# Project 4: Use fuzzy logic to find the direction of motion of a vehicle.

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***Abstract*—Our proposal in this paper is a novel method to determine the direction of motion of vehicles. In other words, we apply "fuzzy logic," which is essentially a clever strategy for decision-making in uncertain situations. Fuzzy logic and time-series analysis of vehicle movement allow us to more accurately determine whether a vehicle is travelling in the Northeast, Southeast, Southwest, North, East, or Northwest directions. We walk through our systematic methodology and demonstrate how fuzzy logic can contribute to more intelligent transportation systems. Traffic management and self-driving cars could be improved by this research.**

***Index Terms*—Fuzzy logic, vehicle motion, direction estimation, trajectory analysis, intelligent transportation systems.**

## I. Introduction

UNDERSTANDING which way vehicles are moving is really important for things like traffic control and self-driving cars. But figuring out direction can be tricky, especially when cars are moving in crowded or confusing environments. Traditional methods for doing this can sometimes struggle when things get complicated. So, we suggest using something called "fuzzy logic," which is like a smart way of making decisions based on uncertain information. It helps us make better decisions when things aren't clear. We're looking at how vehicles move over time and then using fuzzy logic to say if they're going North, East, West, South, Northeast, Southeast, Southwest, or Northwest.unlike other methods which says its is yes or no. fuzzy logic tries to make decision in the ranges like it is kind of true or sort of false.. So it tend to make flexible decisions.

## II. Methodology

**Data Preprocessing:** Load trajectory data from a CSV file containing frame number, track ID, x and y coordinates, width, and height. Filter data is used to select trajectories for analysis based on user-defined track ID.

**Calculate Motion Vectors:** Compute the difference in centroids (dx and dy) between consecutive frames to determine the direction of motion.

**Angle Calculation:** We find out which way the vehicle is moving by looking at how much it moves left or right (x) and up or down (y). We use a special math trick called "arctan2" to help us do this.

**Using Fuzzy Logic in Practice:** We make up fuzzy rules for the eight main directions (like North, Northeast, East, and so on). These rules are like guides that tell us which way the vehicle might be going. Then, we use fuzzy math to figure out how much the vehicle fits into each direction based on its angle.

**Direction Categorization:** Assign the direction with the highest membership value to each data point using the argmax function.

**Visualization:** Plot the predicted direction on an image overlay with arrows representing vehicle motion between consecutive frames. Add direction annotations around the image to indicate the eight cardinal directions.

## III. Results

Fuzzy logic is a mathematical model used to predict the direction of motion of a vehicle from initial frames. The eight directions are assigned angles. Membership functions are also assigned for the directions. The direction having maximum membership function will be the predicted direction in which the vehicle will move. Model also predicts the output of the vehicles from the dataset.

```
0        NaN
1        NaN
2        NaN
3        NaN
4        NaN
        ...
76918     SE
76919     SE
76920     SE
76921     NW
76922     NW
Name: direction, Length: 76923, dtype: object
```

| Frm | Track | xc | yc | w | h | Velocity(kmph) |
|---|---|---|---|---|---|---|
| 1 | 1 | 2373 | 1324 | 95 | 128 | 0 |
| 2 | 1 | 2376 | 1331 | 94 | 128 | 22.12735165 |
| 3 | 1 | 2378 | 1338 | 96 | 127 | 21.32106834 |
| 4 | 1 | 2381 | 1347 | 96 | 129 | 26.45146189 |
| 5 | 1 | 2384 | 1356 | 97 | 129 | 28.12338374 |
| 6 | 1 | 2387 | 1363 | 96 | 128 | 25.49540046 |
| 7 | 1 | 2390 | 1371 | 95 | 130 | 25.49809004 |
| 8 | 1 | 2393 | 1379 | 94 | 130 | 25.47731044 |
| 9 | 1 | 2395 | 1387 | 94 | 128 | 25.08667118 |
| 10 | 1 | 2398 | 1395 | 94 | 128 | 25.14730526 |
| 11 | 1 | 2402 | 1403 | 94 | 130 | 25.58595195 |
| 12 | 1 | 2405 | 1412 | 96 | 130 | 26.39773612 |
| 13 | 1 | 2408 | 1420 | 97 | 130 | 26.16989314 |
| 14 | 1 | 2411 | 1428 | 94 | 130 | 25.98810281 |
| 15 | 1 | 2413 | 1437 | 94 | 130 | 26.35463835 |
| 16 | 1 | 2416 | 1445 | 94 | 130 | 26.15008535 |
| 17 | 1 | 2419 | 1453 | 94 | 130 | 25.97926713 |
| 18 | 1 | 2422 | 1462 | 95 | 129 | 26.44989327 |
| 19 | 1 | 2425 | 1469 | 95 | 130 | 25.66228096 |
| 20 | 1 | 2427 | 1477 | 95 | 130 | 25.37886817 |

