

Lecture 12:

Predictive Associative Memories for Time Series *

* AbouHassan, I; Kasabov, N; Bankar, T; Garg, R; Sen Bhattacharya, B (2024).
ePAMeT: Evolving Predictive Associative Memories for Time Series.
doi: 10.36227/techrxiv.24063975.v1.
Submitted to Evolving Systems, Springer-Nature.

1- Topic/Task/Problem Specification:

- Associative memory (AM) is the ability to learn and remember relationships between multimodal items and to recall these associations using new partial information.
- Existing evolving computing methods for time series, such as neural networks, fuzzy systems, neuro-fuzzy systems and spiking neural networks, do not tolerate recalling incomplete datasets of input variables.
- The challenge is how to use a large scale of temporal data to create an ML model that can be recalled at different times with a smaller number of input variables, measured at shorter times, and further adapted to new variables.

2- The Solution:

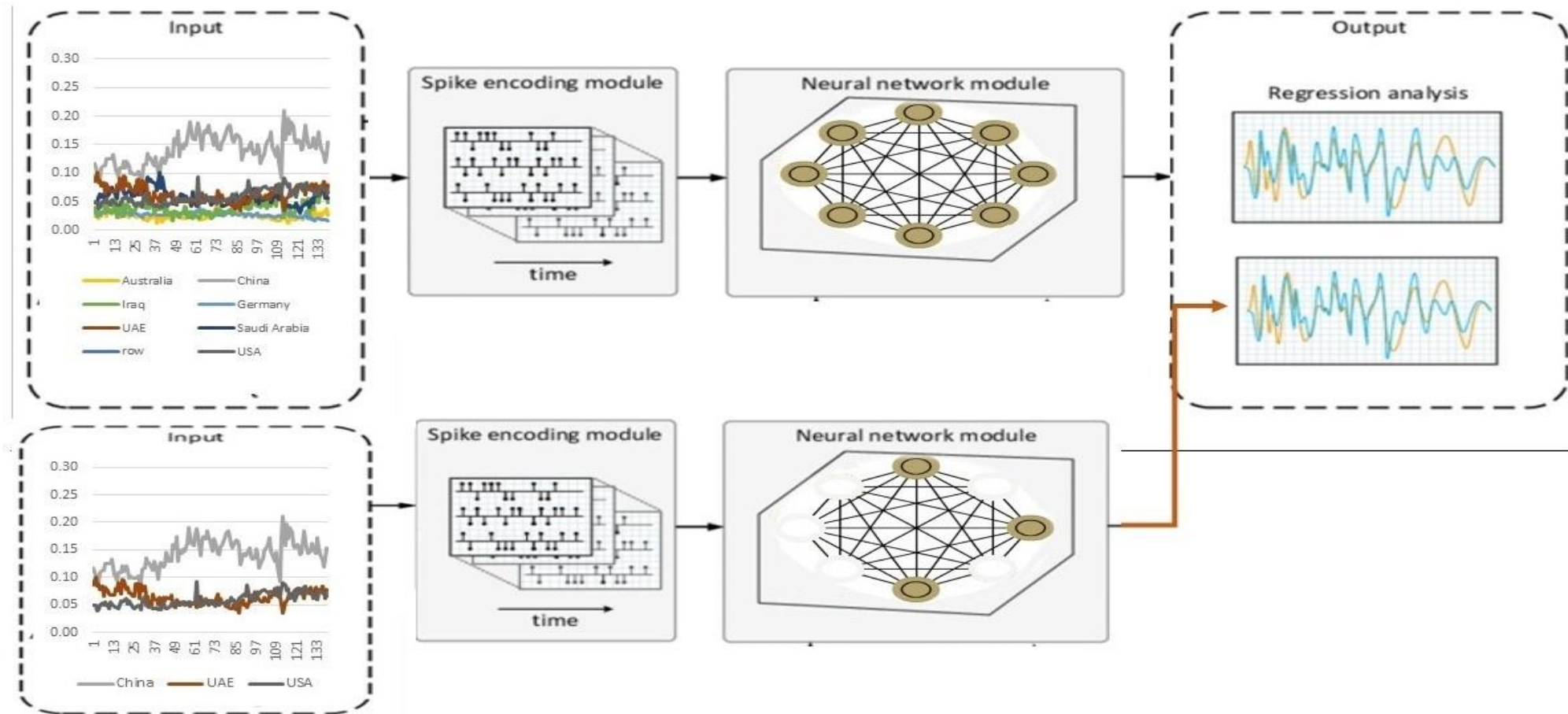
ePAMeT

A new direction in AI

- ePAMeT, a novel method for evolving predictive associative memory for TS based on BI-SNN.
- It is demonstrated on financial time series that are recalled with reduced input features without compromising prediction accuracy and explainability.
- It is further evolved to adapt to new variables and data without retraining them on old data.

