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Topics In Algorithmic Game Theory Final


We must collaborate to fight back
Screw you guys, I'll just live it up

Defending from the Invader:

How the behaviors of humans affect their chances of survival

Modeling the Scenario

		Invader			
		Passive		Active	
		Human 2			
		Collaborate	Self-Interest	Collaborate	Self-Interest
Human 1	Collaborate	a1, b1, c1	a2, b2, c2	a3, b3, c3	a4, b4, c4
	Self-Interest	a5, b5, c5	a6, b6, c6	a7, b7, c7	a8, b8, c8

a# - Payoff for Human 1
b# - Payoff for Human 2
c# - Payoff for invader

Items of Note:

- Human payoffs should be symmetrical
  - Payoff for Collaborative - Self Interested = Self Interested - Collaborative
- Invader actions are independent, can view the game as 2 matrices, passive and active matrix

Defining Payoffs

Goals:

- Come up with simple list of variables that characterize the scenario
- Determine formulas using those variables to determine payoffs

Humanity Focused Variables

- **V** - Resource to strengthen humanity to defend from the invader
- **C** - Cost of self interest
- **S** - Synergistic Factor of Collaboration.
    - The assumption here being that when more people collaborate, the better they can do to defend from the invader

Invader Focused Variables

- **D** - Damage from an aggressive Invader
- **A** - Cost of an Invader's Attack
- **B** - How much Damaged is Reduced in Attack against a collaborative humanity

Defining Payoffs

Collaborative - Collaborative - Passive

Human 1	V/2 * S
Human 2	V/2 * S
Invader	-VS

Collaborative - Collaborative - Active

Human 1	(V/2 * S) - B
Human 2	(V/2 * S) - B
Invader	-(VS - 2B + Λ)

Collaborative - Self Interested - Passive

Human 1	0
Human 2	V
Invader	-V

Collaborative - Self Interested - Active

Human 1	-D
Human 2	V-D
Invader	-(V-2D+Λ)

Self Interested - Collaborative - Passive

Human 1	V
Human 2	0
Invader	-V

Self Interested - Collaborative - Active

Human 1	V-D
Human 2	-D
Invader	-(V-2D+Λ)

Self Interested - Self Interested - Passive

Human 1	(V-C)/2
Human 2	(V-C)/2
Invader	-(V-C)

Self Interested - Self Interested - Active

Human 1	V/2 -C -D
Human 2	V/2 -C -D
Invader	-(V - 2C - 2D +Λ)

Defining Payoffs

Collaborative - Collaborative - Passive

Human 1	V/2 * S
Human 2	V/2 * S
Invader	-VS

Collaborative - Collaborative - Active

Human 1	(V/2 * S) - B
Human 2	(V/2 * S) - B
Invader	-(VS - 2B + Λ)

Collaborative - Self Interested - Passive

Human 1	0
Human 2	V
Invader	-V

Collaborative - Self Interested - Active

Human 1	-D
Human 2	V-D
Invader	-(V-2D+Λ)

Self Interested - Collaborative - Passive

Human 1	V
Human 2	0
Invader	-V

Self Interested - Collaborative - Active

Human 1	V-D
Human 2	-D
Invader	-(V-2D+Λ)

Self Interested - Self Interested - Passive

Human 1	(V-C)/2
Human 2	(V-C)/2
Invader	-(V-C)

Self Interested - Self Interested - Active

Human 1	V/2 -C -D
Human 2	V/2 -C -D
Invader	-(V - 2C - 2D +Λ)

Defining Payoffs

Collaborative - Collaborative - Passive

Human 1	V/2 * S
Human 2	V/2 * S
Invader	-VS

Collaborative - Collaborative - Active

Human 1	(V/2 * S) - B
Human 2	(V/2 * S) - B
Invader	-(VS - 2B + Λ)

Collaborative - Self Interested - Passive

Human 1	0
Human 2	V
Invader	-V

Collaborative - Self Interested - Active

Human 1	-D
Human 2	V-D
Invader	-(V-2D+Λ)

Self Interested - Collaborative - Passive

Human 1	V
Human 2	0
Invader	-V

Self Interested - Collaborative - Active

Human 1	V-D
Human 2	-D
Invader	-(V-2D+Λ)

Self Interested - Self Interested - Passive

Human 1	(V-C)/2
Human 2	(V-C)/2
Invader	-(V-C)

Self Interested - Self Interested - Active

Human 1	V/2 -C -D
Human 2	V/2 -C -D
Invader	-(V - 2C - 2D +Λ)

