Game Theory

An Application in Behavioral Simulation

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Project Overview

Food appears in pairs daily; creatures move randomly towards these pairs.

Creature Strategies:

- Doves: Share food equally (50/50 split).
- Hawks: Attempt to take all food, leading to aggressive interactions.

Survival Rules:

- 1 food unit: Creature survives to the next day.
- 2 food units: Creature survives and reproduces.

Interaction Outcomes:

- Dove vs. Dove: Each gets 1 unit, both survive.
- Hawk vs. Dove: Hawk takes 1.5 units, might reproduce; Dove gets 0.5 units, survival chance 50%.
- Hawk vs. Hawk: Each gets 1 unit, high energy cost leads to no reproduction.

Vultures

Character Traits of Vultures:

- Extremely social; cannot survive alone. Alone at food pair = death.
- Meet another vulture at food pair = reproduce.
- Meet a dove at food pair = reproduce; dove survives.
- Hostile to hawks; always kills hawks when encountered. Vulture survives.

Theoretical Setup for the Baseline Model

$$D = H$$

$$d \cdot 1 + \frac{1}{2} \cdot h = d \cdot \frac{3}{2} + 0 \cdot h$$

$$\because \ 1 = d + h \therefore \ h = 1 - d$$

$$d \cdot 1 + \frac{1}{2} \cdot (1 - d) = d \cdot \frac{3}{2} + 0 \cdot (1 - d)$$

$$d = 0.5 \quad , \quad h = 0.5$$

	Dove	**Hawk**
Dove	1,1	$\frac{1}{2}, \frac{3}{2}$
Hawk	$\frac{3}{2}, \frac{1}{2}$	0,0

Figure 2.1: Baseline Payoff Matrix

Changes in Payoff Matrix

	Dove	**Hawk**
Dove	1,1	$\frac{1}{2}, \frac{3}{2}$
Hawk	$\frac{3}{2}, \frac{1}{2}$	$\frac{1}{4}, \frac{1}{4}$

Figure 2.2: Altered Payoff Matrix

$$d = 0.\overline{3} \quad , \quad h = 0.\overline{6}$$

	Dove	**Hawk**
Dove	1,1	$\frac{1}{2}, \frac{3}{2}$
Hawk	$\frac{3}{2}, \frac{1}{2}$	$\frac{3}{4}, \frac{3}{4}$

Figure 2.3: Prisoner's Dilemma Case

$$d = -1 \quad , \quad h = 2$$

Code Overview

processInteractions Structure

```
processInteractions[pairs_] := Module[{newDoves = 0, newHawks = 0, u=
    RandomReal[]},
       Do[
           Switch[pair,
               {1}, newDoves += 2; oneDove++,
               {2}, newHawks += 2; oneHawk++,
               {1, 1}, newDoves += 2; twoDoves++,
               {2, 2},Null; twoHawks++,
               {1, 2} | {2, 1},
               If[RandomReal[] < 0.5, newHawks += 1, newHawks += 2];
               If[RandomReal[] < 0.5, newDoves += 0, newDoves += 1];
               doveAndHawk++
           ],
           {pair, pairs}
       ];
       {newDoves, newHawks}
   ];
```

- Interactions at each location are processed by simulatePopulations, using nested loops and a Switch statement to apply predefined hawk/dove behavior rules.
- Food allocation for hawks and doves is determined through random chance mechanisms, with results tracked using specific counters like oneDove, twoHawks, etc.

Scenario 2: Changing Payoffs

Changes in the Switch statement

```
1 ....
2 {2, 2}, If[RandomReal[] > 0.75, newHawks += 1];
3 If[RandomReal[] > 0.75, newHawks += 1];twoHawks++
4 ....
```

- We change the payoff matrix so that if two hawks meet their probability of surviving is 25%
- So, the probability of a hawk surviving will happen if RandomReal[] is more than 0.75, which happens 25% of the time.

Scenario 3: Prisoner's Dilemma

Changes in the Switch statement

```
1 ....
2 {2, 2}, If[RandomReal[] > 0.25, newHawks += 1];
3 If[RandomReal[] > 0.25, newHawks += 1];twoHawks++
4 ....
```

- We change the payoff matrix so that if two hawks meet their probability of surviving is 75%
- So, the probability of a hawk surviving will happen if RandomReal[] is more than 0.25, which happens 75% of the time.

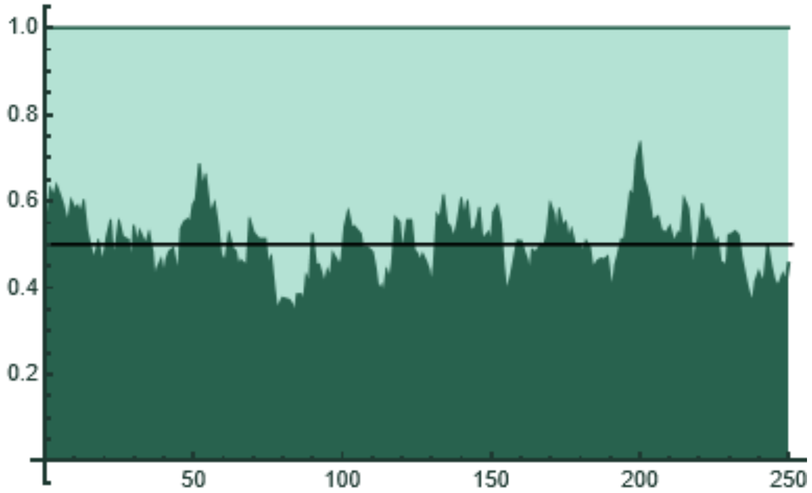
Vultures Code

processInteraction

```
1 {3}, Null; oneV++,
2 .....
3 {3, 3}, newV += 3; twoV++,
4 {3, 2} | {2, 3}, newV += 1; VH++,
5 {3, 1} | {1, 3}, newV += 2; newDoves++; VD++,
6 ....
```

- We changed the processInteraction module where we add new conditions which reflects the characteristics of the vultures.