ePAMeT

The Methodology



The proposed ePAMeT framework consists of a spike encoding module, 3D SNN, and regression module for each of the training (the upper part) and recall (lower part) procedures.

ePAMeT

Case Study: India's Trade Imports Time Series Data - by Commodity



India's merchandise imports exceeded \$700 billion in 2023.

India's top imports include crude oil, coal, and diamonds.

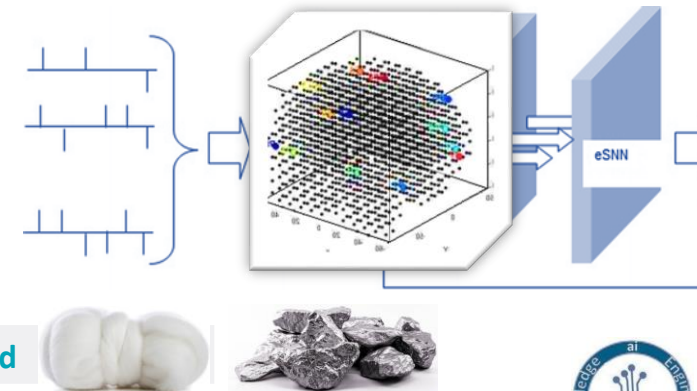
China is still India's major import partner.

(www.eximpedia.app)