Specific Payoffs

Variables:
V-15 **D**-20
C-10 **A**-5
S-1.5 **B**-2

		Invader			
		Passive		Active	
		Human 2			
		Collaborate	Self-Interest	Collaborate	Self-Interest
Human 1	Collaborate	11.25, 11.25, -22.5	0, 15, -15	9.25, 9.25, -23.5	-20, -5, 20
	Self-Interest	15, 0, -15	2.5, 2.5, -5	-5, -20, 20	-22.5, -22.5, 40

Analyzing the Scenario

- Modeling the strategy evolution between 2 Humans and 1 Invader through iterative games
- Modeling population dynamics of Humans and Invaders

Analyzing the Scenario

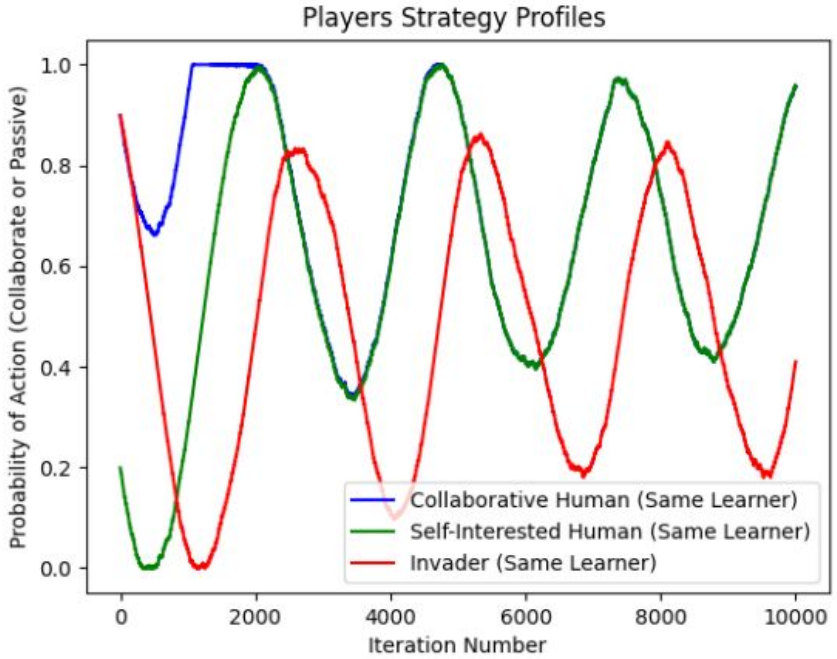
- **Modeling the strategy evolution between 2 Humans and 1 Invader through iterative games**
- Modeling population dynamics of Humans and Invaders

Iterative Game

- Players play game 10,000 times
- Humans:
  - Probability P of being collaborative
  - (1-P) of being self-Interested
- Invaders:
  - Probability P of being Passive
  - (1-P) of being Active

- Probabilities update after every game
  - Each Agent can update their probabilities at different Learning Rates (Low, Medium, and High LRs)

