Semi-supervised Credit Card Fraud Detection via Attribute-driven Graph Representation

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INTRODUCTION

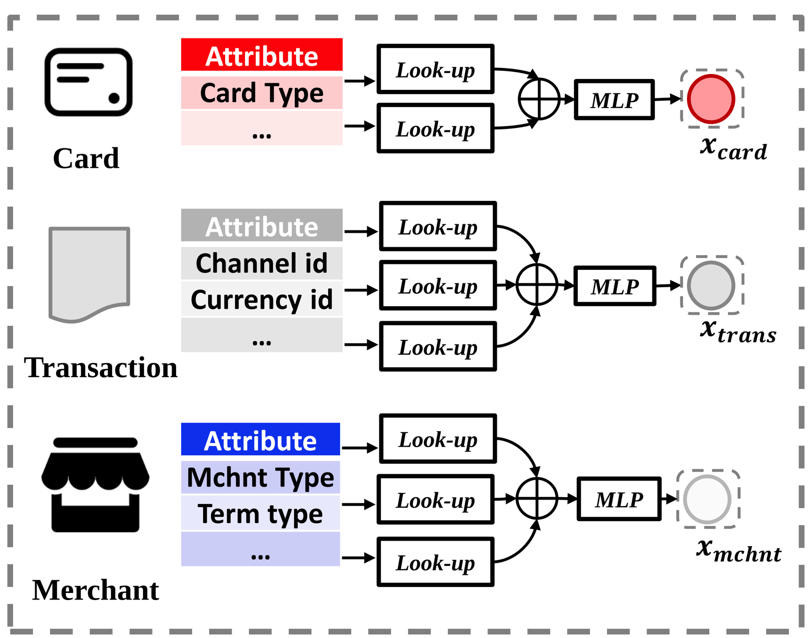
The great losses caused by financial fraud have attracted continuous attention from academia, industry, and regulatory agencies. For example, fraudulent behaviors against credit card payments, such as illegal card swiping, have caused property losses to online payment users. An important line of research in financial fraud detection is credit card fraud detection, where credit card fraud is a general term for the unauthorized use of funds in a transaction, typically by means of a credit or debit card. In the literature, many existing predictive models have been extensively studied to detect fraud transactions, which can be classified into two categories: (1) Rule-based methods [1] ; (2) Machine learning-based methods [2] . Recently, graph machine learning-based methods have been proposed [3] where the transactions are modeled as a graph, and the advanced graph embedding techniques are deployed.

MOTIVATIONS

The state-of-the-art fraud detection techniques can well capture the temporal or graph-based patterns of the transactions and significantly advance the performance of credit card fraud detection. However, they have at least one of the following three main limitations: (1) ignoring unlabeled data containing rich fraud pattern information; (2) ignoring categorical attributes, which are ubiquitous in the real production environment; and (3) requiring too much time on feature engineering, especially for categorical features. Therefore, it is necessary to design a new method to address these three issues.

