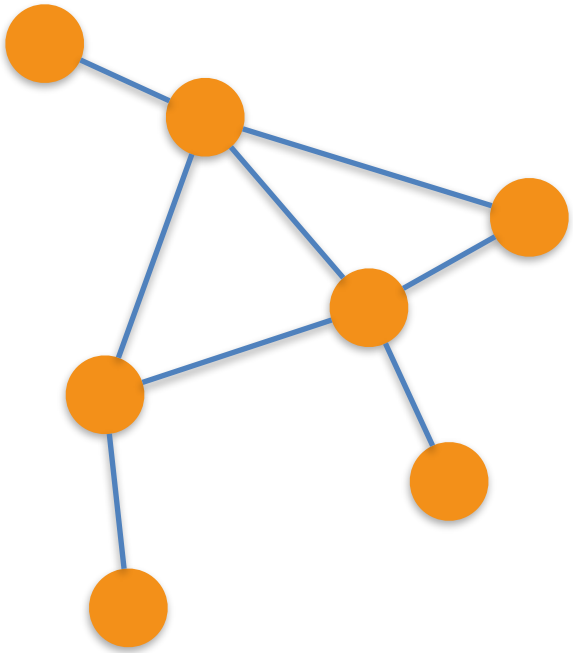

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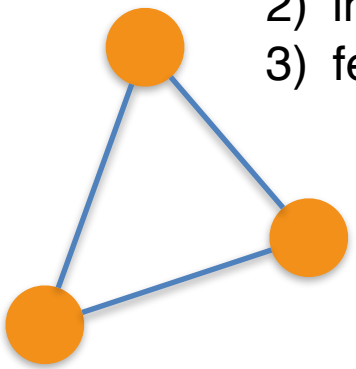

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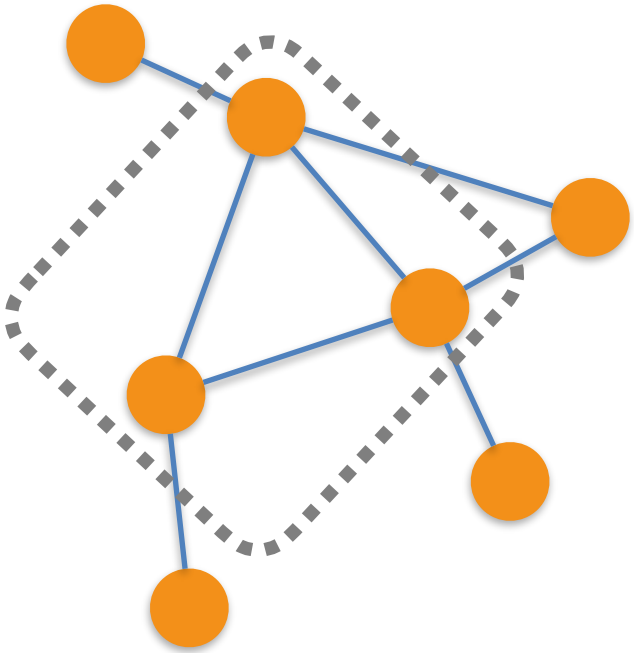

Closed

Open

Problem Statement

- We don't know if our (closed) games/sims are good approximations of real-world (open) systems.
- More specifically, we do not know if
  - Causality is accurately represented
  - Correct emergent dynamics occur (e.g. innovation, cooperation…etc).

Proposed Solution 1.1

- Goal: Create a new framework for measuring the utility of simulations and games
  - Characterize the way in which, and how well different simulations capture different aspects of a given real-world system
  - Provide quantitative metrics that can be used to compare the utility of different simulations

Proposed Solution 1.2

- Research Environment:
  - Google Research Football
  - Models of social-contagion

Proposed Solution 1.2

- Experiments: tune the realism of a simulation

(b) Run to Score

(c) 11 vs 11 with Lazy Opponents

(e) Pass and Shoot

(f) Easy Counter-attack

A library of thousands of simulated worlds

Proposed Solution 1.2

- Experiments: causal structure detection

(b) Run to Score

Methods in brief:

1) Actors, state space, action space
2) Identify local causal neighborhoods (LCNs) / Markov Blankets

Proposed Solution 1.2

- Experiments: system mapping theory

(b) Run to Score

Methods in brief:

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3) Apply Machine Learning to describe the LCNs decision-making policy (Q-learning)

- Friston's Free Energy (internal/external states)

4) Measure how simulation policies reflect to a given real-world system, i.e. system mapping…

5) Rank which games/sims are better at capturing particular aspects of real-world systems

Proposed Solution 1.2

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Real-world game data:

1) Player/ball position through time
2) Only one match… just a glimpse, not a library
3) We are not doing machine learning on this

Project outcomes

- Causal structure theory is a new way to compress and order information about complex systems
- System mapping theory allows for the comparison of complex systems:
  - e.g. the way in which and how well different simulations capture different aspects of a given real-world system

Why should DARPA care?

- (War)game design and improved training
- Anomaly detection and anticipating innovation (NGS2, SIGMA+)
- 3rd Wave AI (AI that can contextualize; AI that can play games it has never seen before)

What programs might grow from this?

1. In this project: causal structure detection and system mapping of 22 soccer players…
   - now scale up to millions of agents (militaries, national economies… etc).