Iterative Game

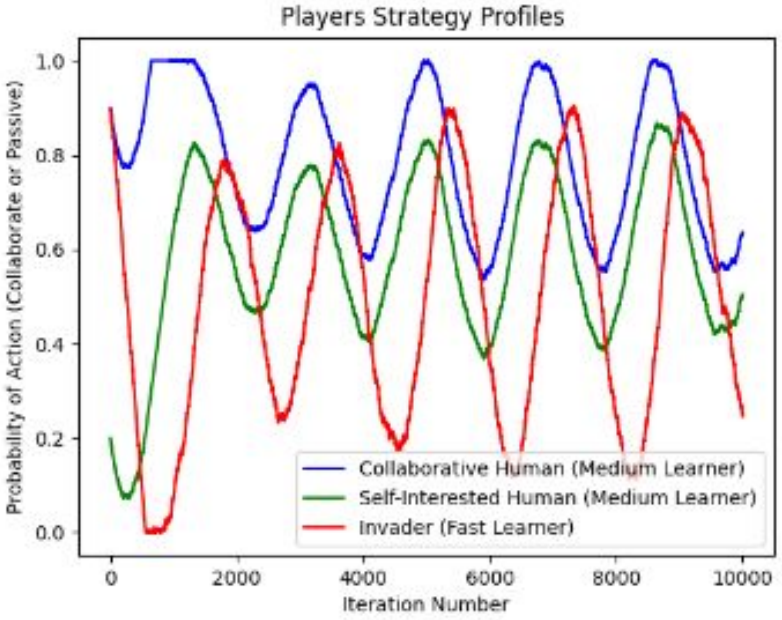


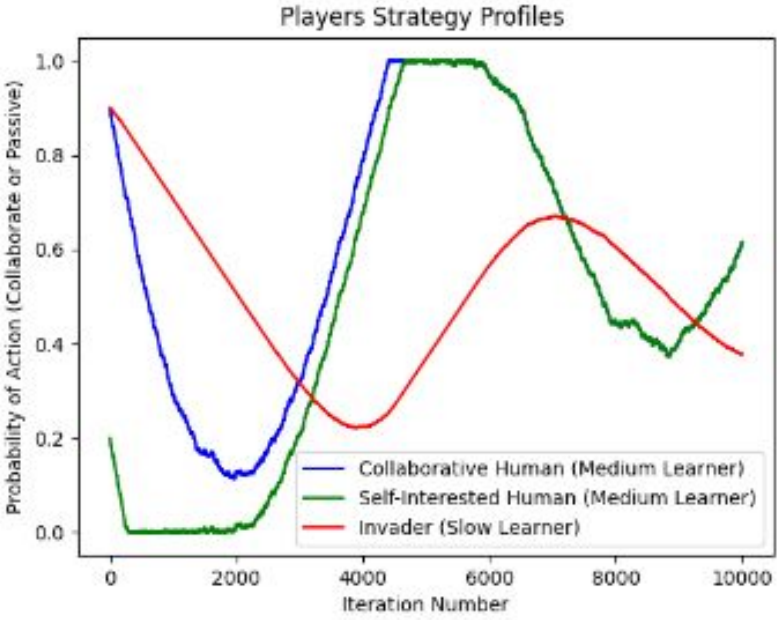
Collaborative Human - Initially 90% of being collaborative

Self Interested Human - Initially 10% of being collaborative

Invader - Initially 90% of being passive

Iterative Game





Analyzing the Scenario

- Modeling the strategy evolution between 2 Humans and 1 Invader through iterative games
- **Modeling population dynamics of Humans and Invaders**

Population Game

- Envision a population which consists of:
  - H_C - Proportion of collaborative Humans
  - H_S - Proportion of Self-Interested Humans
  - I_P - Proportion of Passive Invaders
  - I_A - Proportion of Active Invaders
- H_C + H_S + I_P + I_A = 1

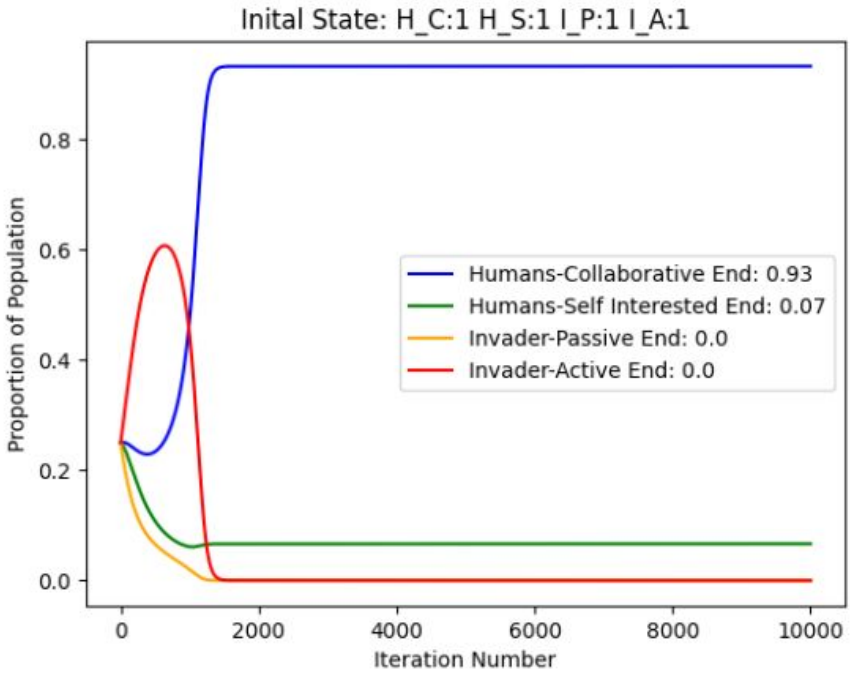
Given initial conditions of all populations. The change in the population can be defined by:

$$\frac{dx_i}{dt} = x_i(f_i - \phi).$$

f_i: The average fitness of population i, given the current proportions of the population

