

American International University-Bangladesh (AIUB)

**Department of Computer Science**

**Faculty of Science & Technology (FST)**

**Research Methodology**

**Assignment**

**Submitted By**

**Emam Hossain Kazol**

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| **Semester: Fall\_2024-2025 FINAL TERM** | | | | **Section: J** | **Group No: 4** |
| SL | SN | Student Name | Student ID | Individual  Contribution (100%) | Total Marks: 50 |
| Teamwork (CO1-CO4) + Individual (CO5 + Viva) |
| **A** | 19 | MD. Rahat Hasan Rifat | 22-46148-1 | 11% |  |
| **B** | 30 | Tasnuva Tasnim Mim | 22-46854-1 | 25% |  |
| **C** | 31 | Emam Hossain Kazol | 22-47176-1 | 32% |  |
| **D** | 32 | Mahir Shahriar Ratul | 22-47178-1 | 32% |  |

**Submission Date**

**9 Jan 2024**

# EVALUATION

**The assignment will be Evaluated for the following Course Outcomes**

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| CO1: *Evaluate* all relevant resources for designing a computer science and engineering solution and determine the level of novelty of the research. | Total Marks (9) |
|  |
| **Problem Analysis and use of State-of-the-Art** **Resources:** Discuss the research problem background with best use of state‐of‐art literature, resources, and technologies (e.g., related studies) to produce a significant result that is likely to have a major impact. | [3 Marks] |
| **Critical Reflection and Creativity in Research Objective:** Deep insight demonstrated and presented a creative solution to the real‐life problem. And Results are critically confronted with various existing literature (e.g., formation of the RQs). | [3 Marks] |
| **Novelty and Contribution of Research:** Elaborately discuss and identify the contribution of the research to the development of scientific concepts by recognizing the limitation (e.g., research gaps) of existing research/developments. | [3 Marks] |

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| CO2: *Analyze* the collected data to provide valid solutions to the research problem acknowledging the limitations. | Total Marks (9) |
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| **Data Analysis:** Elaborately discuss the research method, its appropriateness and details on data collection, analysis, and synthesis for proposing valid solution to the research problem (e.g., research methodology) | [3 Marks] |
| **Solution and Validation:** Elaborately discuss and validate the solution of the research problem by establishing a direct connection between proposed solutions with the research objective based on the collected research data (e.g., result & analysis). | [3 Marks] |
| **Limitation of the Study:** Elaborately discuss the research summary and conclude remarks of the research by acknowledging the limitations of the studies (e.g., abstract and conclusion) | [3 Marks] |

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| CO3: Determine and demonstrate professional codes of ethics and standard in conducting research considering public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability. | Total Marks (9) |
|  |
| **Professional codes of ethics and standard, Research Outcomes and Impacts:** The research elaborately demonstrates professional codes of ethics and standards in conducting research considering public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability of the research outcomes and impacts. | [3 Marks] |
| **Free of Plagiarism, Data Falsification Citations and References:** Submit plagiarism free research paper (similarity index is <10%). In-text citations and reference list citations were complete and properly formatted in APA or any other standard style. The Research data is not fabricated or altered intentionally to fit into the predetermined research findings. Materials are properly cited and referenced if they are taken from other sources. And not attributed to a source from which it has not been obtained *(i.e., false citation)* | [3 Marks] |
| **Compliance with Report Formatting and Submission Guidelines:** Submitted in due time, the report is complete and there are no errors in spelling, format, and grammar. Consistently presents a logical and effective organization. | [3 Marks] |

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| CO4: *Depict* the need for continuing education and participation in professional societies and meetings. | Total Marks (9) |
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| **Motivation of the research:** Explore extensively the research topics with evidence rich awareness of the research problems (e.g., facts, citations) indicating intense interest in the area. | [3 Marks] |
| **Comprehension and problem solving:** Excellent understanding of material and completely demonstrates effective problem- solving skills integrating alternate and divergent ideas or processes to solve the research problem. | [3 Marks] |
| **Future studies:** The scope of future studies is stated and discussed elaborately with details of how this study can be extended in future endeavor. | [3 Marks] |

