



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

James Watson

DARPA Seedling 2020

Assistant Professor, Oregon State University

email: james.watson@oregonstate.edu

web: jwatson.ceoas.oregonstate.edu/



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



Scrimmage

Big Picture Issue

- Another solutions is: (social) simulation



Social-sims

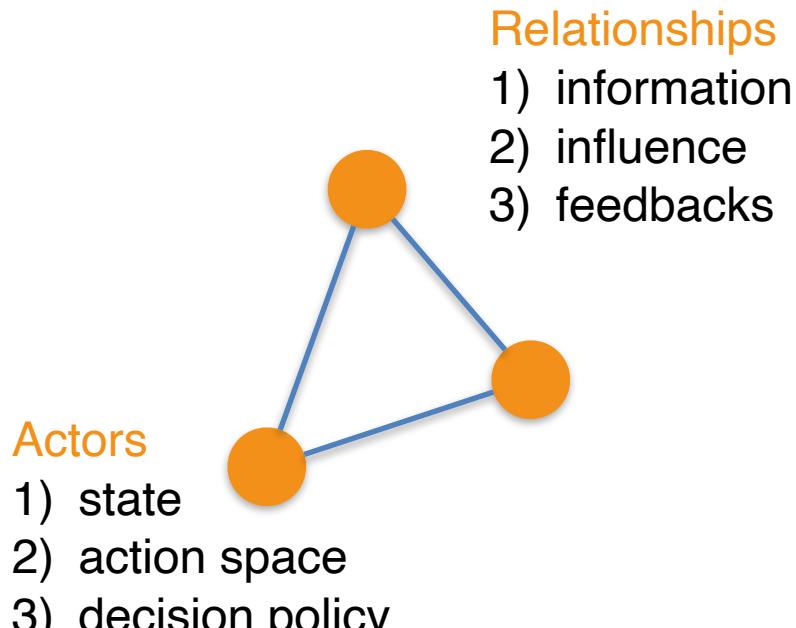


Soccer
computer
game



Specific Problem to Overcome

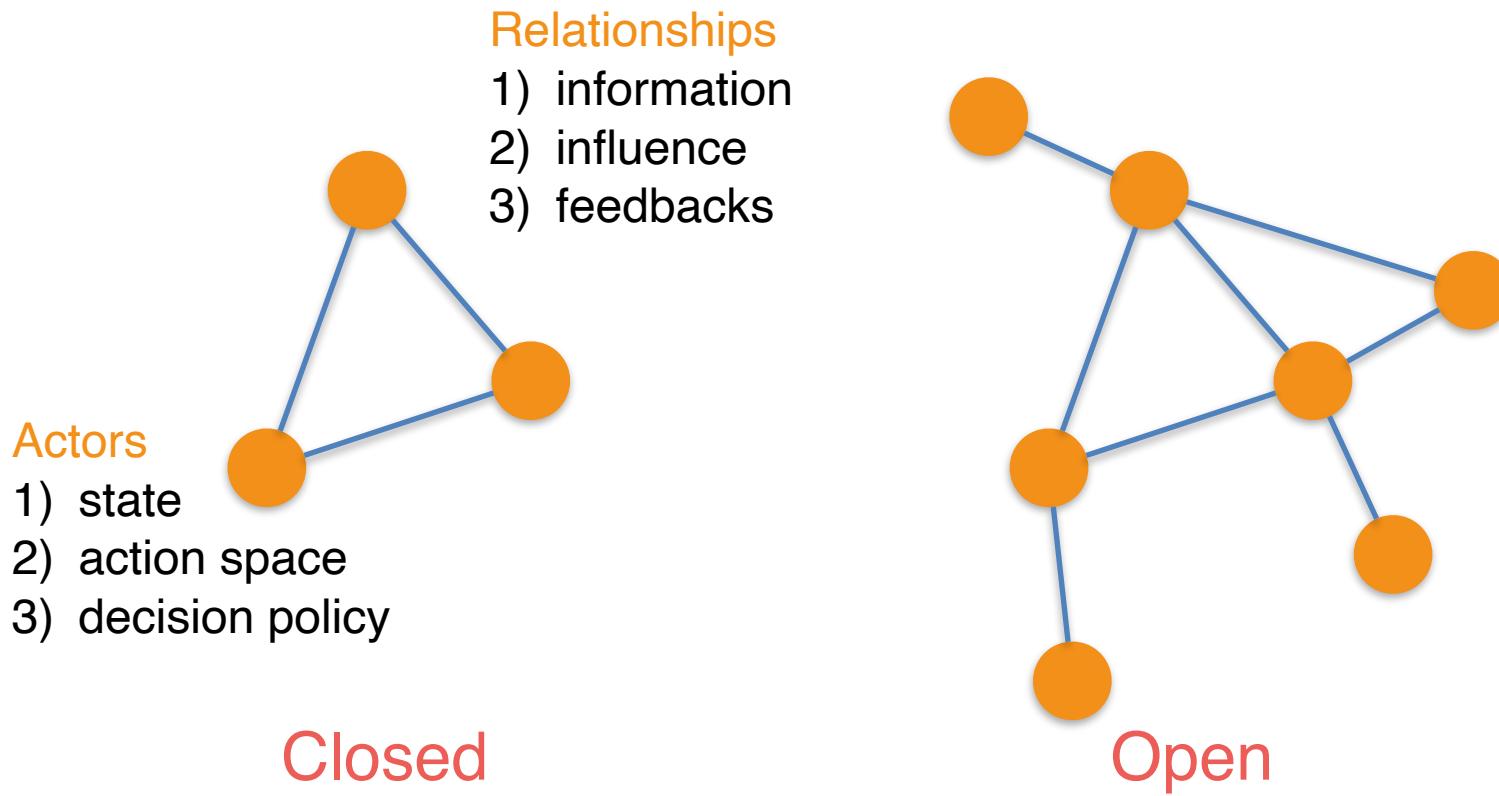
- Simulations/games are **closed** by design
- Real-world systems are **open** by nature