India's import commodities

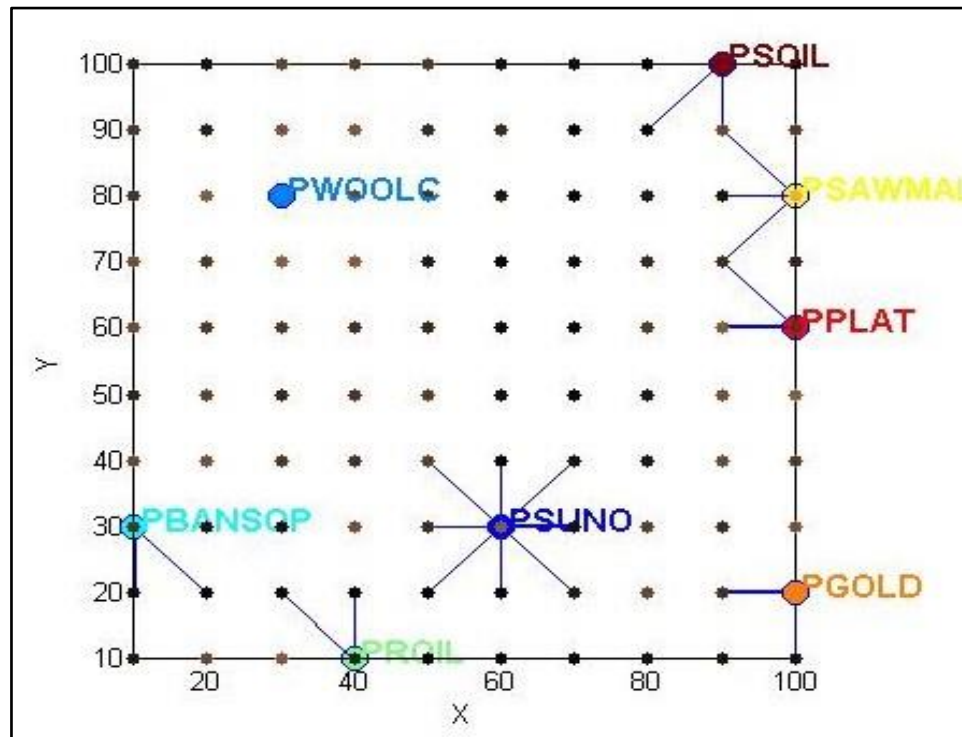


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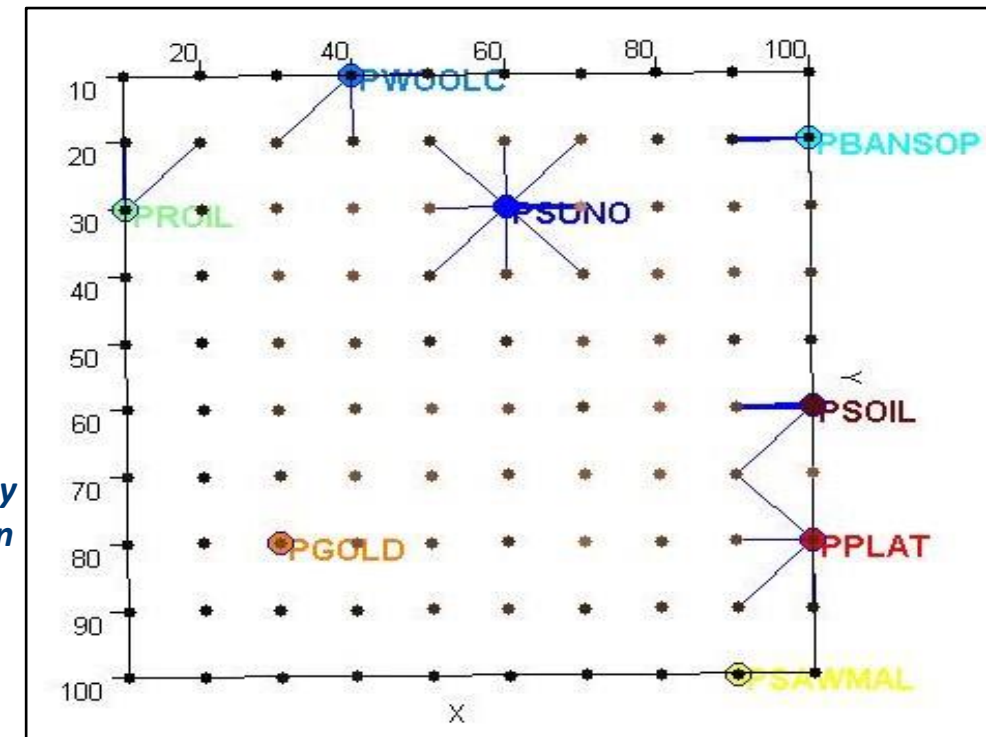
ePAMeT

Explainability and knowledge discovery



global training on full input stream (RMSE=7%)