Phi: Overall average fitness of all populations

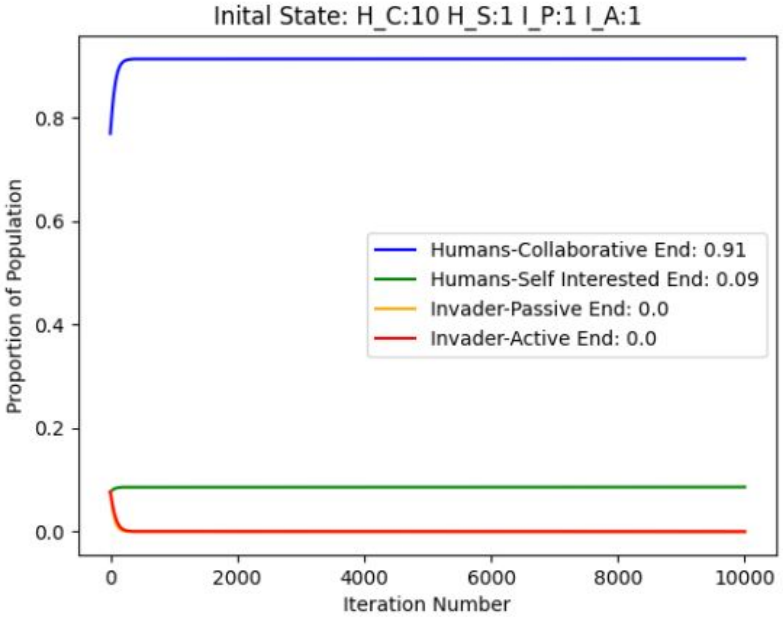
Population Game

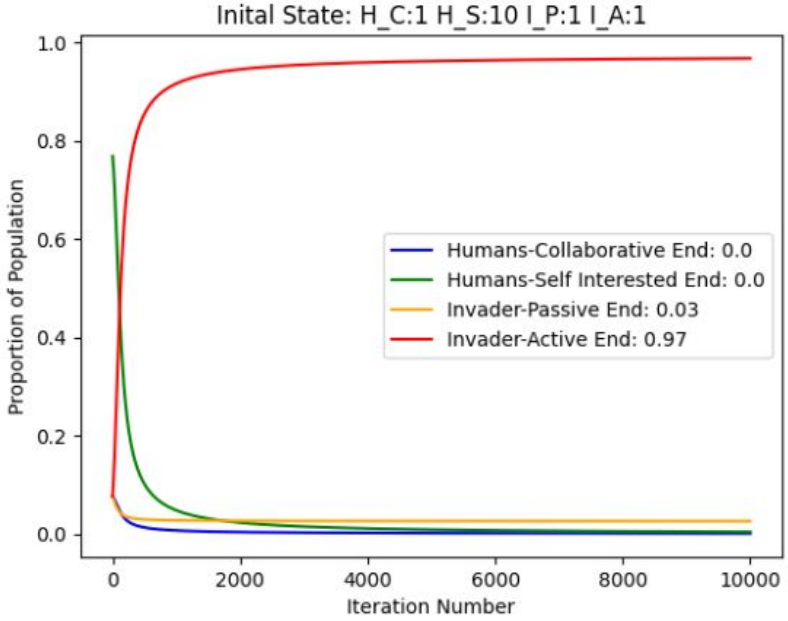


Initial State:

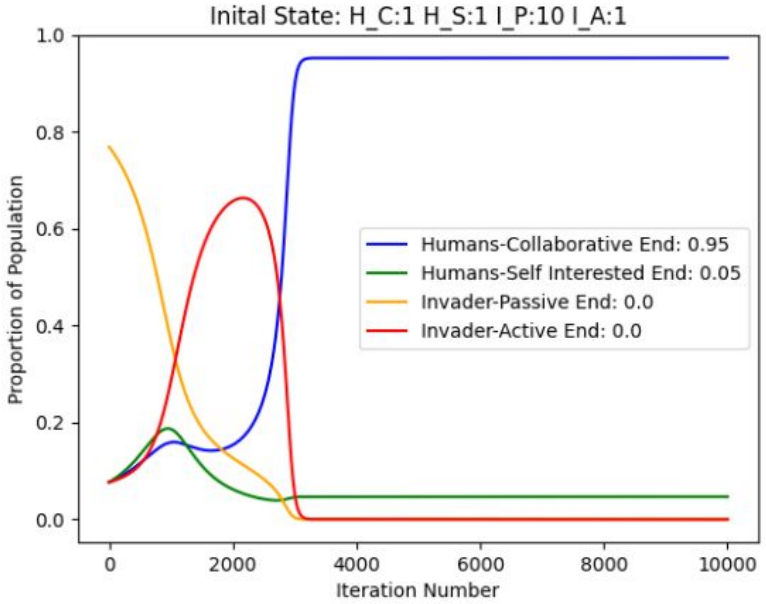
- Collaborative Human - 1 Part
- Self Interested Human - 1 Part
- Passive Invader - 1 Part
- Active Invader - 1 Part