Closed

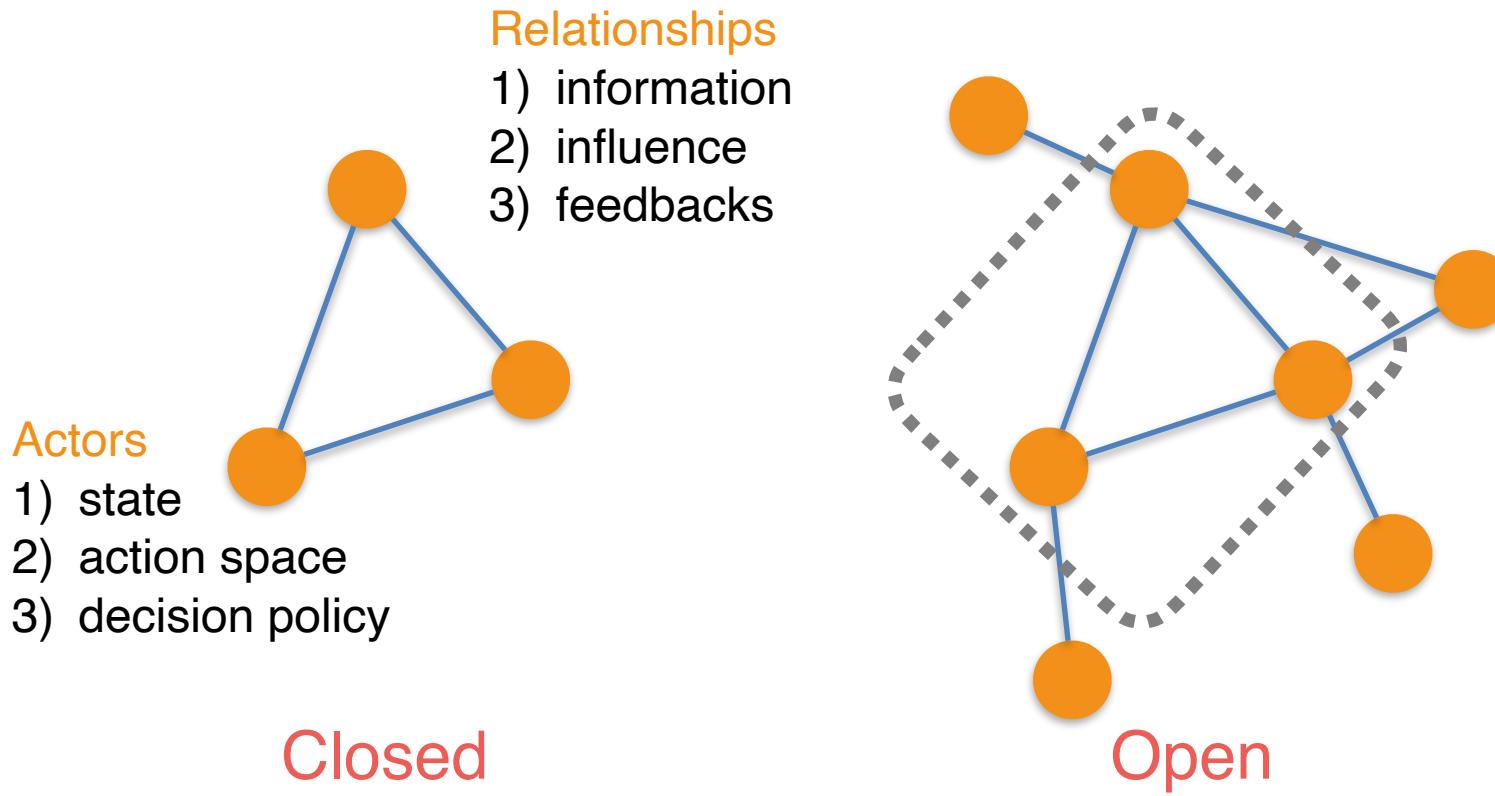
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Problem Statement