The
connectivity
evolution in
NeuCube
during

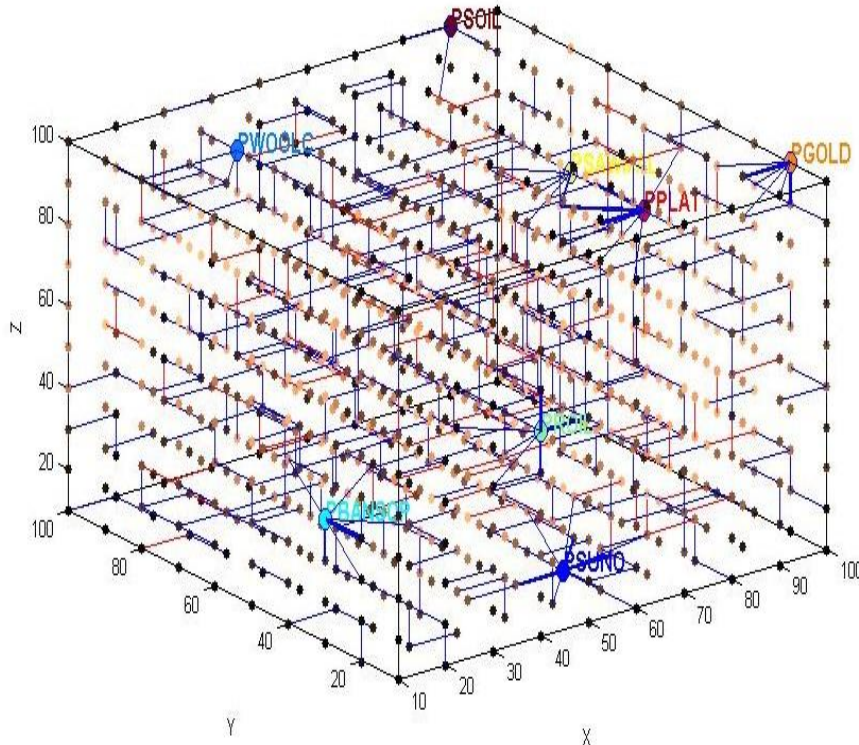
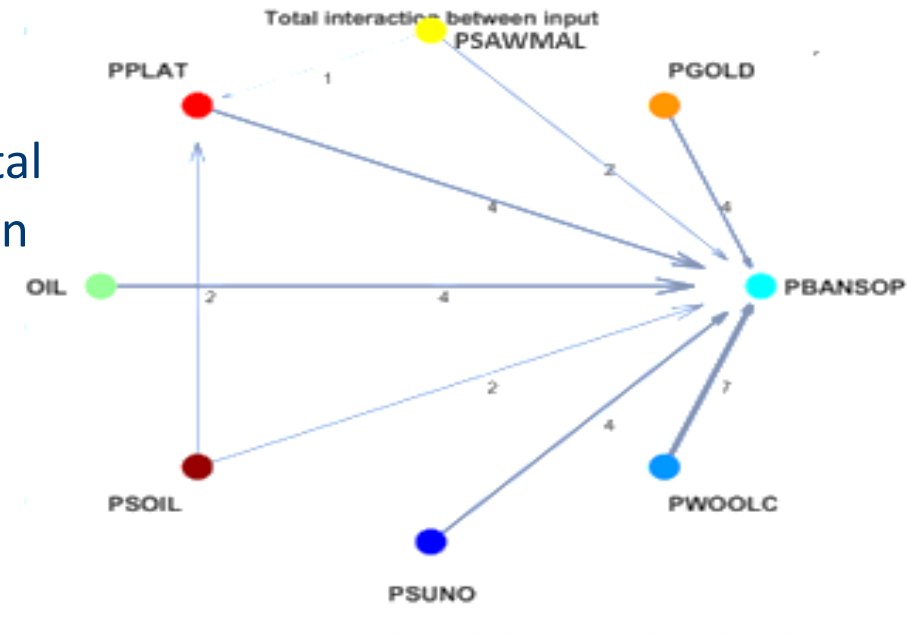


local recall on fewer input features ($\Delta=4.2\%$)

ePAMeT









Explainability and knowledge discovery

Measured directed graph of total information exchanged between features' connected neurons based on spike communication clustering method.



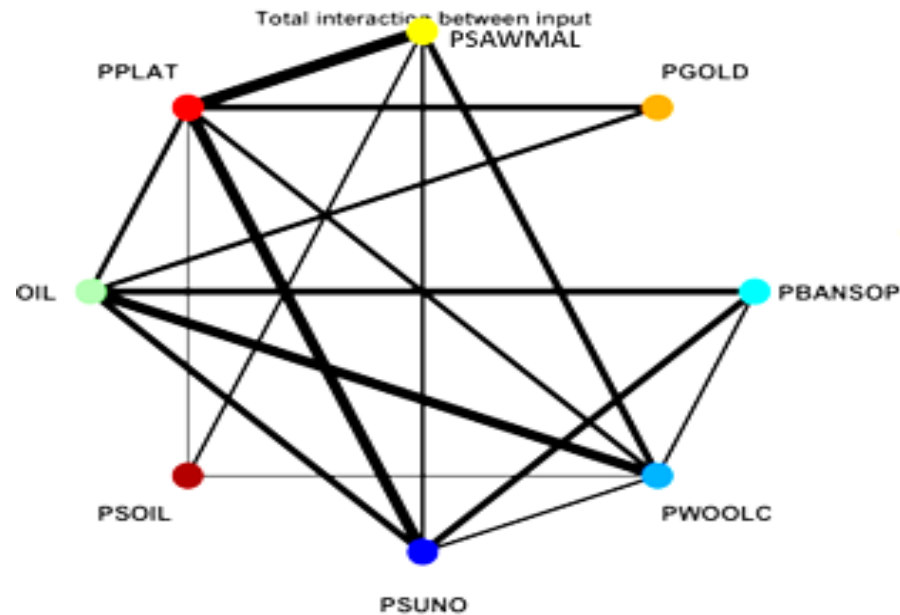
The connectivity in the reservoir during global unsupervised learning on market price data of eight commodities.

