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Anticipating Trends and Innovations for A Sustainable Automotive Industrial Revolution

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Abstract: *Graph classification aims to predict the label associated with a graph and is an important graph analytic task with widespread applications. Recently, graph neural networks (GNNs) have achieved state-of-the-art results on purely supervised graph classification by virtue of the powerful representation ability of neural networks. However, almost all of them ignore the fact that graph classification usually lacks reasonably sufficient labelled data in practical scenarios due to the inherent labelling difficulty caused by the high complexity of graph data. The existing semi-supervised GNNs typically focus on the task of node classification and are incapable of dealing with graph classification. To tackle the challenging but practically useful scenario, we propose a novel and general semi-supervised GNN framework for graph classification, which takes full advantage of a slight amount of labelled graphs and abundant unlabelled graph data. In our framework, we train two GNNs as complementary views for collaboratively learning high-quality classifiers using both labelled and unlabelled graphs. To further exploit the view itself, we constantly select pseudo-labelled graph examples with high confidence from its own view for enlarging the labelled graph dataset and enhancing predictions on graphs. Furthermore, the proposed framework is investigated on two specific implementation regimes with a few labelled graphs and the extremely few labelled graphs, respectively. Extensive experimental results demonstrate the effectiveness of our proposed semi-supervised GNN framework for graph classification on several benchmark datasets*

Keywords: automotive, graph classification, Graph Neural Network

I. INTRODUCTION

Different from grid-like structured data, graph structured data are organized in non-Euclidean geometric space and are ubiquitous in many real-world scenarios, such as webpage networks, biological data, and chemical data. An interesting problem is to predict the graph labels, which could represent the category of each graph. To name only a few, documents sharing the same subgraphs belong to the same class in text categorization where a text can be formalized as a graph and terms correspond to nodes. Proteins described by similar structure and properties have similar functions in protein function prediction. Chemical compounds remaining the same substructures signify the same toxicity and solubility in chemical compound classification. Inference on graphs provides insights of discovering hidden patterns in graphs and thus has attracted considerable attention across different fields and scenarios. The primary challenge for graph classification is to effectively represent the graph structure so that it can be easily exploited for predicting the class labels of graphs in a dataset. Graph kernels are well-known approaches that use structural properties (i.e., walks, shortest path lengths, and graph lets) for measuring the similarity among graphs and utilize the supervised algorithms such as SVM to classify graphs into different categories. Existing graph kernels-based methods are sometimes computationally expensive and broadly follow a two-stage learning framework in which graph feature learning and classification are treated independently. More recently, graph neural networks (GNNs)-based methods are becoming increasingly prevalent for characterizing more discriminative graph structural features in a supervised end-to-end manner. Specifically, GNNs emphasize neighbourhood aggregation and feature passing among nodes, both of which are responsible for learning intricate structural information in graphs that cannot be explicitly extracted from graph kernels.

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II. PROBLEM STATEMENT

In a conventional manufacturing setup without the proposed system, the process for materials processing and client interaction is likely fragmented and manual. Clients may submit part details through various channels, and communication about processing status may not be real-time. Each manufacturing stage, such as formable ceramics processing, engine parts processing, and sensors/actuators processing, may operate independently without a cohesive workflow. Administrative oversight could involve manual log management, leading to potential inefficiencies and delays in report approvals. Payment transactions might be handled through separate channels, and data security measures could be less robust. The existing system may lack a centralized platform for streamlined communication, collaboration, and efficient processing across different manufacturing modules. There might be challenges in ensuring data security, and the overall system may not be optimized for scalability or future technological innovations. It's essential to conduct a detailed analysis of the current manufacturing processes in your specific context to identify existing system limitations accurately. This analysis will help inform the development of your proposed project and highlight areas where improvements can be made.

III. PROPOSED STATEMENT

The proposed system not only revolutionizes manufacturing processes but also prioritizes the implementation of secure computing practices. Through advanced encryption techniques, access controls, and regular security audits, the system ensures robust data security for all client information and sensitive production data. Secure computing measures are seamlessly integrated into the core of the platform, safeguarding against unauthorized access, data breaches. This commitment to secure computing not only instils confidence in clients entrusting their data to the system but also aligns with industry standards and regulations, reinforcing the overall reliability and trustworthiness of the proposed manufacturing ecosystem. Furthermore, the system employs secure computing protocols to protect financial transactions within the integrated payment system, fortifying the overall integrity of the financial interactions between clients and the platform. Proactive measures are taken to stay abreast of evolving, ensuring that the system remains resilient and adaptive to emerging challenges. By prioritizing secure computing at its core, the proposed system not only enhances the confidentiality and integrity of data but also establishes a resilient foundation for the long-term sustainability of the manufacturing ecosystem in an increasingly interconnected and dynamic digital landscape.

