Fuzzy Logic

By - Jayabharathi Hari
Deakin University
✉: s224643593@deakin.edu.au

Fuzzy Logic

Fuzzy Logic in Traffic Light Control Systems

Q1. Target Domain and Application:

This report explores the application of fuzzy logic in the domain of traffic management, focusing on its use in traffic light control systems. Traditional traffic light systems rely on fixed timing cycles, which can lead to inefficient traffic flow and congestion, especially during varying traffic volumes. Fuzzy logic offers a dynamic approach to optimize traffic light timing based on real-time conditions.

Q2. How Fuzzy Logic Fits In and Advantages:

Traffic conditions are inherently fuzzy. Factors like vehicle density, turning lanes, and pedestrian crossings are not always crisp values. Fuzzy logic excels in such situations by:

Modeling Traffic Dynamics:

Fuzzy systems can capture the complex relationships between various traffic factors and adjust light timings accordingly.

Adaptability:

Traffic light control adapts to changing traffic patterns throughout the day. For example, longer green lights during rush hour or shorter ones during off-peak times.

Reduced Congestion:

Optimized light timings can minimize waiting times and smoothen traffic flow, leading to reduced congestion.

Advantages of using Fuzzy Logic in Traffic Light Control Systems:

Improved Traffic Flow:

Dynamic light timing based on real-time traffic data leads to smoother traffic flow and reduced congestion.

Reduced Emissions:

Less idling time for vehicles translates to lower emissions and a more environmentally friendly traffic system.

Shorter Wait Times:

Optimized light timings minimize waiting times for drivers and pedestrians, improving overall traffic efficiency.

Ease of Implementation:

Fuzzy logic systems can be integrated with existing traffic light infrastructure, making them a practical solution.

Q3. Flow of the System using Fuzzy Logic:

Here's a breakdown of the fuzzy logic system in a traffic light control system:

- **Traffic Data:** Real-time traffic data is collected from sensors like vehicle detectors , pedestrian buttons , vehicle count on different lanes, and time of day are fed as inputs.

- **Fuzzification:** Each input is converted into fuzzy sets defined by membership functions (e.g., "low," "medium," "high" for traffic density). Membership grades represent the degree of belongingness to each fuzzy set.
- **Rule Base:** A set of IF-THEN rules are defined based on the relationships between fuzzy inputs and desired outputs (e.g., green light duration, yellow light duration). These rules capture traffic flow management strategies.
- **Inference Engine:** The fuzzy rules are evaluated using the membership grades of the inputs. This determines the degree of activation for each rule's consequence (output).
- **Defuzzification:** The activated fuzzy outputs are aggregated into a crisp output value (e.g., specific green light duration) suitable for controlling the traffic lights.
- **Light Control:** The calculated crisp values (green light duration, yellow light duration) are used to control the traffic lights.
- **Traffic Flow:** The optimized traffic light timings aim to improve overall traffic flow, reducing congestion and wait times.
-

Q4. Fuzzy System Rules:

1. Traffic Density and Green Light Duration:

Rule 1: IF main road traffic density is "high" AND side street traffic density is "low" THEN extend green light for the main road.

Rule 2: IF the overall traffic density is "low" THEN shorten green light duration for all directions.

Rule 3: IF traffic density in a specific direction is "high" AND a turning lane is present THEN consider a slight extension of the green light for that direction.

2. Pedestrian Crossing and Light Signals:

Rule 4: IF the pedestrian button is pressed AND traffic density is "medium" THEN activate the pedestrian crossing signal and slightly extend the yellow light duration.

Rule 5: IF the pedestrian button is pressed AND there are pedestrians detected waiting to cross THEN prioritize extending the green light for that direction to allow safe pedestrian crossing.

3. Time of Day and Light Cycle:

Rule 6: IF the time of day is "evening rush hour" THEN increase the overall green light cycle duration for major roads.

Rule 7: IF the time of day is "late night" with low traffic THEN consider implementing a flashing yellow light all-way stop for specific intersections.

4. Adapting to Congestion:

Rule 8: IF traffic density on the approaching direction has been "high" for an extended period THEN gradually increase the green light duration for that direction to alleviate congestion.

Rule 9: IF multiple directions experience "high" traffic density simultaneously THEN activate a short all-red phase to allow for overall traffic flow reevaluation before assigning new green light durations.

5. Balancing Traffic Flow:

Rule 10: IF the green light duration on one direction has been significantly longer than another due to high traffic, AND traffic density on the shorter green light direction increases to "medium" THEN consider adjusting green light durations to achieve a more balanced traffic flow.

REFERENCES

[1]: Microsoft research website
[2]: Microsoft: Software Engineering for Machine Learning: A Case Study Paper.