

# eT2FIS-EDL: Evolving Type-2 Neural Fuzzy Inference System with Embedded Deep Learning in Dynamic Portfolio Rebalancing

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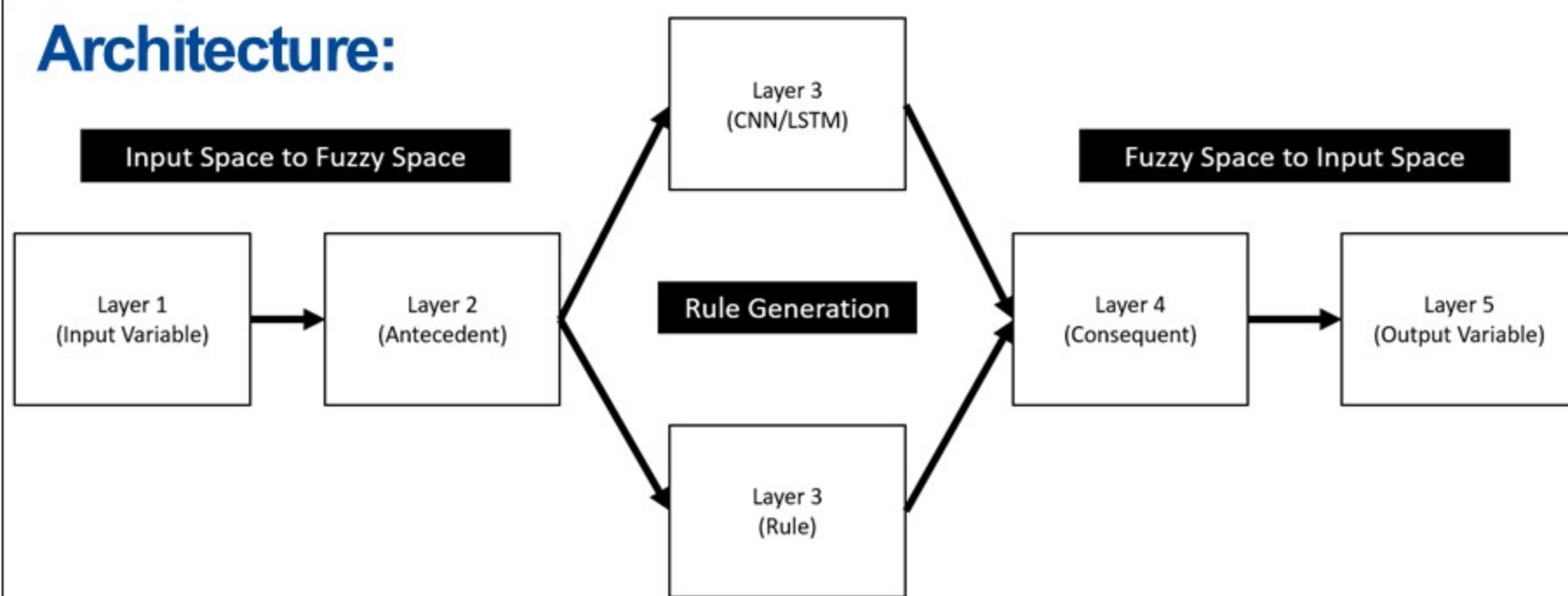
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## Abstract:

eT2FIS-EDL model is proposed to enhance the prediction performance in noisy dynamically changing data. **Deep neural networks** can increase prediction ability but is black-box in nature. The integration with **Type-2 Mamdani fuzzy system**, therefore, provides interpretability with noise tolerance through IF-THEN rule base.

There are **two eT2FIS-EDL variations**, one with convolutional neural network (CNN) and the other with long short-term memory (LSTM). The model demonstrated its effectiveness through various **prediction tasks in stocks and ETF prices**, as well as integrating with reinforcement learning (RL) to form a robust **dynamic portfolio rebalancing strategy**.

