Fuzzy Logic versus simple Rules Based system for controlling an AI video game car

Jay Bretherton 1800231 Report for MAT301

# Introduction

## Overview

This project aims to evaluate the performance of a fuzzy logic system in solving a simple video-game oriented problem. To achieve this, an implementation of a fuzzy logic system that was written by this author was tested against a very simple control class which implements a rules-based solution to the same problem.

The aim is to prove if a more complex fuzzy inference system out-performs a more naive solution. The devised test is to drive a Kart around a lap of a track in the fastest time, while avoiding crashing into the walls of the track.

## Techniques

The solution, naturally, implements a fuzzy logic inference system as this is the system this experiment aims to test, and it implements a very simple rules based inference system as a baseline comparison.

The fuzzy system defines fuzzy numbers as being in a combination of five states (Tutorials Point, n.d.): Large negative, Medium negative, Close to zero, Medium positive, and Large positive. It then uses these fuzzy numbers to allow the construction of logical statements that do not need precise “crisp” values in their antecedent and consequent phrases. This means logical rules can be built up without having to define exact scenarios where they would come into effect. Furthermore, it contains systems for taking in crisp input data and converting it into fuzzy numbers (fuzzifying) and taking fuzzy output numbers and turning them back into crisp numbers that can be used by the rest of the solution (de-fuzzifying). This allows the system to be integrated into the solution in exactly the same way as the rules based system.

By comparison, the rules based system is intentionally far simpler. It consists of a series of evaluations comparing the data to exact numerical values and a list of Boolean logical rules. It then evaluates those rules and returns an output for the system. An RBS was chosen as the control it has the closest mapping onto a fuzzy rules system, with the main difference being the lack of fuzzy numbers – the key characteristic of fuzzy systems.

## Description of Solution

The solution implements an example microgame developed by (Unity Technologies, 2021) int which each AI controls a kart and attempts to drive it round a course. There is a sensor class which gathers information about the current state of the kart, and a controller class for each AI system. Each controller class takes data from the sensor and formats it before it is used as the input for its AI system. It then takes the suggested output given by its AI and validates it before passing this to the class which controls the Kart.

The example includes a countdown timer, but there are several “checkpoints” throughout the course which add time on to this. For this reason, each solutions’ time performance is recoded externally. The number of wall collisions will be counted manually by the individual carrying out the test.

## Hypothesis

The hypothesis held is that the fuzzy system will outperform the rules based system in both the time-to-complete of the lap, and in the number of collisions.

# Background

## Fuzzy Logic

Fuzzy logic is built off fuzzy set theory first proposed by (Zadeh, 1965). This model attempts to emulate the way natural logic is performed by people, where strict and exact values are not used but instead they use “fuzzy” values such as “tall, large, cold, or few”. It is particularly useful whenever discussing systems where statements can have degrees of truth and the system’s state can be in more than one form at once (Cintula, 2017). Because of this, fuzzy logic can be used in very complex systems so long as each attribute of the system is expressible on a scale of large negative to large positive (Guru99, n.d.). These are then used to build up a rules base which is used by the fuzzy logic inference engine to determine the behaviour of the system for a given input.

An idealised fuzzy logic system is outlined below.

Crisp Input

Rules

Inference Engine

Fuzzifier

De-Fuzzifier

Fuzzy Input

Fuzzy Output

Crisp Output

Figure

As can be seen in Figure 1 here, crisp input is passes to the Fuzzifier which produces a fuzzy input. This is then passed to the inference engine which uses the rules set and fuzzy logic to produce Fuzzy output. This is then passed to the De-Fuzzifier which produces a crisp output.

## Simple Rules Based System

Rules based systems are in many ways identical to fuzzy rules based systems, as fuzzy logic systems are a subset of rule based systems. RBS use a list of rules in much the way a fuzzy logic system would but uses crisp numbers throughout. This means that each logical statement must be made with exact values for each rule (Deep AI, n.d.).

# Methodology

## Experiment Overview

## Unity Setup and Integration

### Kart Controller

### Kart Sensor

## System Design Fuzzy Logic

## Code Implementation – Fuzzy System

## Code Implementation – Simple Rules Based System

# Results

Raw Data

Direct Comparison

Adjustments and Results

# Discussion

## Results Overveiw

## Causes

## Outliers and Adjustments

## Explanations of failures

# Conclusion

## Hypothesis

## Critical Analysis

# References

Cintula, P. C. G. F. a. C. N., 2017. *Fuzzy Logic.* [Online]   
Available at: https://plato.stanford.edu/archives/fall2017/entries/logic-fuzzy  
[Accessed 2021].

Tutorials Point, n.d. *Artificial Intelligence - Fuzzy Logic Systems.* [Online]   
Available at: https://www.tutorialspoint.com/artificial\_intelligence/artificial\_intelligence\_fuzzy\_logic\_systems.htm  
[Accessed 2021].

Unity Technologies, 2021. *Karting Microgame.* [Online]   
Available at: https://assetstore.unity.com/packages/templates/karting-microgame-150956  
[Accessed 2021].

Zadeh, L., 1965. Fuzzy sets. *Information and Control,* 8(3), pp. 338-353.