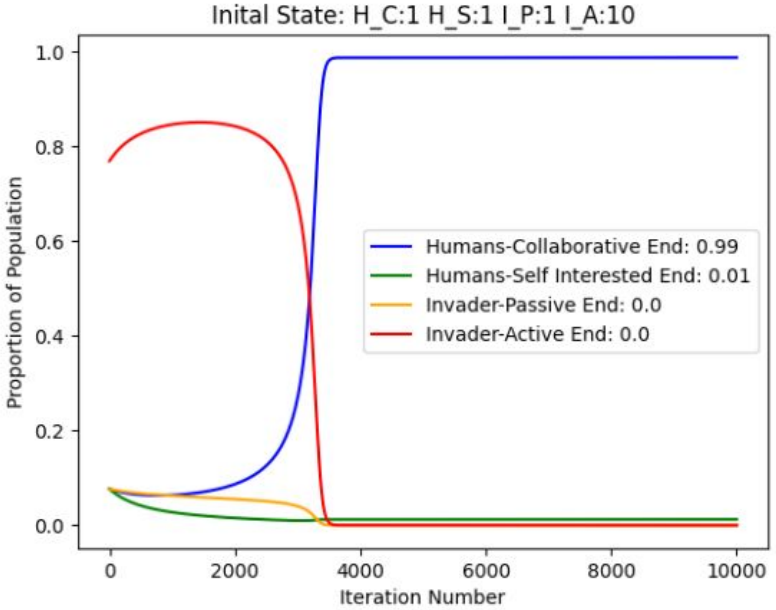
Population Game



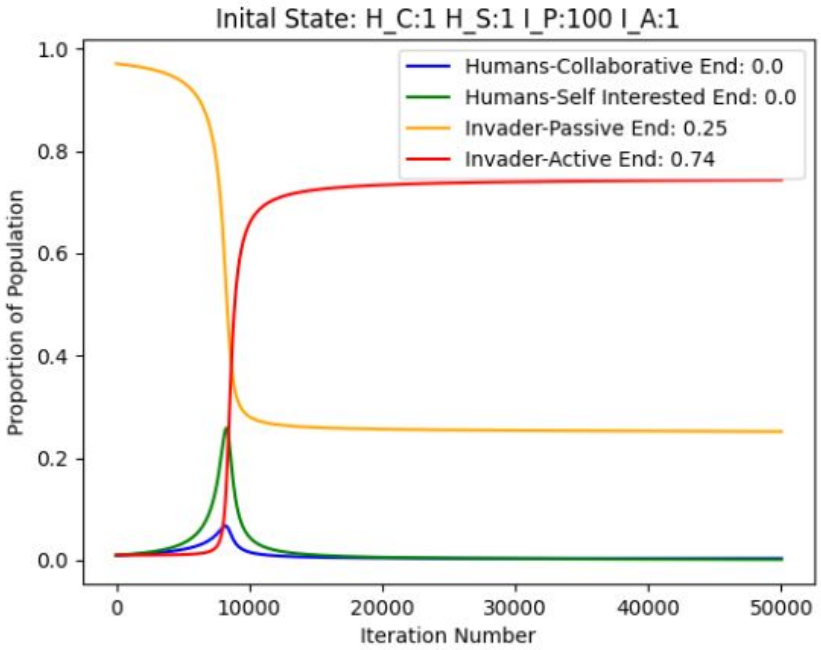


Population Game





Population Game



Future Potential Work

- **Assumptions that can be adjusted**
  - Variable values
  - Payoff Functions
  - Is matrix approach even appropriate

- **Game Gimmicks additions**
  - Different types of Humans/Invaders
  - Invaders not being able to repeatedly attack/having limited attacks
  - Payoff Matrix changing over time

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Applications to other domains with multi-group dynamics

- Companies
- Sport teams
- Political Parties

Q&A