ePAMeT

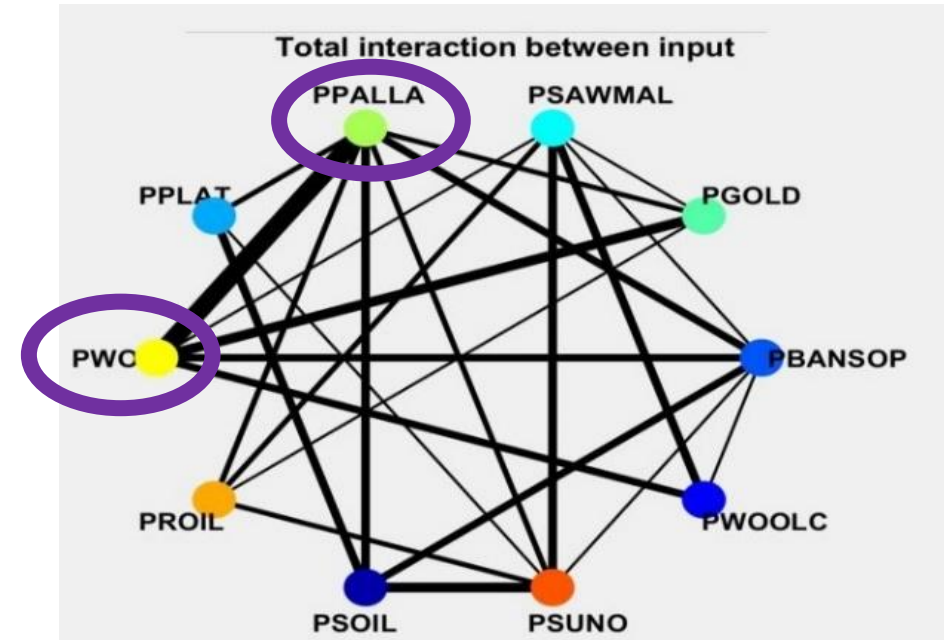
Time Frame for recall [T1/T]	Number of features for recall [K1]									RMSE
0.5	8 (full)	1	1	1	1	1	1	1	1	0.09
0.5	7	1	1	1	1	1	1	0	1	0.11
0.5	6	1	0	1	1	1	1	0	1	0.19
0.5	5	1	0	1	1	0	1	0	1	0.09
0.5	4	1	0	1	1	0	1	0	0	0.09
0.5	3	0	0	1	1	0	1	0	0	0.24
0.5	2	0	0	0	1	1	0	0	0	0.25
0.5	1	0	0	0	1	0	0	0	0	0.28

ePAMeT

Evolvability of the ePAMeT model on new variables



Total information exchanged between the neuronal clusters of commodities, weighted by the thickness of the connections.



Enhanced total information exchange between the neuronal clusters of all ten variables post-training, highlighting the increased engagement from the 2 newly introduced features.

ePAMeT

Comparison of Prediction Model Performance

Model	RMSE
K Nearest Neighbor (KNN)	0.194
Multi-Layer Perceptron (MLP)	0.182
Radial Basic Function	0.189
Dynamic Evolving Neuro-Fuzzy Inference System (DENFIS)	0.0224
Evolving Fuzzy Neural Networks (EFuNN)	0.0266
Predictive Associative Memory for Time Series (ePAMeT-SNN)	0.0200

Conclusion

ePAMeT

A new direction in AI

- ePAMeT is a **pioneering model** for the creation of **evolving predictive associative memories for time series**.
- ePAMeT **provides unprecedented adaptability** in processing time series data.
- ePAMeT excels **not only in functioning efficiently with reduced input features during recall** but also in seamlessly **integrating newly introduced input features**, thus **establishing a pioneering capability previously unexplored in existing frameworks**.
- ePAMeT may be useful in real-world applications like financial forecasting, environmental monitoring, and crisis response, and can be further developed for health problems, earthquakes, pollution, trade.
- Our findings highlight the model's high accuracy and explainability, significantly outperforming traditional methods in dynamic and uncertain environments.

Thank you for your attention!