METHODS

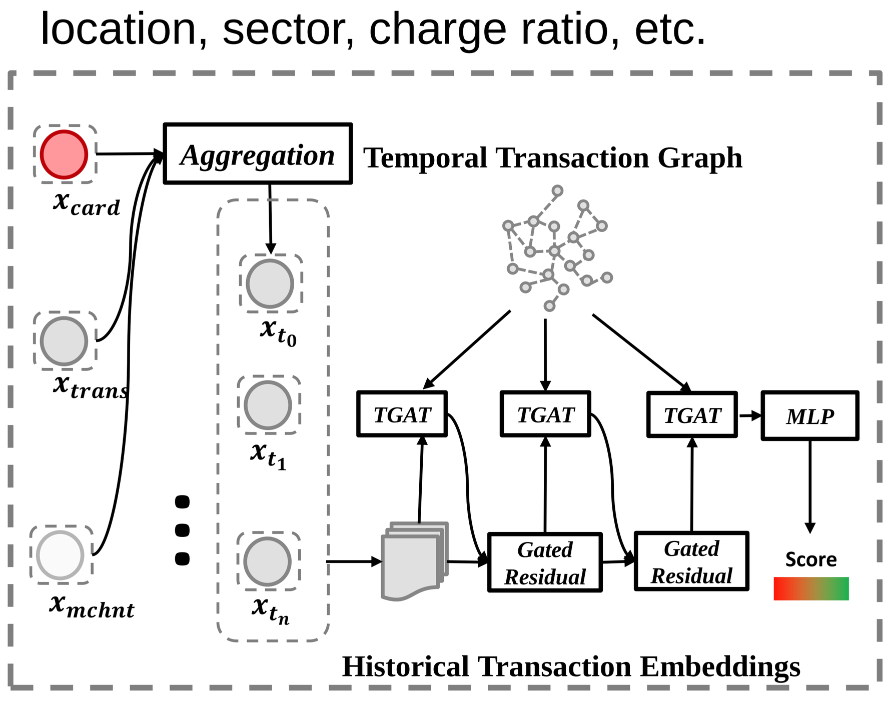
The input data of our methods contain four parts: card attributes, transaction attributes, merchant attributes and temporal transaction graphs. The attribute data come from real-world transactions and corresponding cardholders and merchants. The temporal transaction graphs were generated through adding temporal edges among transactions according to their cardholder and chronological order.



(a) Attribute Embedding

Raw attributes of transaction records are first learned by the attribute embedding look-up and feature learning layer, which includes feature aggregation with a multi-layer perception (MLP). In our implementation, the attributes of the card include the card type, cardholder type, card limit, remaining limit, etc. The transaction attributes include the channel ID, currency ID, transaction amount, etc. The merchant attributes contain merchant type, terminal type, merchant location, sector, charge ratio, etc.

Then, we devise a gated temporal attention network to aggregate and learn the importance of historical transaction embeddings. Afterward, we leverage a two-layer MLP to learn the fraud probability from these representations. The whole model can be optimized in an end-to-end mechanism jointly with the existing stochastic gradient descent algorithm.



(b) Gated Temporal Attention Networks

References

[1] Seeja, K.R., & Zareapoor, M. (2014). FraudMiner: A Novel Credit Card Fraud Detection Model Based on Frequent Itemset Mining. *The Scientific World Journal*, 2014.

[2] Fiore, Ugo et al. "Using generative adversarial networks for improving classification effectiveness in credit card fraud detection." *Inf. Sci.* 479 (2017): 448-455.

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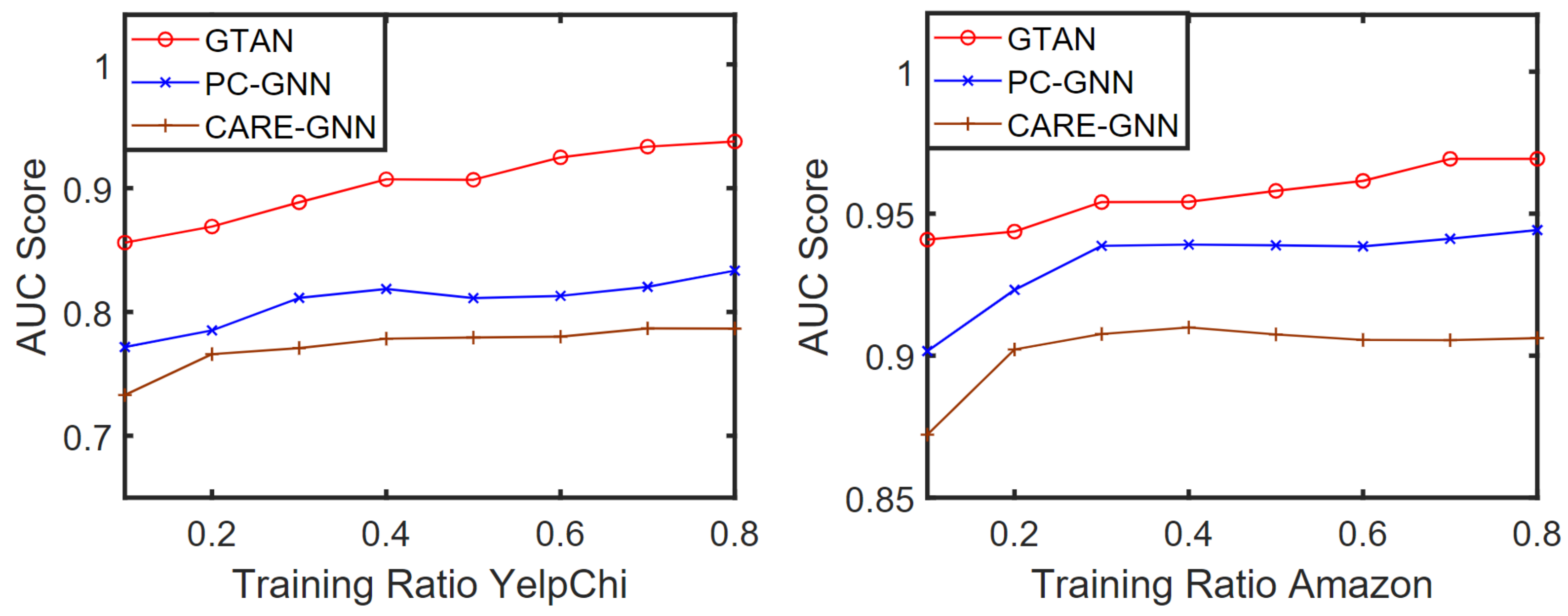
RESULTS

