Adapting to the Stream: An Instance-Attention GNN Method for Irregular Multivariate Time Series Data

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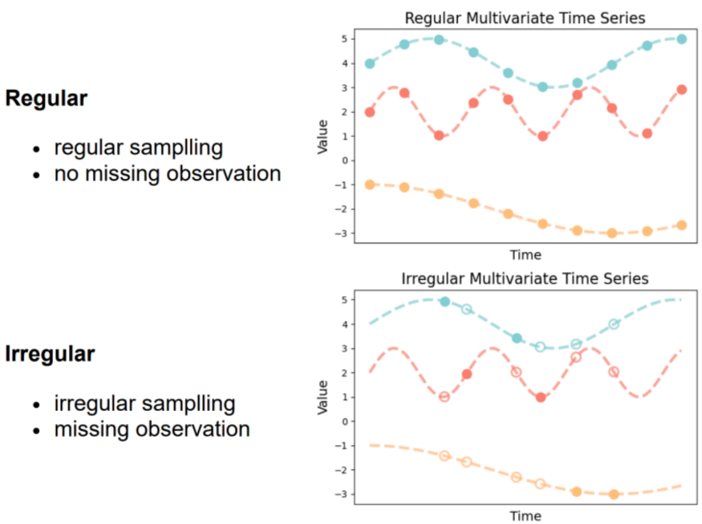
Problems & Proposed Approach

Problems of irregular multivariate time series (IMTS):

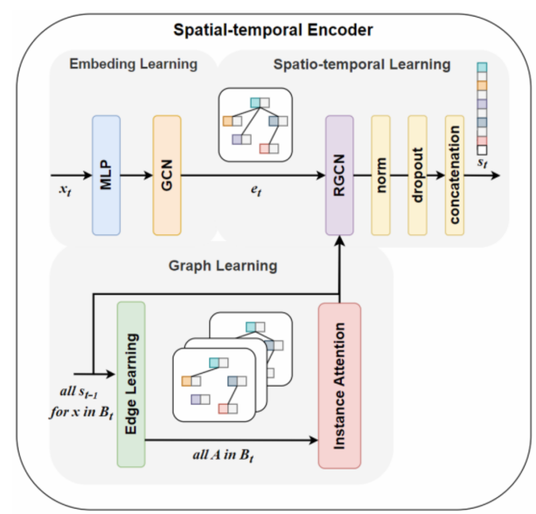
- Challenges such as sensor failures can result in **irregular, a misaligned data with missing values**, thereby complicating time series analysis.
- The **graph structure** is essential for GNN-based methods, either pre-existing or inferred from adequate data to properly capture node correlations.
- IMTS data are often streamed and waiting for future data to estimate a suitable graph structure becomes **impractical**.

Proposed approach

- A **dynamic GNN** model suited for streaming characteristics of IMTS data, incorporating an **instance-attention mechanism,** embedding l earning and spatial-temporal learning that **dynamically** learns and updates graph edge weights for **real-time analysis.**



Comparison of regular and irregular MTS. Different colors represent variables. Solid circles denote observed data points; hollow circles indicate missing data points.

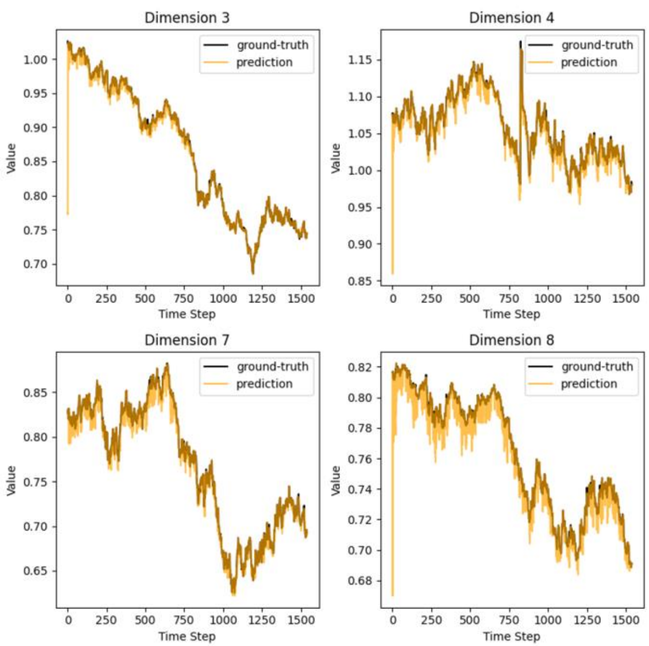


Framework of DynIMTS

Main Contributions

Contributions:

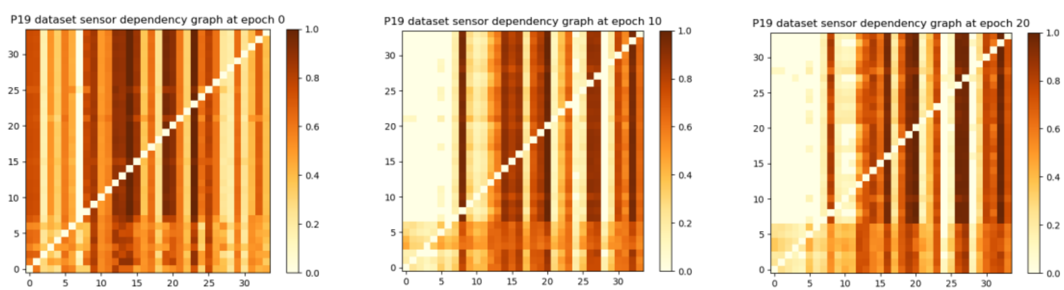
- We introduce a **novel instance-attention** strategy that learns and dynamically updates the graph structure in response to newly incoming data at each timestamp.
- Our model is versatile, **efficiently managing both imputation and non-imputation** tasks, with customized strategies for different sampling rates in IMTS.
- Experimental results show that our model's performance **surpasses current state-of-the-art** approaches.



Visualization of the imputation results produced by our model with a 20% missing data ratio on the Exchange-rate dataset across four dimensions.

Table 2 Evaluation on P12 and P19 datasets using AUROC% and AUPRC% (mean ± std).

	P12		P19	
	AUROC	AUPRC	AUROC	AUPRC
RITS	71.2 ± 2.0	16.4 ± 2.7	86.7 ± 0.7	47.2 ± 3.1
Raindrop	60.9 ± 5.3	14.7 ± 2.0	74.1 ± 0.8	33.6 ± 1.7
GRIN (all-ones)	70.8 ± 2.0	12.5 ± 2.8	**87.1 ± 1.1**	**48.4 ± 2.0**
DynIMTS	**75.1 ± 1.6**	**25.2 ± 3.0**	**87.1 ± 1.1**	**48.4 ± 1.9**



Visualization of the adjacency matrices of epochs 0, 10 and 20 on the P19 dataset.