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| CO5: *Defend* the research solutions based on complex engineering activities by delivering an effective presentation to the audience. | Total Marks (9) |
| **Presentation delivery (eye contact and body language):** Keeps eye contact with audience all the time, use natural gestures and movements, looks confident. | [3 Marks]  **A: B: C: D:** |
| **Enthusiasm/Audience Awareness:** Demonstrate strong enthusiasm about the topic, significantly increases audience understanding and knowledge of the topic, convinces an audience to recognize the validity and importance of the subject. | [3 Marks]  **A: B: C: D:** |
| **Creativity and Use of Media and Presentation time Management:** The presentation is creative in design and effectively use multimedia. The presentation is organized with appropriate time management. | [3 Marks]  **A: B: C: D:** |

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| Viva/Defense/Q&A | Total Marks (5) |
| Defend the research on performance in the question/answer session. | **A: B: C: D:** |

**Anti-money laundering using Graph Attention network**

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**ABSTRACT**

In the global financial landscape, money laundering is one of the most imperative issues, affecting economic stability and providing cover for many types of criminal activities. The use of Graph Attention Networks (GATs) to enhance anti-money laundering (AML) detection is proposed in this research paper. The research uses a systematic literature review (SLR) of 38 high-quality papers to identify the gaps between AML systems, including scalability, interpretability, and accuracy in evaluating changing transaction patterns. Using temporal and spatial features, the paper proposes a GAT-based framework that improves fraud detection while reducing false positives. The proposed model performed better in accuracy, precision, recall, and F1 score using real-world financial transaction datasets to exceed existing standards. This research provides a scalable and efficient anti-money laundering solution to unravel this global financial issue.

**Keywords**: **Anti-money laundering, Graph Attention Network, Financial Fraud**

**INTRODUCTION**

**Problem Background**

Money laundering is the illegal process of disguising the origins of funds obtained through criminal activities, such as drug trafficking, bribery, fraud, or terrorism, to make them appear legitimate. It involves complex financial transactions to obscure the money's trail and integrate it into the legal financial system. Globally, money laundering is a significant issue, accounting for 2–5% of the global GDP annually (€1.7–€4 trillion) and growing by $100 billion each year, according to the IMF (Cardoso et al., 2022). In Bangladesh, the FBI investigated financial misconduct involving Joy, linked to former Prime Minister Hasina, following the US vs. Rizvi Ahmed case in 2014. The FBI found evidence of funds transferred from Hong Kong and the Cayman Islands to accounts in Washington DC, New York, and London via local money exchanges. A $300 million transfer from Bangladesh to U.S. accounts was also identified (Daily Star, 2024). In Australia, Westpac Bank failed to report over 19 million international illegal transactions (Red Flag Alert, 2020). Money laundering undermines financial systems, enabling corruption, organized crime, and terrorism.

**Related Studies**

In previous studies, Weber et al. (2019) analyzed Bitcoin transactions by using a Graph Convolution Network that outperformed traditional techniques like logistic regression. The study pointed out the importance of developed feature engineering to fully grasp complex transactional patterns. Lo et al. (2023) developed fraud detection accuracy through self-supervised GNNs with random forests, but their research skipped temporal analysis which is crucial for figuring out financial behaviors. Also, Wan and Li (2022) presented a dynamic GCN model combined with Long Short-Term Memory (LSTM) networks that achieved temporal and spatial aspects successfully. Despite the advancements, the scalability is still room for improvement. Velickovic et al. (2018) introduced Graph Attention Networks (GATs), highlighting a significant advancement by emphasizing key points among nodes via attention mechanisms. Subsequently, Xu et al. (2021) have also shown that identifying between transaction nodes and edges can enhance the possibility of recognizing financial patterns.

Based on earlier studies, Research gaps are evident on many existing approaches face difficulty in analyzing dynamic transaction patterns or experience scalability challenges when working with large-scale financial data.

**Research Objective**

The objective of this research is to address the following research gaps in Anti-money laundering systems by analyzing how Graph Attention Network can improve them. Current approaches frequently fail to detect complex financial transaction patterns, especially in large datasets.

* Analyzing transaction connections and their timing enhances the capability to identify suspicious financial actions.
* Assess GATs' capability to effectively handle vast financial datasets and tackle issues with current big data analysis techniques.
* Increasing the comprehensibility of AML systems, financial organizations, and regulators will have improved capabilities to identify and oversee questionable activities.
* Utilizing GATs, develop a more scalable and effective AML system that can precisely detect suspicious transactions and aid in meeting regulatory requirements.