Table 1: Given dataset

Table 1 contains the first 20 frames of vehicle no.1 from the given dataset. It has frame numbers, the track ID of the vehicle, x-coordinate(xc) and y-coordinate(yc), the width and height of the boundary box, and its velocity.

| Frm | angle | S | SW | direction |
|---|---|---|---|---|
| 1 | | | | |
| 2 | 1.1659045 | 0.5155242 | 0.4844757 | S |
| 3 | 1.2924966 | 0.3543421 | 0.6456578 | SW |
| 4 | 1.2490457 | 0.4096655 | 0.5903344 | SW |
| 5 | 1.2490457 | 0.4096655 | 0.5903344 | SW |
| 6 | 1.1659045 | 0.5155242 | 0.4844757 | S |
| 7 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 8 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 9 | 1.3258176 | 0.3119165 | 0.6880834 | SW |
| 10 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 11 | 1.1071487 | 0.5903344 | 0.4096655 | S |
| 12 | 1.2490457 | 0.4096655 | 0.5903344 | SW |
| 13 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 14 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 15 | 1.3521273 | 0.2784179 | 0.7215820 | SW |
| 16 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 17 | 1.2120256 | 0.4568010 | 0.5431989 | SW |
| 18 | 1.2490457 | 0.4096655 | 0.5903344 | SW |
| 19 | 1.1659045 | 0.5155242 | 0.4844757 | S |
| 20 | 1.3258176 | 0.3119165 | 0.6880834 | SW |

Table 2: Prediction

Table 2 contains the output predicted by the fuzzy logic. Here, the angle is the angle between two consecutive frames, and S (south) and SW (southwest) indicate the membership value in that direction. For this example, the vehicle has no membership value in N, NW, NE, W, E, or SE directions. From the two membership values model predicts the direction in which the value is higher, which is shown in the direction column in table 2.

## IV. Discussion

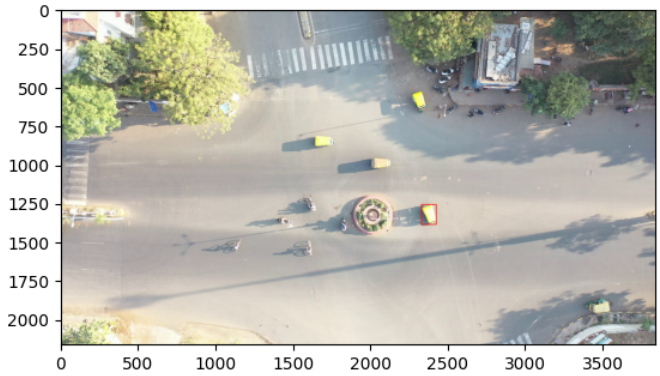


Image 1

In image 1, it detects vehicle 1 and creates the boundary box around it with the given data shown in Table 1.


Image 2

Image 2 shows the direction in which vehicle 1 is going in the given dataset, which is the same as the direction predicted by the fuzzy logic which are S and SW, given in table 2.

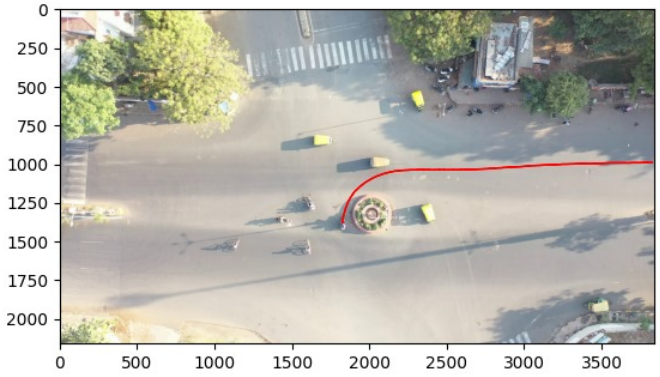


Image 3

Image 3 shows the example of object 13's trajectory direction.

## V. Discussion and Summary

In summary, our study shows that using fuzzy logic can help us figure out which way vehicles are moving more accurately. This could make traffic control and self-driving cars better. While fuzzy logic is flexible, we still need to make it work in real-time better. In the future, we can improve fuzzy logic and use it with other technologies like machine learning to make direction estimation even better. This would help transportation systems become more efficient and safer.

## VI. Conclusions

In summary, our study shows that using fuzzy logic can help us figure out which way vehicles are moving more accurately. This could make traffic control and self-driving cars better. While fuzzy logic is flexible, we still need to make it work in real-time better. In the future, we can improve fuzzy logic and use it with other technologies like machine learning to make direction estimation even better. This would help transportation systems become more efficient and safer.

## VII. References

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