Nureal Networks And Fuzzy Logic

Tittle :Traffic Control System using Neuro-Fuzzy Logic

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Introduction :

Basically now-a-days traffic congestion has become a significant problem in modern cities due to increasing vehicle numbers and inadequate adaptive control systems. Traditional traffic lights operate with fixed time intervals and fail to adjust to real-time traffic flow. This project introduces a Smart Traffic Control System using Neuro-Fuzzy Logic, a combination of Artificial Neural Networks (ANN) and Fuzzy Logic, to optimize and automate traffic light control based on dynamic traffic conditions, such as vehicle density, time of day, and emergency vehicle presence.

Working:

1. The Fuzzy Logic system uses rules such as:
   - IF vehicle density is high AND time is peak hours -> THEN increase green light duration
   - IF emergency vehicle is detected -> THEN give immediate green signal
2. The Neural Network learns from historical traffic data and patterns.
3. The Neuro-Fuzzy System (ANFIS) combines learning capability with fuzzy logic to improve the decision-making process.
4. Based on these decisions, the traffic controller allocates appropriate green light durations to each direction.

Block Diagrams :

[Sensor Inputs / Simulated Data]

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[Fuzzy Logic System]

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[Neural Network Model]

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[Neuro-Fuzzy Decision System]

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[Traffic Light Controller]

Objective:

To develop an intelligent traffic light control system using Neuro-Fuzzy logic that adapts in real-time to traffic conditions, thereby reducing congestion, waiting time, and fuel consumption.

Technologies Used:

- **Python** (Implementation and simulation)
- **scikit-fuzzy** (Fuzzy logic system)
- **TensorFlow/Keras** (Training the neural network)
- **Sensors (simulated):** Vehicle count sensors, emergency vehicle detection

Implementation of Code:

```
import numpy as np

import skfuzzy as fuzz

from skfuzzy import control as ctrl

vehicle_density = ctrl.Antecedent(np.arange(0, 101, 1), 'vehicle_density')

time_of_day = ctrl.Antecedent(np.arange(0, 24, 1), 'time_of_day')


green_time = ctrl.Consequent(np.arange(10, 121, 1), 'green_time')

Membership functions for Vehicle Density

vehicle_density['low'] = fuzz.trimf(vehicle_density.universe, [0, 0, 40])

vehicle_density['medium'] = fuzz.trimf(vehicle_density.universe, [30, 50, 70])

vehicle_density['high'] = fuzz.trimf(vehicle_density.universe, [60, 100, 100])

Membership functions for Time of Day
```

time_of_day['offpeak'] = fuzz.trimf(time_of_day.universe, [0, 0, 9])

time_of_day['normal'] = fuzz.trimf(time_of_day.universe, [8, 12, 16])

time_of_day['peak'] = fuzz.trimf(time_of_day.universe, [15, 20, 23])

Membership functions for Green Time

green_time['short'] = fuzz.trimf(green_time.universe, [10, 10, 40])

green_time['medium'] = fuzz.trimf(green_time.universe, [30, 60, 90])

green_time['long'] = fuzz.trimf(green_time.universe, [80, 120, 120])

rule1 = ctrl.Rule(vehicle_density['high'] & time_of_day['peak'], green_time['long'])

rule2 = ctrl.Rule(vehicle_density['medium'] & time_of_day['normal'], green_time['medium'])

rule3 = ctrl.Rule(vehicle_density['low'], green_time['short'])

rule4 = ctrl.Rule(vehicle_density['high'] & time_of_day['offpeak'], green_time['medium'])

rule5 = ctrl.Rule(vehicle_density['medium'] & time_of_day['peak'], green_time['long'])

traffic_ctrl = ctrl.ControlSystem([rule1, rule2, rule3])

traffic_sim = ctrl.ControlSystemSimulation(traffic_ctrl)

References:

1. Jang, J.-S. R. (1993). *ANFIS: Adaptive-network-based fuzzy inference system*. IEEE Transactions on Systems, Man, and Cybernetics, 23(3), 665–685.
2. scikit-fuzzy Documentation. https://scikit-fuzzy.github.io/scikit-fuzzy/
3. TensorFlow Documentation. https://www.tensorflow.org/
4. MATLAB Help Center. *Adaptive Neuro-Fuzzy Inference System (ANFIS)*. https://www.mathworks.com/help/fuzzy/adaptive-neuro-fuzzy-inference-system-anfis.html
5. Passino, K. M., & Yurkovich, S. (1998). *Fuzzy Control*. Addison-Wesley Longman.
6. IEEE Xplore Digital Library – Research papers on Intelligent Transportation Systems (ITS).

Conclusion :

The Smart Traffic Control System using Neuro-Fuzzy Logic presents an efficient, adaptive solution to urban traffic congestion. By leveraging the hybrid power of fuzzy logic and neural networks, the system can analyze real-time data such as vehicle density and time of day to dynamically control traffic signal durations.

This approach eliminates the rigidity of traditional traffic lights by enabling intelligent decision-making that adjusts according to live traffic conditions. The integration of fuzzy rules provides human-like reasoning, while the neural network component allows the system to learn from historical data, improving accuracy over time.

The project demonstrates how Neuro-Fuzzy systems can significantly enhance traffic flow, reduce fuel consumption, and improve commuter satisfaction. With further integration of IoT devices, emergency response inputs, and cloud-based monitoring, this system can scale into a fully functional smart city traffic management framework.