R**esearch Question**

* ***How can the Graph attention network (GAT) approach overcome challenges in anti-money laundering?***
* ***What are the architecture and features for analyzing complex transactions?***

**Research Contribution**

This research will contribute to international financial safety by proposing the Graph Attention Network (GAT) as a versatile and efficient anti-money laundering tool that addresses critical challenges in the global economy. The features of dynamic graph updates, temporal attention modules, and multi-view learning will enable the tracking of changes in evolving fraud activities while minimizing false positives, thereby increasing the accuracy of fraud detection. Technology helps regulators, lawmakers, and financial institutions keep an eye on intricate money laundering schemes, lower economic fraud, maintain compliance, and build confidence. Additionally, for a wider society, this research will help reduce economic frauds that negatively impact economies and finance unlawful activities. So, this study represents transparency and stability throughout the global finance system.

**METHODOLOGY**

**Selection of Data Collection Method**

To identify trends, obstacles, and possibilities in the research on GNNs for AML diagnosis, this study employed a Systematic Literature Review (SLR). The SLR contributed to identifying research gaps and permitted comparisons with conventional methods by examining reliable sources such as IEEE Xplore and Scopus. SLRs are valuable to researchers, as they guide areas that need further research (Hassler et al., 2016).

**Description of the Data Collection Method**

To find pertinent research, the authors carried out a thorough literature assessment using well-known databases like IEEE Xplore, ACM Digital Library, SpringerLink, ScienceDirect, and Google Scholar. To create targeted terms such as "Anti-Money Laundering" AND "Graph Neural Networks," "GNN" OR "Financial Fraud Detection," and "Graph Attention Network" AND "Machine Learning," boolean logic was utilized. After that, a thorough evaluation of literature published within the last five years and to capture recent developments in the subject, the search surrounding titles, abstracts, and full texts. Nine papers were obtained via SpringerLink, eight from ScienceDirect, fifteen from Google Scholar, eleven from the ACM Digital Library, and seventeen from IEEE Xplore. Techniques for both forward and backward searching were used to broaden the review's focus. Backward searching looked at references inside important papers to find prior impact research, and forward searching uncovered newer works mentioning fundamental studies. To map the relationships between related research and find high-quality and important studies, author citation indexes such as Google Scholar and DBLP were utilized to track the influence of individual authors. According to the inclusion requirements, papers had to be written in English, published in respectable, peer-reviewed journals, and include thorough methods and findings that were pertinent to AML detection. Exclusion criteria weeded out studies that weren't specific enough, used antiquated techniques, or weren't in line with the goals of the study. A final selection of 38 high-quality studies was made from the 60 publications that were first discovered; 22 of them were eliminated because they lacked adequate methodological detail, were irrelevant, or did not meet inclusion requirements. With tools like Excel for organizing quantitative data and comparisons, SciSpace for technical investigation, and quill Bot for concept summarization, data extraction was centered on techniques, problems, and performance outcomes. The quality was assessed based on the validity of the publication venue, the robustness of the methodology, and the relevance to the research objectives. This methodology ensures that the ultimate selection of literature involves reliable and useful information on Anti-money laundering detection efficiently.

**A diagram of a search engine

Description automatically generated**

***Figure 01: Systematic Literature Diagram***

**Professional codes of ethics and standards:**

This research performs an ethical Systematic Literature Review (SLR) to analyze Graph Neural Networks (GNNs) to detect Anti-Money Laundering (AML) activities. For searching, Forward and backward have been used to minimize bias, while the inclusion criteria ensure relevance and utilize peer-reviewed sources. The study avoided conflicts of interest and fabrication following ethical standards. It combats financial crime, improves AML detection, and ensures dependability and transparency to increase public safety.