Baseline Scenario Results

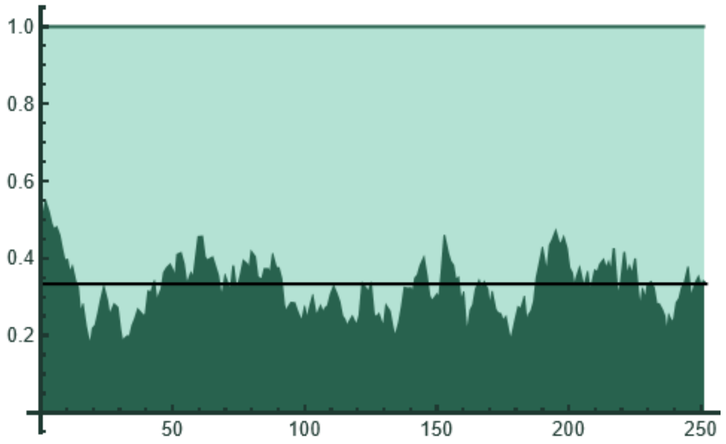


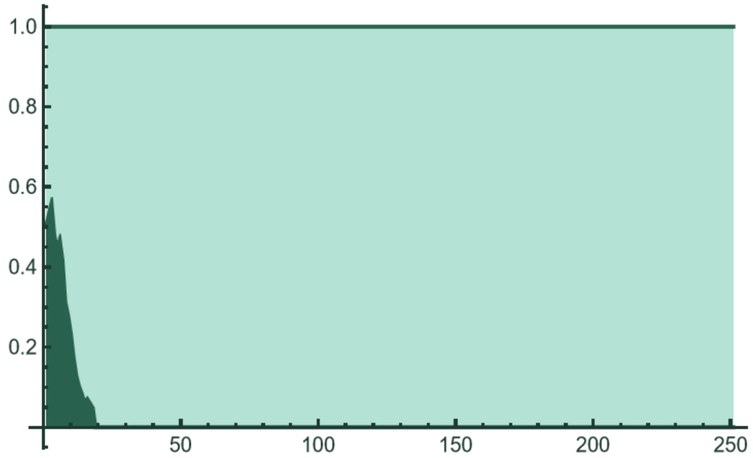
Hawks

Doves

0.487 ± 0.014 (95% CI)

Changing Payoff Matrix Results





0.319 ± 0.015 (95% CI)

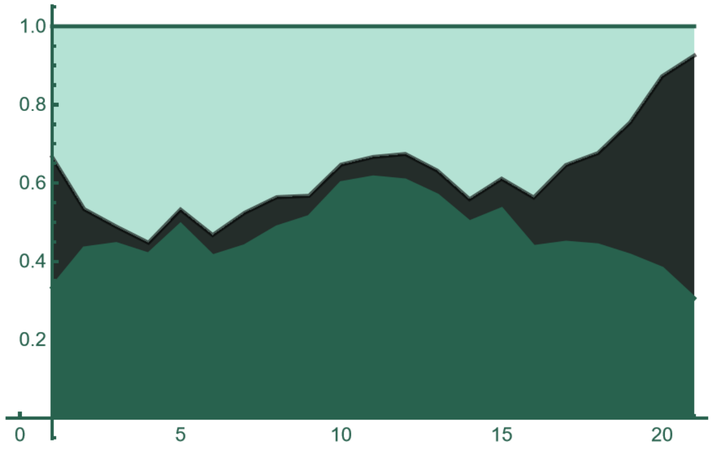
0

Hawks

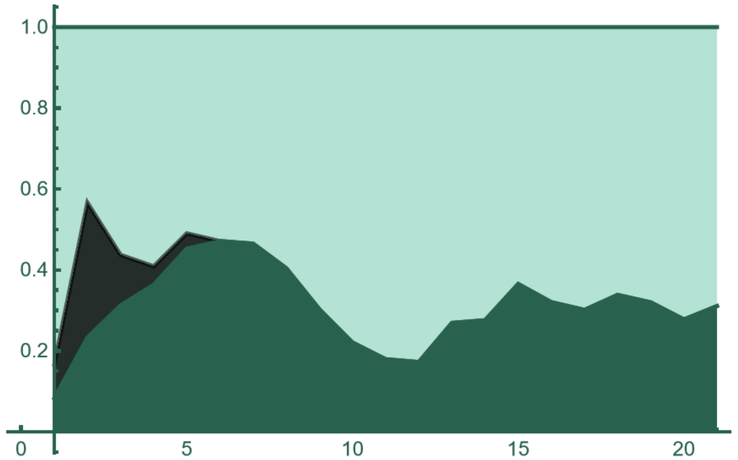
Doves

Simulating Vulture Behavior

Less Food



More Food



Hawks

Doves

Vultures

Thank you!

Time for questions