We test the fraud detection performance through experiments on three datasets.

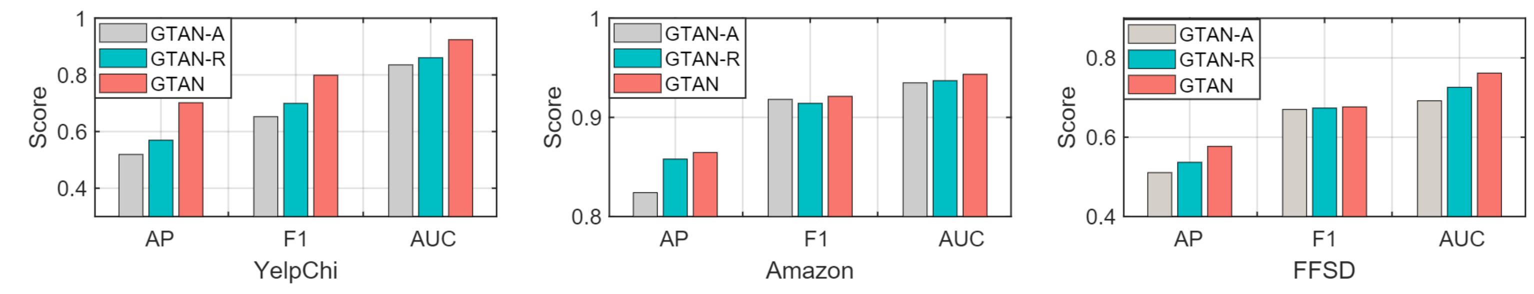
Table 1: Statistics of the three fraud detection datasets.

Dataset	YelpChi	Amazon	FFSD
#Node	45,954	11,948	1,820,840
#Edge	7,739,912	8,808,728	31,619,440
#Fraud	6,677	821	33,858
#Legitimate	39,277	11,127	141,861
#Unlabeled	-	-	1,645,121