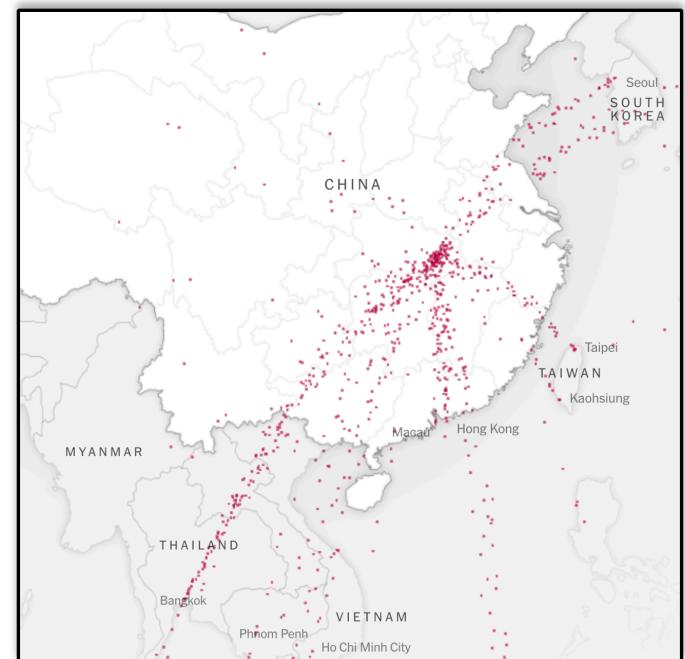
- We don't know if our (closed) games/sims are good approximations of real-world (open) systems.
- More specifically, we **do not know** if
 - **Causality** is accurately represented
 - Correct **emergent dynamics** occur (e.g. innovation, cooperation...etc).

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
 - Provides 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 sim...



(b) Run to Score



(c) 11 vs 11 with Lazy Opponents



A library of thousands of simulated worlds

Proposed Solution 1.2

- **Experiments:** compare causal structure



(b) Run to Score



(c) 11 vs 11 with Lazy Opponents



Data from one real world match

A library of thousands of simulated worlds

Proposed Solution 1.2

- **Experiments:** methods in brief...



