Edith Cowan University
CSG2341
Intelligent Systems
Assignment 1A

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Contents

1 Introduction

This report examines fuzzy logic and its practical use in a video game called Saucers. Saucers is a two player game, where each player indirectly controls their flying saucer using a fuzzy logic controller. The saucers meet on a battle space, a rectangular xy plane, with the purpose of destroying each other. The walls of this space cannot be travelled through, and will cause the saucer to ricochet off the wall when hit.

The saucers begin with equal amounts of energy at the start of the game, and this energy is consumed as they fly around or fire their auto-aiming cannon mounted on a rotating turret. The rounds fired from the cannon are ballistic. They travel in a straight line from the cannon and are not guided. When a saucer is hit by a round, energy is depleted. Amount of energy depletion depends on how far away the round was fired. In other words, rounds fired will lose energy the further they have to travel, and will eventually fade away. They are much more lethal in close combat.

Saucers cannot stop flying and will always consume energy. However, the speed of a saucer can be controlled. The slowest speed consumes the least amount of energy, while the fastest speed consumes the most. The saucer's heading can also be controlled, and can turn left or right in any direction. Currently, there is no energy penalty for turning. Each saucer is also equipped with a sensor, which determines how far away the opponent is, the opponent direction, and how much energy the opponent has, which are used as inputs for fuzzy logic.

When a saucer loses all of its energy, it disappears from the battle space and loses. The remaining saucer with energy left over is the winner. The goal of this report is to design a fuzzy logic controller so that it's saucer will have the most amount of remaining energy at the end of the battle.

2 Idea

The tactics of this controller are based on two facts:

- Saucers will always consume energy, no matter what they are doing.
- Cannon rounds are much more effective at close range.

Since saucers will always consume energy during all regimes of flight, this report believes that it is more efficient to be in a position to fire the weapon and attempt to degrade the enemy's energy at a faster rate, rather than fly defensively without firing at all. It is also more effective to be within close range of the enemy to cause more damage with the cannon, but on the other hand, the enemy's cannon will also be just as dangerous.

Therefore, the tactics of the controller will be as discussed below.

2.1 Flight regime

If the enemy is far while winning, commit to engagement and fly aggressively towards the enemy. Otherwise if the enemy is close, and winning or the score is even, fly at a slow speed to stay within close range. This will also allow the enemy to pass so that the saucer can stay behind the enemy and avoid overshooting him. During winning or even scores, the saucer will always turn towards the enemy attempting to close the distance to a much more lethal firing range.

If losing, break contact and fly away from the enemy at the appropriate speed. If close, fly as fast as possible away from the enemy. If near, fly moderately, and if far, then fly at the minimum speed to conserve energy.

2.2 Weapon employment

Since cannon shots lose energy the further they travel, only fire at close or near ranges to maximise efficiency of energy. When close and winning, fire at maximum power. When close and the score is even, fire at medium power. When near and winning or the score is even, fire the cannon at maximum power to ensure that the cannon round will reach the enemy. During other circumstances, hold fire to conserve energy.

3 Fuzzy variables

Three linguistic variables have been selected for input, based on the sensor readings of the saucer: Distance to target, energy difference and heading angle.

Conversely, three linguistic variables have been selected for output: Turn, speed and firepower.