2. Complex systems analogy generator (e.g. financial markets are like an ecosystem, militaries are like an immune system… etc etc)
   - When do analogies break down?

Team

Dr. James Watson
Oregon State University
(PI, complex systems)

Dr. Mathew Titus
The Prediction Lab LLC
(math, probability theory)

Mazen Alotaibi
Oregon State University
(undergraduate, computer science)

Dr. George Hagstrom
Princeton University
(Physics, complex systems)

Project Timeline

- Deliverable: successful demonstration of 1) causal structure theory, 2) system mapping theory

Activity Weeks:	-8-0	1-5	6-10	11-15	16-20	21-28
WP1: Simulation environments + real-world data	JW, MT	JW, MT, PDS	JW, MT, PDS			
WP2: Causal structure theory		MT, JW, PDS	MT, JW,PDS	MT, JW, PDS		
WP3: Policy mapping theory			MT, PDS	MT, PDS	MT, PDS	
WP4: Toy data test			MT, PDS	MT, PDS	MT, PDS	
WP5: Application to socio-spatial soccer data			MT, JW, PDS	MT, JW, PDS	MT, JW, PDS	MT, JW, PDS
WP6: Application to social network dynamics				MT, PDS	MT, PDS	MT, PDS
Expanded impact	JW, MT	JW, MT	JW, MT	JW, MT	JW, MT	JW, MT

Table 1. Project schedule, key milestones (M1-M5) and responsibilities: JW/James Watson, MT/Mat Titus, PDS/ post-doctoral scholar (TBD). Colors denote major project milestone and work packages.

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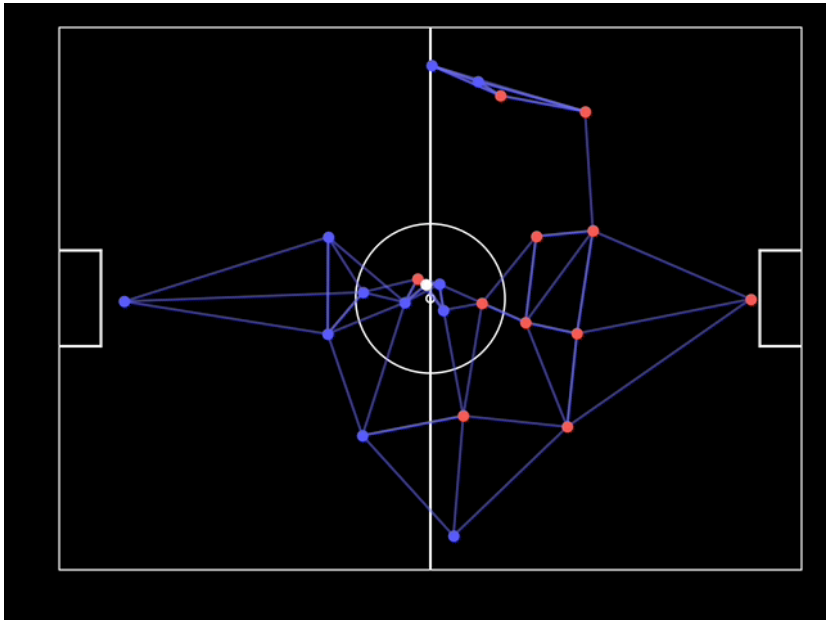

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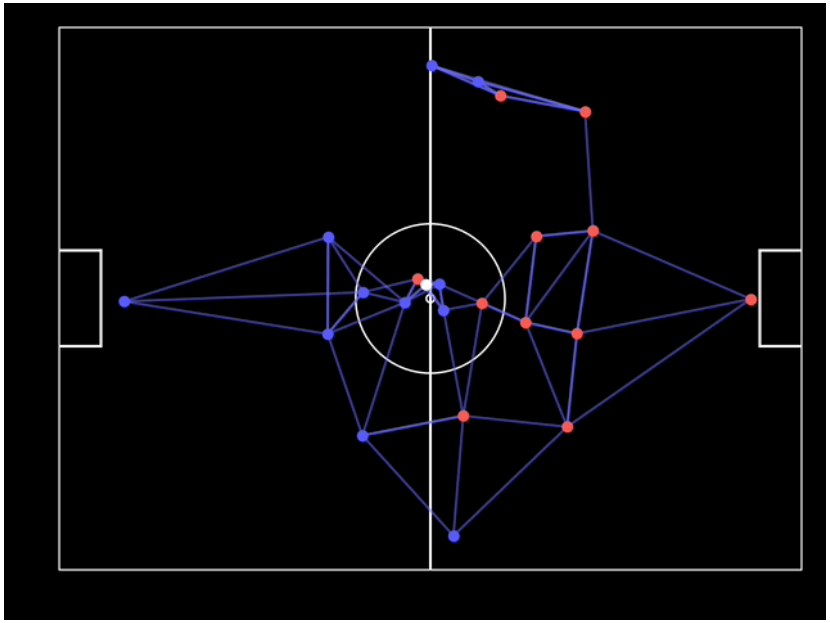

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Spare Slides

Big Picture Issue

- How do we prepare for known knowns, known unknowns and unknown unknowns?

Use deep mind
Playing uno?