Seek & Destroy

John Doyle, Marco Forte, Ronan Loftus, Tristan Audam

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Predator-Prey model with constrained turning and velocities in a bounded area

A.K.A. 'Robot Wars Redux!'

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Problem Outline

The objective of this project was to decide a strategy for the predator to follow in order to win the game outlined below.

The game consists of a $30x30m$ course where the Predator has to catch the Prey within five minutes, otherwise the game is drawn(the prey's desired outcome). The two players must be pre-programmed with a set of instructions that they must follow. Each player is fitted with a GPS tracker and is aware of their position and their opponents position at all times during the game.

Assumptions

A number of general assumptions were made:

- Predator has maximum speed of $5ms^{-1}$ and maximum turning radius of $2m$.
- Prey has maximum speed of $4ms^{-1}$ and maximum turning radius of $1m$.
- The Predator and Prey are represented by circles $1m$ in diameter.
- Predator will destroy prey upon contact.
- Acceleration to maximum speed is instantaneous.
- Both Players always travelled at their maximum velocities.
- Both players take initial positions anywhere within $1x30m$ rectangles at opposing ends of the arena.

Predator Strategy

The initial rules of the game, it turned out, led to to very one sided matches in favour of the predator.

Thus the predator did not need an extremely elegant path finding algorithm.

Pure Pursuit

The predator followed a strategy of "pure pursuit":

1. Using the GPS input, find the current position of Prey.
2. While adhering to the movement limitations, travel in this direction.
3. Repeat.


RUN AWAY!!!

Prey Strategy

It was relatively easy for the predator to win the game.

In our opinion, the determining factor in the outcome of the game then became the prey's 'intelligence' and agility (How well the prey was able to outmanoeuvre the predator and then ideally even trick it into an infinite loop!)

Prey Strategy: Implementation I

After teamwork, intuition and lots of trial & error we developed a strategy that brought the prey's win percentage approximately up to a whopping $<1\%$.

This was achieved by giving the prey a fairly simple strategy which relied on it trying to keep away from the edges when not in immediate danger,fleeing when the predator was starting to come too close and if danger is extremely imminent to use it's superior turning to evade and make ground (see case #1)

Prey Strategy: Implementation II

Run For Your Life

The prey's survival strategy:

1. If distance-to-predator $<$1.25m or distance-to-wall $<$1.25m double back on predator, in the direction of the centre
2. Check to see if the predator is $>$4m & distance to the wall is $>$4m
   If both are true then move towards centre of board
3. Check to see if the distance to predator is $<$4m if true try to move in the direction directly opposite the predator

Case 1: "Last Second Swerve"

This case occurred when: the predator was chasing directly behind the prey and was closing ground. The prey would then try to sharply turn out of the predator's way in the direction of the board's centre.

The outcome it led to was: A significant increase in the prey's survivability time. It was still a case of delaying the inevitable, but this manoeuvre did manage to buy the prey some extra time.

Extensions I

There are also a number of interesting cases we found that can happen under certain conditions. For instance for certain fixed velocities, there is a tactic for the Prey that always results in a stable state, provided the Prey can stop instantaneously.

- if the Predator moves towards the Prey in the game, then the Prey should move directly towards the Predator
- when a certain displacement between the two players is reached the Prey turns 90 degrees at it's minimum turning radius directly followed by turning 90 degrees again in order to be oriented in the direction the Prey was pointing before the manoeuvre
- the Prey then stops

Extensions II

After this manoeuvre, the Predator will keep circling the Prey, but it will never be able to catch the Prey, resulting in a draw.

Extensions cont.

Another interesting case is when the Predator spirals inwards forcing the Prey into its own inward spiral until the Predator finally catches the Prey. For this to work the players' cannot be able to moderate their velocities, otherwise the Prey can alter its velocity and be able to run out the clock

Outcomes & Conclusion

The initial formulation of the problem was perhaps not perfect, as the predator has such an extreme advantage. This was a good thing though in some ways. It forced us to look at this problem from both sides and thoroughly examine lots of the multitude of possible scenarios and outcomes.

Overall this problem was a great learning exercise and it definitely challenged us and allowed us to stretch our critical thinking muscles.