(b) Run to Score

- 1) Actors
- 2) State space
- 3) Action space
- 4) Identify local causal neighborhoods (LCNs)

- 5) Apply Machine Learning to describe the LCNs decision-making policy (Q-learning)
- 6) Measure how closely real-world systems adhere to the policy (**system mapping**)
- 7) Rank which games/sims are better at capturing particular aspects of real-world systems



Data from one real world match

Proposed Solution 1.4

- System mapping allows for characterizing the way in which, and how well different simulations capture different aspects of a given real-world system
- System mapping provides quantitative metrics that can be used to compare the utility of different simulations

Why should DARPA care?

- Anomaly detection and **anticipating innovation** (NGS2, SIGMA+)
- **3rd Wave AI** (AI that can contextualize; AI that can play games it has never seen before)
- **(War)game design** and improved training
- **Teaming** (hybrid human/AI teams)
- Complex systems **analogy generator** (e.g. financial markets are like an ecosystem, DoD is like an immune system... etc etc)

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

Activity	Weeks:	-8-0	1-5	6-10	11-15	16-20	21-28
WP1: Simulation environments + real-world data		JW, MT	JW, 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

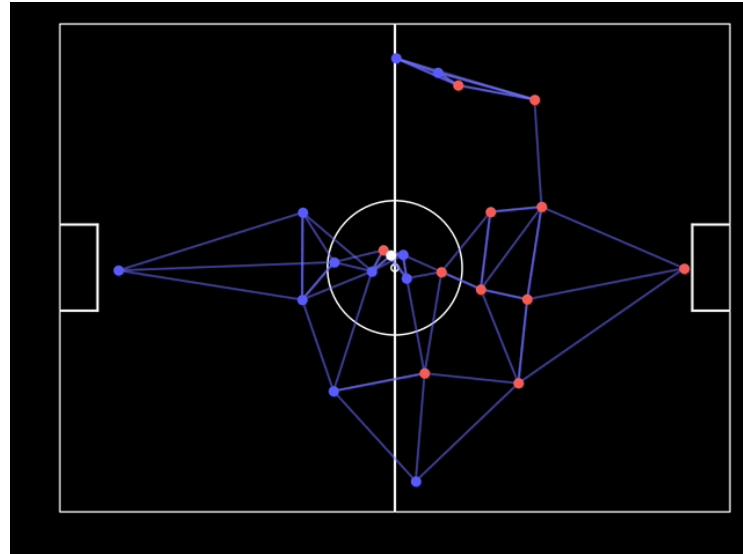
Table 1. Project schedule, key milestones (M1-M5) and responsibilities: JW/James Watson, MT/Mat Titus, PDS/ post-doctoral scholar (TBD). Colors denote major project milestone and work packages.

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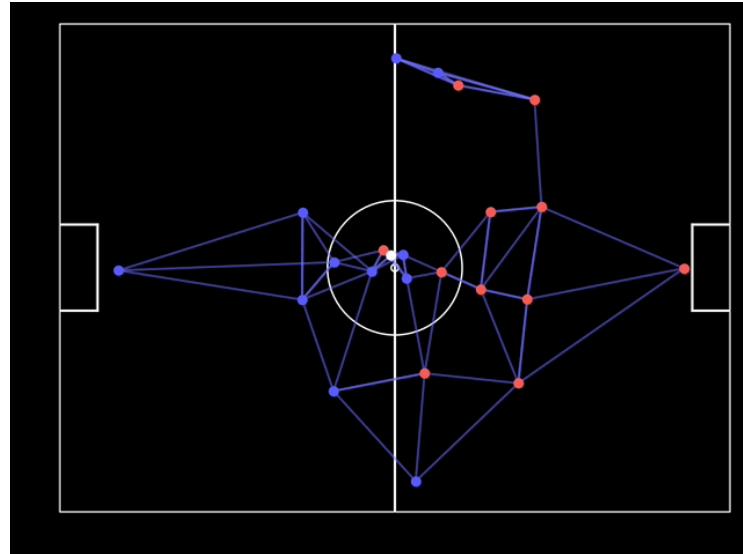


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