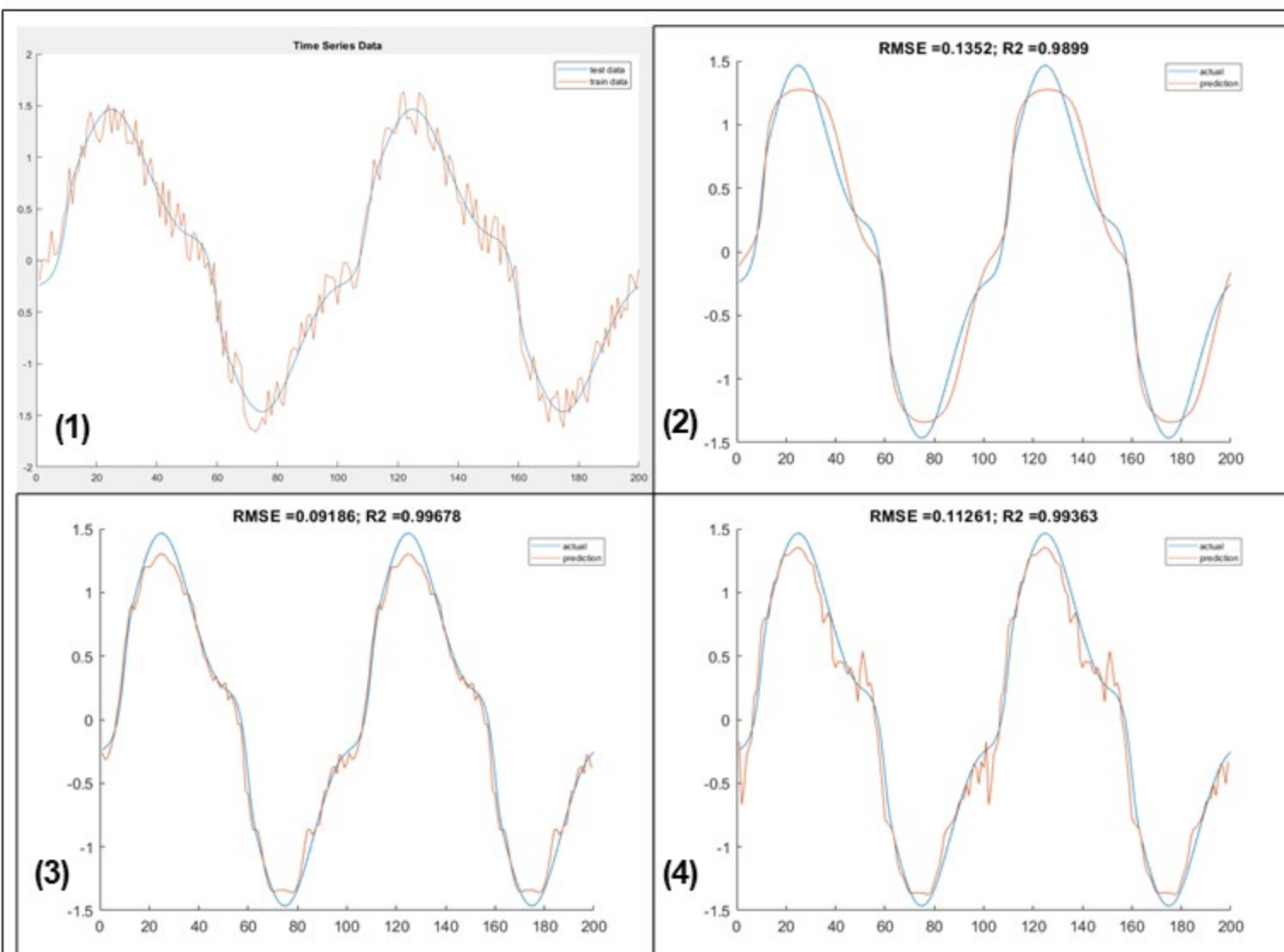
## Architecture:



## Learning Mechanism:

1. Rule generation
2. Rule merger
3. Rule deletion

These aims to keep an up-to-date and concise rule base against data drifts and shifts.



(1) Train test data visualization of a noisy nonlinear system. (2) Actual vs prediction in eT2FIS from [1]. (3) Actual vs prediction in eT2FIS-EDL CNN. (4) Actual vs prediction in eT2FIS-EDL LSTM.

## Prediction of Asset Price

Model	Closing price (2010 – 2019)			
	Singtel		STI-ETF	
	RMSE	R	RMSE	R
eT2FIS [1]	0.1286	0.9499	0.0573	0.9327
eT2FIS-EDL (CNN)	0.043859	0.96775	0.065732	0.9402
eT2FIS-EDL (LSTM)	0.048348	0.95921	0.0566	0.9609

## Rebalancing Portfolio

	Total return (%)	Average return (%)	Volatility
Buy and Hold	9.0196	0.0177	0.00547
Equal Weight	8.9566	0.0176	0.00539
Inverse Variance	3.4833	0.0066	0.00183
Max Sharpe Ratio	7.8566	0.016	0.00605
RL (lagged)	10.4686	0.0203	0.00567
RL and eT2FIS-EDL CNN	11.5268	0.0278	0.01216
RL and eT2FIS-EDL LSTM	10.7489	0.0245	0.01038

In prediction tasks, eT2FIS-EDL consistently outperform the base model eT2FIS-EDL in [1]. The rebalancing portfolio strategy proposed shows promising results with high returns compared to existing portfolio management strategies.