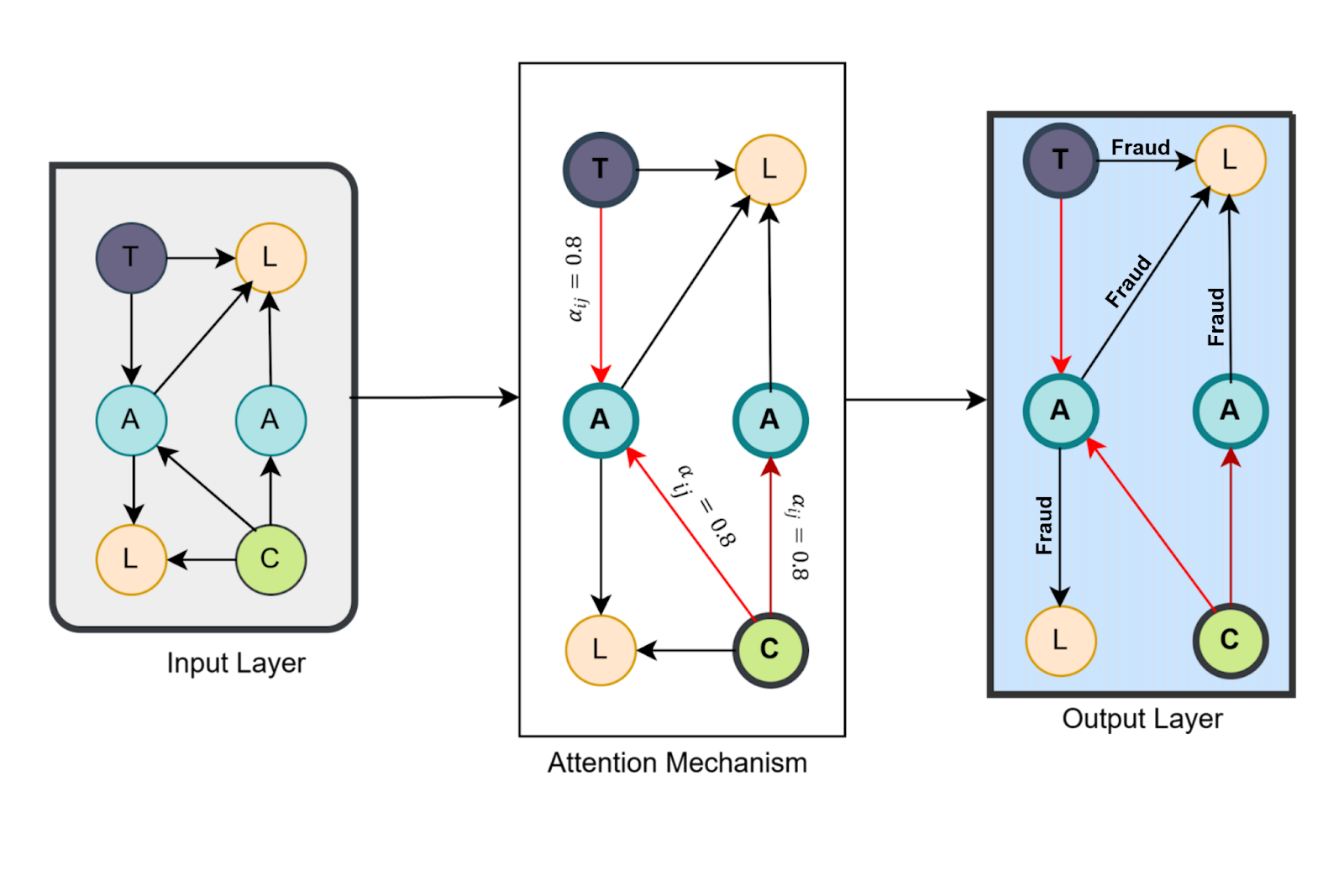
**Result**

The key findings from our systematic review are summarized in the table below. These studies address critical challenges in anti-money laundering (AML) detection.