3.1 Input variables

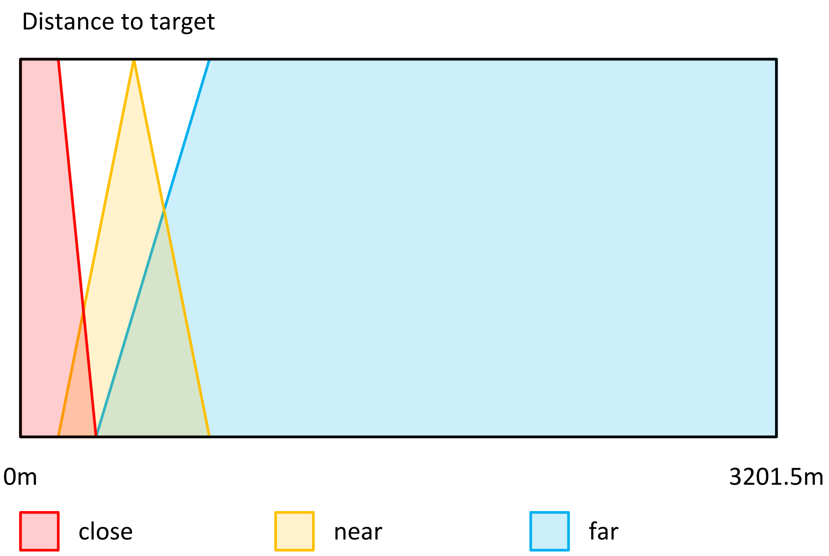
3.1.1 Distance to target

Distance to target is the distance from the saucer to the opponent, and is measured in meters. The universe of disclosure for distance is between 0 meters and the diagonal length of the battle space. The formula has been supplied in the existing code as:

$$\sqrt{\text{width} \cdot \text{width} + \text{height} \cdot \text{height}}$$

This linguistic variable is used to determine how much energy will be committed to firing the cannon. As mentioned previously, the cannon will only be fired at close or near distances. Therefore, three fuzzy sets are associated with distance:

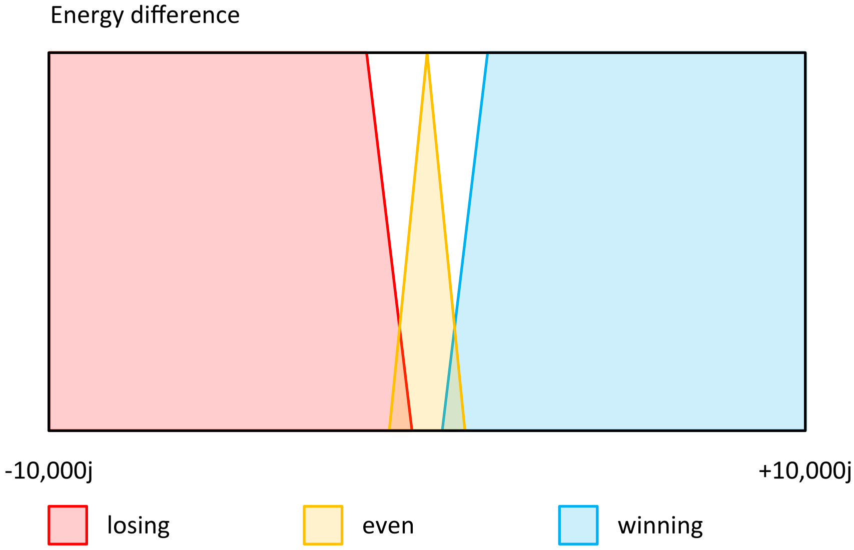
Figure 1: Distance to target fuzzy sets



3.1.2 Energy difference

Energy difference is the difference between the saucer's energy and the opponent's energy. The universe of disclosure for energyDifference is between -10,000j to +10,000j, where 10,000j is the amount of energy that the saucers begin with. This linguistic variable determines who is winning, who is losing, or if the score is even. It is used as input to decide how much energy is committed in firing the weapon, as well as whether or not to turn into or away from the enemy. The following fuzzy sets are created for energy difference:

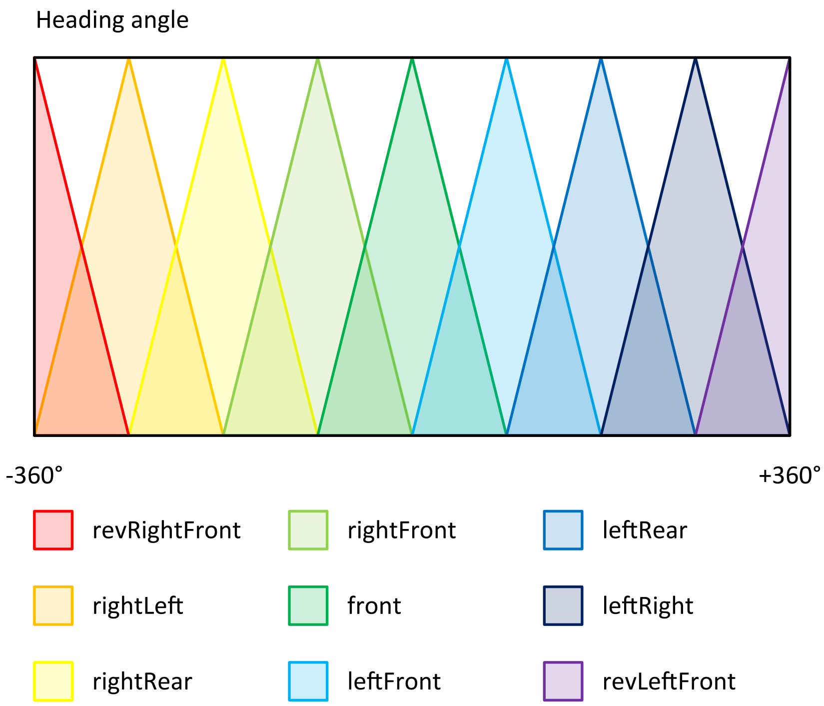
Figure 2: Energy difference fuzzy sets



3.1.3 Heading angle

Heading angle is the direction of the opponent in relation to the saucer, in degrees. After printing `opponentDirection` during execution, it is assumed that the universe of disclosure for this linguistic variable is from -360° to +360°. The variable, in conjunction with energy difference, dictates how the saucer will turn, and has been configured with the following fuzzy sets:

Figure 3: Heading angle fuzzy sets



3.2 Output variables

3.2.1 Turn

The turn linguistic variable defines which heading the saucer will take, in degrees, according to the rules that govern turning. A zero value will turn towards the opponent, while 180° will turn away from the opponent and head into the opposite direction, turning left while doing so. A negative value will turn right, and a positive value will turn left. The linguistic variables used as input for the turning rules are energy difference and heading angle. See Table 1 for the turn rule table.

Table 1: Turn rule table

	Losing	Even	Winning
revRightFront	-180.0	0.0	0.0
rightLeft	-90.0	+90.0	+90.0
rightRear	+180.0	-180.0	-180.0
rightFront	+90.0	-90.0	-90.0
front	-180.0	0.0	0.0
leftFront	-90.0	+90.0	+90.0
leftRear	-180.0	+180.0	+180.0
leftRight	+270.0	-270.0	-270.0
revLeftFront	-180.0	0.0	0.0

When winning or if the score is even, turn towards the enemy and commit to the engagement. Otherwise, if losing, turn away from the enemy and keep him at a relatively safe distance to minimize damage from cannon fire.

For example: IF (winning) AND (front) THEN (0.0)
In other words, if winning and enemy is in front, then keep heading towards him.

In contrast: IF (losing) AND (front) THEN (-180.0)
This will perform the opposite, and the saucer will turn right, into the opposite direction if the enemy is in front.

3.2.2 Speed

The speed linguistic variable defines how much energy to use for flight and is governed by rules which use distance and energy difference as inputs. See Table 2 for the speed rule table.

Table 2: Speed rule table

	Losing	Even	Winning
Close	125.0	50.0	50.0
Near	100.0	50.0	125.0
Far	50.0	100.0	125.0

When winning, the strategy is as follows. If close or near, use the minimum speed to prevent overshooting the enemy, and also allow the enemy to overtake so that it can be followed. If near, use maximum speed to catch up to get within a more lethal range for the cannon.

When the score is even, the strategy is to be more conservative with energy and only used medium speed if far. Otherwise, use the minimum speed if close or near.

When losing, the strategy is to fly fast away from the enemy if close, and fly at a moderate speed if near. Otherwise use the minimum speed if far away.

3.2.3 Firepower

The firepower linguistic variable determines how much energy to use when firing the cannon, and is controlled by rules which use energy difference and distance as inputs. See Table 3 for the firepower rule table.

Table 3: Firepower rule table

	Losing	Even	Winning
Close	50.0	50.0	100.0
Near	0.0	100.0	100.0
Far	0.0	0.0	0.0

When winning, and the enemy is close or near, fire the cannon using maximum power. Otherwise if the score is even, only fire the cannon at medium power when the enemy is close, or at maximum power when the enemy is near. This is to increase the chance that the cannot round will reach the target. Finally, if losing, do not fire the cannon at all at, unless at close range.

4 Sample fuzzy rule

5 Learnings

6 Conclusion

References