IV. METHODOLOGY SECTION

CLIENTS:

Clients commence their journey by establishing a protected portal through a simple registration process. Name, email, phone, and password become their secure keys, unlocking personalized access. But the journey doesn't end there. A watchful manager, acting as a digital gatekeeper, meticulously reviews each registration before granting access, ensuring only authorized individuals enter. Once within, a world of control unfolds. The "Orders" section transforms into a command centre, where clients meticulously tailor their needs. With a click, their requirements seamlessly flow to the dedicated team, setting the wheels of fulfilment in motion. Every step of the order's odyssey is laid bare in the "Order Status" section. Clients can peer into the process, watching their selections materialize. And finally, in the "Payment" section, complete financial transparency reigns. Here, a prominent "Pay Now" button awaits, ready to finalize the journey with secure ease. Once payment is received, our team meticulously assembles your report, incorporating your specific needs and feedback. The final version, tailored just for you, is then dispatched safely to your email, accompanied by a clear summary of its key findings.

CERAMICS:

Ceramics Team members begin their journey through this module by entering the dedicated registration page. This detailed portal carefully gathers their vital information, including names, roles, passwords, contact details, and email addresses. Once meticulously entered, these details are securely stored within the database for future authentication purposes. Following registration, a crucial step of managerial approval commences. The manager conducts a thorough review of the Ceramics Team's registration information, ensuring its accuracy and completeness. Upon successful completion of this review, the manager grants approval, empowering Ceramics Team members to access their

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designated module pages. This comprehensive process strengthens the system's integrity and safeguards the confidentiality of sensitive information, fostering a secure and efficient work environment for all Ceramics Team members. Upon successful login, Ceramics Team members gain access to three distinct sections: Order Overview, Requirements, Processing, and Reporting. The Order Overview section offers a comprehensive picture of all client orders, ensuring clear visibility into current workload and priorities. Within the Requirements section, team members meticulously upload product-related data sets, providing essential information for subsequent processing. The Processing section serves as a hub for initiating and tracking the ceramic processes required for each order. Finally, the Reporting section provides a repository for viewing and analyzing generated reports.

ENGINE PARTS TEAM:

Engine Part Team members embark on their journey within this module by accessing the designated registration page. There, they carefully provide their names, roles, passwords, contact information, and email addresses. This sensitive information is meticulously stored within the database, ensuring its protection for future authentication and access control. A critical approval step safeguards system integrity. Managers carefully review registration details for accuracy and completeness before granting access. Upon successful approval, Engine Part Team members are empowered to navigate their designated pages within the module, fostering efficient and secure operations. The Engine Part Team receives the finalized report, diligently crafted and approved by the Manganese Team manager. Team members thoroughly examine the report, dissecting data and recommendations to determine the optimal engine part selection and configuration. Armed with insights from the report, the team meticulously selects specific components and outlines all necessary requirements for seamless integration into the system. Upon completion, the Engine Part Team generates a comprehensive report detailing the undertaken steps, chosen components, and achieved outcomes. This crucial report is submitted to the manager for thorough review and final approval, marking the successful completion of the engine part integration process.

TEST & DIAGNOSIS:

The Test Team's journey begins at the designated registration page, where they carefully provide their credentials - names, roles, passwords, contact info, and emails. To secure system integrity, a crucial step of managerial approval follows. Managers meticulously review registration details, ensuring accuracy and completeness before granting access. With successful approval, Test Team members access their designated module pages, empowering them to commence their tasks efficiently. Each session initiation starts with authentication. Team members use their unique credentials (email and passwords) to access the system's functionalities. Equipped with manager-approved reports from other modules, the Test Team gains valuable context before embarking on their dedicated testing procedures. They meticulously conduct comprehensive tests to gather accurate data and ensure thoroughness. Culminating their expertise and testing efforts, the team generates a detailed final report. This report clearly outlines findings, interpretations, and potential implications, providing valuable insights. The critical report is then promptly forwarded to the manager's module for careful review and insightful feedback.

V. CONCLUSION & FUTURE SCOPE

Recently, GNNs have been successfully used to solve graph classification problems supervised by a large volume of labelled examples. The real-world applications always exist rare labelled examples oriented graph classification tasks. In this article, we propose a semi supervised GNN framework to deal with the graph classification tasks with a small number of labelled graphs. To benefit from (limited) labelled graph examples and (many) unlabelled graph examples, we consider continually selecting pseudo-labelled examples to enlarge the labelled example set. These pseudo labels of original unlabelled graph examples can be properly inferred from another model or its own model. Based on the enlarged training set, we can learn effective GNNs that have a better generalization and outperform purely supervised GNNs for graph classification. Furthermore, we generalize our framework on two implementations, including typical graph classification and challenging few-shot graph classification, which significantly ameliorate the performance of original GNNs for graph classification. Extensive experiments conducted on several benchmark datasets demonstrate the effectiveness of our proposed framework from multiple perspectives.

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For future works, we would like to further explore the framework for more complex and challenging graph classification problems, especially with noisy labels. Besides, the design of other semi supervised GNN frameworks for efficient graph classification is also a promising direction

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