Fuzzy-Embedded Deep Learning Network(FE-TNN)
## for Interpretable Stock Market Prediction

Motivation

The opaque nature of traditional deep learning models often deters their use by financial market analysts. Fuzzy Embedded TimesNet Neural Network model(FE-TNN)is designed to integrate the:
1. **Precision** of a neural network model, and
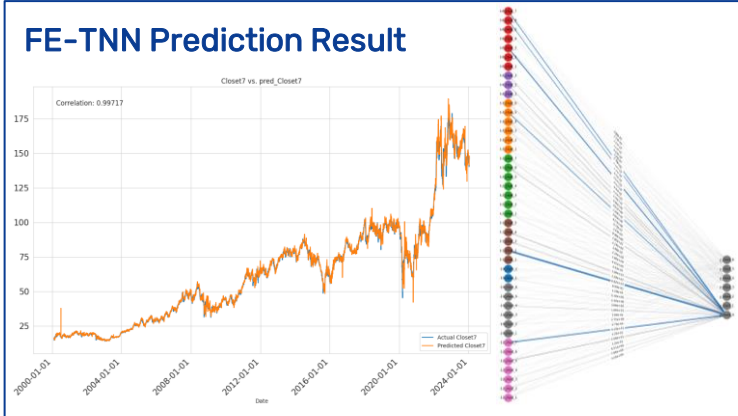2. **Explainability** of a fuzzy-based rule generation system

With the predicted result, we also aim to explore the predictions' applications in stock trading and portfolio management using reinforcement learning(RL).

Architecture

- 5-Layer: Input, fuzzification, inference, defuzzification, output
- Inference layer have TimesNet model and fuzzy rule base, sharing save input/output
- Triggered fuzzy rules can elucidate the TimesNet model
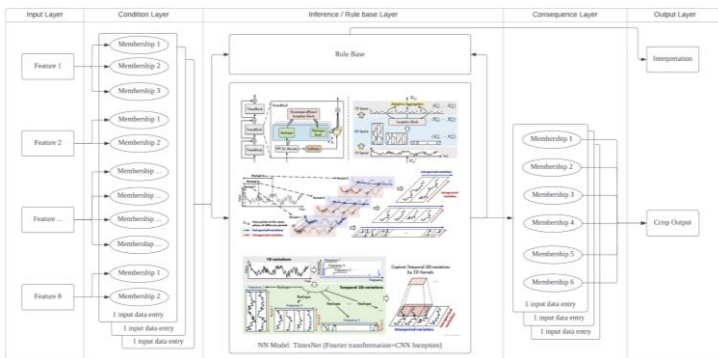
FE-TNN Prediction Result

Multi-model Approach

Use one model to predict one timestep, 14 models for prediction T+1 to T+14

Multiple Model Approach

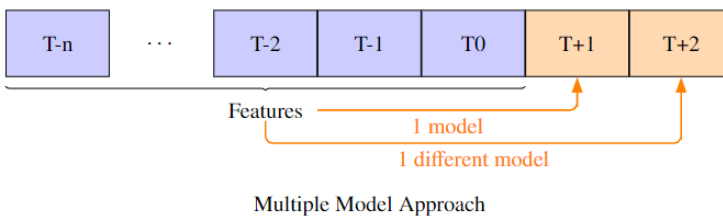## Application: RL Trading

- Environment: uses historical stock data and simulates market conditions through OpenAI Gymnasium and Stablebaseline3
- States: comprised of basic stock data and technical indicators
- Agent: employs an ensemble of RL algorithms (A2C, DDPG, PPO)

Experiment Procedure

1. Choose stock portfolios, gather features (X) and targets (y) from the stocks.
2. Train univariate clustering model on each feature & target to create fuzzy vocabulary.
3. Train TimesNet using the fuzzy vocabulary.
4. Generate fuzzy rules with inputs and outputs of the TimesNet.
5. Incorporate the neuro-fuzzy system into a RL multi-stock trading system and evaluate its performance against buy-and-hold.

RL Trading Results

	DJI_PORT	p-DJI_PORT	f-DJI_PORT
Annual return	-0.063480418	0.066580516	0.020494382
Cumulative returns	-0.243260043	0.315143054	0.090046758
Annual volatility	0.162108629	0.1562709	0.149079387
Sharpe ratio	-0.323324569	0.490701146	0.210748242
Calmar ratio	-0.14950914	0.310455636	0.099672623
Stability	0.787444672	0.695971507	0.294896876
Max drawdown	-0.424592223	-0.214460646	-0.205616963
Omega ratio	0.932152228	1.104719912	1.043551568
Sortino ratio	-0.436605324	0.743609847	0.301566842
Tail ratio	0.87406738	1.047963049	1.043874013
Daily value at risk	-0.020631758	-0.019383988	-0.018657562