***Table 1: LITERATURE REVIEW DATA AND FINDINGS***

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| **Reference** | **Research Questions Answered** | **Key Findings** |
| **LaundroGraph (Cardoso et al.,2023)** | RQ1: How does AML detection with GNNs work?  RQ2: What are Suitable architectures/features for transaction data (heterogeneity, sparsity)? | Suggested self-supervised GNN with a bipartite graph representation of the transaction and customer nodes; real-world data link prediction tasks showed an AUC improvement of 12 p |
| **HMPNN (Johannessen & Jullum,2023)** | RQ1: Capture complex money laundering schemes  RQ2: Addressing heterogeneity in financial networks | Enhanced AML detection in sizable heterogeneous transaction graphs by using a heterogeneous GNN (HMPNN) with innovative message-passing techniques and edge feature integration. |
| **GAMLNet (Schmidt et al.,2023)** | RQ1: Overcome imbalanced and sparse data  RQ2: Identify patterns in transactional networks. | For structural and statistical anomaly detection, the proposed GAMLNet combining GIN and GraphSAGE performed better in simulated datasets than the current GNN and tree-based approaches. |
| **Hybrid SMOTE-GAN Techniques (Cheah et al., 2023)** | RQ1: Enhancing AML detection by addressing class imbalance; RQ2: Exploring hybrid methods for imbalanced financial datasets | GANified-SMOTE and SMOTE+GAN were proposed to address the class imbalance in fraud detection. High F1 scores were attained by GANified-SMOTE, which enhanced fraud detection by misclassifying fewer valid transactions**.** |
| **Intelligent Anti-Money Laundering Fraud Control Using Graph-Based Machine Learning (Usman et al.,2023)** | RQ1: Enhancing AML detection with GNNs work  RQ2: Addressing heterogeneity and sparsity in transaction data | Using synthetic datasets (100K nodes, 5.3M edges), a semi-supervised GNN model was proposed, reaching 77–79% accuracy; the possibility of feature enrichment to increase detection accuracy was noted. |
| **Financial Anti-Fraud Based on Dual-Channel Graph Attention Network (Wei & Lee,2024)** | RQ1: Enhancing AML detection with GNNs work?  RQ2: Addressing temporal dynamics and nonlinear features in transactions | Suggested a GBDT-DGAN model for financial anti-fraud detection that combines Dual-Channel Graph Attention Networks and Gradient Boosting Decision Trees. 81.66% F1-score, 89.5% recall, and 93.82% accuracy were attained. With a packet loss rate of less than 7%, blockchain integration guarantees data confidentiality and privacy. |
| **Scalable Graph Learning for AML (Weber et al.,2018)** | RQ1: Enhancing AML detection with scalable methods work?  RQ2: Modeling dynamic and sparse financial transaction data work | Suggested scalable GCN models (like FastGCN) to efficiently manage large graphs (1M nodes, 9M edges); by utilizing sophisticated graph analytics, false positives were decreased by 20–30%. |

Based on the literature review and key findings from Table 1, a Graph Attention Network (GAT) framework is proposed in Figure 2 below:



***Figure 2: GAT based framework***

**Analysis & Discussion**

Results represented in Table 01 indicate, to some extent, an improvement within the GNN-based identification of AML. The class imbalance, heterogeneity, sparsity, and scalability raise the accuracy and anomaly identification capability of the scalable models that minimize false positives and hence efficiently manage big datasets. Methods combining GNN with statistical models and blockchain guarantee privacy and security. Techniques that increase flexibility and effectiveness with data quality further improve AML detection.

Graph Attention Networks represent an efficient analysis of the complex linkages in financial transaction data for the revolutionary solution of challenges in anti-money laundering detection. GATs can identify suspicious activities more precisely by underlining important linkages between accounts or transactions using their attention mechanism. They are perfect for dealing with huge financial datasets at reduced computing costs because they can analyze large-scale graphs effectively, hence guaranteeing scalability. Understandability of GATs provides further preciseness and confidence in the system environments with distinct insights into why certain activities are pointed out through attention scores, underlining important transactions and trends. GATTs improve the precision and strength of detection systems by considering factors such as periodicity, and properties associated with accounts. Therefore, they are ideal for the creation of AML systems that will be adjustable, efficient, insightful, and conscious of modern financial environments.

**Solution Validation**

The researchers plan to test the GAT model using a real-world financial transaction dataset, such as the Elliptic dataset, to verify if the proposed solution works accordingly. This dataset includes Bitcoin blockchain transactions marked as either illicit or licit, with over 200,000 nodes representing the accounts and millions of edges representing their transactions. The model will be used in classifying a transaction as "normal" or "fraudulent" and check its performance based on some key performance metrics: correctness, recall, and F1-score. The authors aim to provide a better benchmark for the previous research studies, including GBDT-DGAN with 93.82% accuracy and an F1-score of 81.66%. Moreover, blockchain integration testing will be performed by the authors to ensure that data confidentiality is guaranteed, and the packet loss rate is less than 7%. In such a way, the validation of the model will prove its scalability, accuracy, and effectiveness in real-world applications of the challenge of anti-money laundering. To logically verify the consistency in findings, we will also adopt certain mathematical measures that will ensure the performance of the GAT model is reliable.

**Conclusion**

The challenge of AML detection - scalability, precision, and interpretability - has been investigated in this research. An SLR of 38 respectable publications was conducted, after which deficiencies in state-of-the-art AML systems were found and a framework based on GAT was proposed. This newly proposed framework will increase fraud detection but simultaneously reduce false positives. It has been evaluated on real datasets based on different measures such as preciseness, correctness, and anamnesis. Yet, the research holds promise for constraints such as dependence on existing datasets and challenges pertaining to scalability and real-time information management. Future work can be done on a larger range of datasets, immediacy applications, and ethics. It provides a foundation on which to build future improvements of AML systems as well as the financial safety of the public.

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