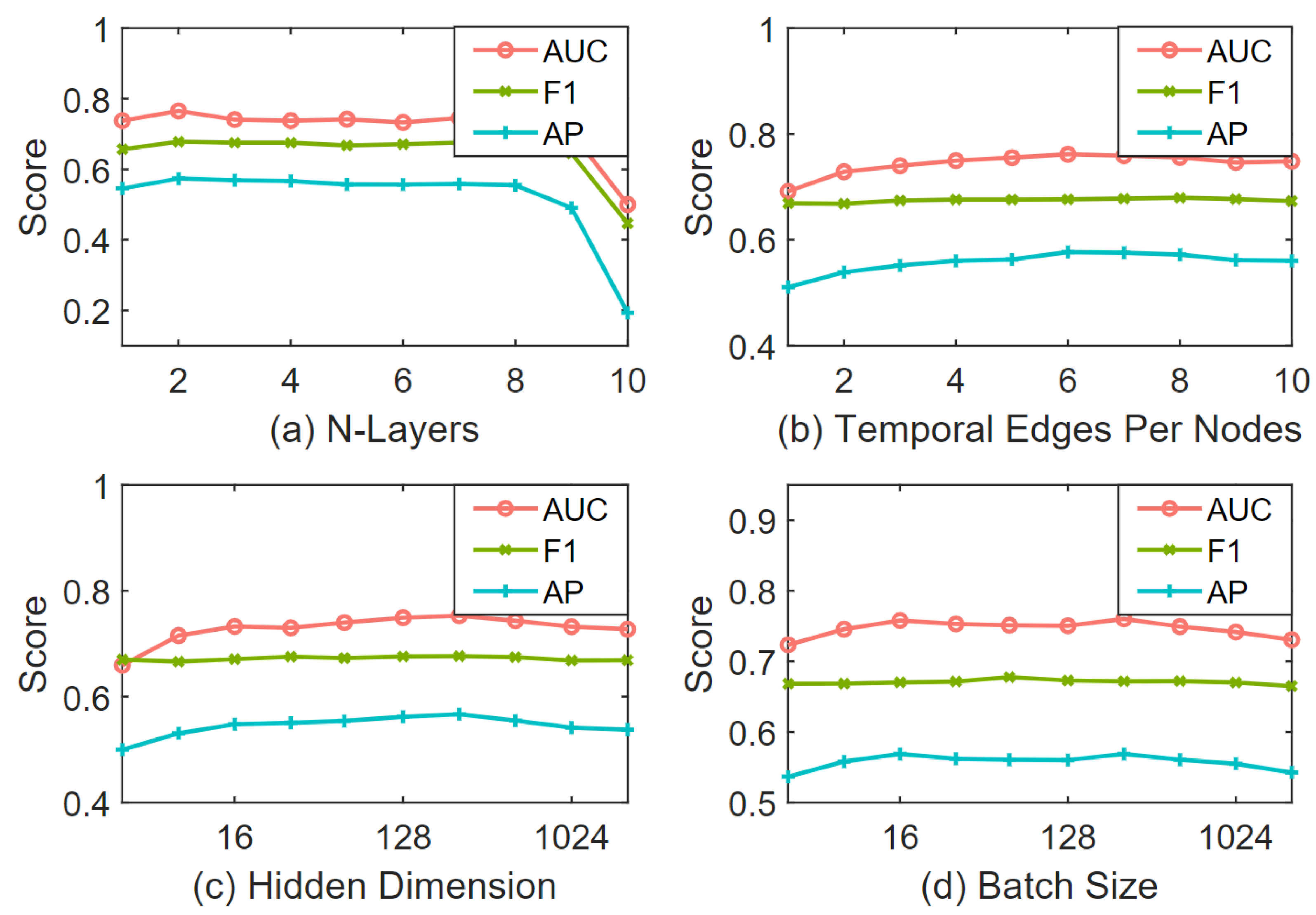
Semi-supervised experiment



Ablation Study



Parameter Sensitivity



CONCLUSIONS

Considering that the labeling of credit card fraud transactions is time-consuming and cost expensive, we proposed an effective semi-supervised credit card fraud detection method by modeling data with temporal transaction graphs and developing attribute-driven gated temporal attention networks. The comprehensive experiments demonstrated the superiority of our proposed methods in three fraud detection datasets compared with other baselines. Semi-supervised experiments demonstrate the excellent fraud detection performance of our model with only a tiny proportion of manually annotated data. In the future, we will study the temporal fraud patterns and risk-propagation patterns in an effective and efficient way.

Acknowledgments

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