Part 01

Design of the NN System to Predict Weather

A diagram of a training set

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Figure 1 Flowchart of the NN Design

Architecture of CFNN:

* Multiple layers comprise the CFNN, including an input layer, one or more concealed layers, and an output layer.
* Each layer comprises neurons or nodes that are interconnected.
* The CFNN has a cascade structure, which means that the output of one layer sequentially functions as the input for the next layer.

Architecture of FFNN:

* A FFNN comprises of an input layer, one or more hidden layers, and an output layer.
* In an FFNN, information flows only forward, from the input layer to the concealed layers and then to the output layer.
* Each neuron in a layer is connected to neurons in the layer beneath it and the layer above it.

Training Method:

* Both CFNN and FFNN can be trained using the backpropagation algorithm, which is a popular training method for neural networks.
* The backpropagation algorithm modifies the network's weights and biases in response to the prediction error.
* During training, the algorithm modifies the network's parameters iteratively to minimise the gap between the predicted and expected output.

Inputs and Results:

* Inputs to the neural network include meteorological characteristics such as precipitation, temperature, wind speed, etc.
* The neural network's output is the predicted weather condition or a particular weather-related parameter.

Pre-processing:

* Before training the neural network, it is necessary to pre-process the input data.
* Normalisation of data, management of missing values, and conversion of categorical variables to numerical representations may be included in pre-processing.

Model Training and Evaluation:

* The neural network model is trained with historical meteorological data from a named dataset.
* The dataset is divided into training and testing sets to evaluate the performance of the model.
* Training entails iteratively adjusting the network's weights and biases to minimise the prediction error.
* The efficacy of the model is evaluated by comparing the predicted and actual weather conditions in the testing set.

Model Deployment and Prediction:

* Once the neural network model has been trained and evaluated, it can be used to predict the weather.
* The trained model can predict the corresponding weather condition or parameter when presented with new input data (weather characteristics).

The selection of CFNN or FFNN is dependent upon the specific requirements of the weather prediction problem and the dataset's complexity. Due to its cascade structure, CFNN is suitable for capturing complex data relationships, whereas FFNN is simpler and more uncomplicated for relatively straightforward weather prediction tasks.

Backpropagation is a popular training technique for both CFNN and FFNN models. During training, it modifies the network's weights and biases based on the prediction error, progressively enhancing the model's accuracy.

Design of the FL System to Control Water

A diagram of fuzzy data

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Figure 2 Fuzzy Logic System Design

## **Rules:**

FuzzyA: IT defines 14 rules for the FuzzyA system. These rules regulate the relationship between the inputs of Rainfall and Temperature and the output of Water. The rules seek to capture the fuzzy relationships between inputs and outputs and are based on expert knowledge or observations.

FuzzyB: It defines 12 rules for the FuzzyB system. These rules dictate the relationship between the inputs Rainfall and Temperature and the output Sprinkler. Similar to FuzzyA, these principles are intended to represent fuzzy relationships based on the needs of the system and the knowledge of experts.

## **Membership Functions:**

FuzzyA: The Rainfall and Temperature inputs are divided into linguistic terms or fuzzy sets, each of which is represented by a membership function (MF) in FuzzyA. FuzzyA has four MFs for rainfall and five for temperature. The selection of MFs is contingent on the characteristics of the input variables and their distribution within the dataset. For instance, Rainfall includes MFs such as 'no\_rain', 'heavy', 'light', and'medium', whereas Temperature includes MFs such as'very\_cold','very\_hot', 'hot', 'cold', and'medium'. The shape and range of the membership function are determined by the parameters of each MF (e.g., sigmf, gaussmf, trimf).

FuzzyB: Like FuzzyA, FuzzyB includes MFs for Rainfall, Temperature, and Sprinkler output. FuzzyB is equipped with 4 MFs for Rainfall, 3 MFs for Temperature, and 5 MFs for Sprinkler output. FuzzyB's selection of MFs is determined by its control requirements and the intended sprinkler system behaviour.

The optimal configuration for the fuzzy logic technique is determined using a combination of domain knowledge, system requirements, and data analysis. Effectively capturing fuzzy relationships requires careful consideration of the input variables, their linguistic terms, and the nature of the membership functions. The rules in the inference engine should encompass all possible combinations of inputs and outputs while considering the desired system behaviour.

Overview of the System

A diagram of weather forecasting

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Figure 3 System Overview

Neural Networks and Fuzzy Logic Integration: The system utilises the predictive capability of neural networks with the decision-making capacity of fuzzy logic. Based on input data, the neural network predicts weather labels, which are then used as inputs to the fuzzy logic controller to determine the water supply recommendation.

Assumptions: The system implies that the input weather data has been collected and pre-processed appropriately, including the handling of missing values and the normalisation of the data. Additionally, it is assumed that the trained neural network and fuzzy logic system are already accessible for prediction and control.

Error Handling: The system may include error handling mechanisms to manage any unanticipated errors or exceptions that may arise during data collection, pre-processing, prediction, or control processes. This can include error messages, management of exceptions, and graceful system shutdown.

User Interface: It consists of input fields for users to submit weather information, Days selection, NN selection and Fuzzy logic selection, and a button to initiate the prediction and control process. On the GUI, the predicted weather labels and recommended water supply plots are displayed.

Additional Features: The system may include additional features such as data visualisation to present historical weather patterns, retrieval of real-time weather data, user customization options (e.g., selection of different neural network architectures or fuzzy logic rule sets), and performance evaluation metrics to assess the accuracy and reliability of the predictions and control decisions.

The overall design includes the Neural Network Weather Prediction System and the Fuzzy Logic Water Sprinkler Controller, allowing users to input weather data and receive recommendations for the water supply amount. The GUI provides a user-friendly interface for interacting with the system.