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Patent citation link prediction based on graph neural network

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Team: Intelligence and System Platform Team

Department: Knowledge System Department

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Outline

- **Link prediction model of patent citation relationship**
 - ◆ **Research purpose**
 - ◆ **Data basis**
 - ◆ **Model and algorithm**
 - ◆ **Empirical results**



Patent citation link prediction



■ A Preliminary Study on Patent Literature Data

➤ The formation of citation relationship: citation mark, inventor, agent, examiner

(12) **United States Patent**
Li et al. (10) **Patent No.:** US 12,100,315 B2
(45) **Date of Patent:** Sep. 24, 2024

(54) **PEER-INSPIRED STUDENT PERFORMANCE PREDICTION IN INTERACTIVE ONLINE QUESTION POOLS WITH GRAPH NEURAL NETWORK**

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(72) Inventors: **Haotian Li**, Hong Kong (CN); **Yong Wang**, Hong Kong (CN); **Huan Wei**, Hong Kong (CN); **Huamin Qu**, Hong Kong (CN)

(73) Assignee: **The Hong Kong University of Science and Technology**, Hong Kong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 758 days.

(21) Appl. No.: **17/343,769**

(22) Filed: **Jun. 10, 2021**

(65) **Prior Publication Data**

US 2021/0398439 A1 Dec. 23, 2021

Related U.S. Application Data

(60) Provisional application No. 63/102,509, filed on Jun. 18, 2020.

(51) **Int. Cl.**
G09B 7/02 (2006.01)
G06N 3/045 (2023.01)

(Continued)

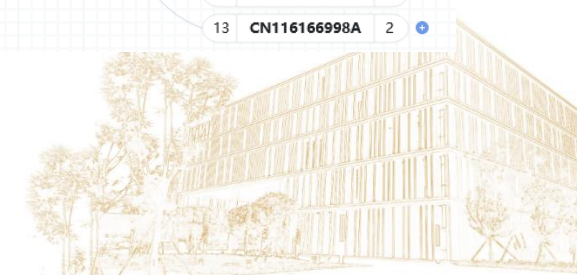
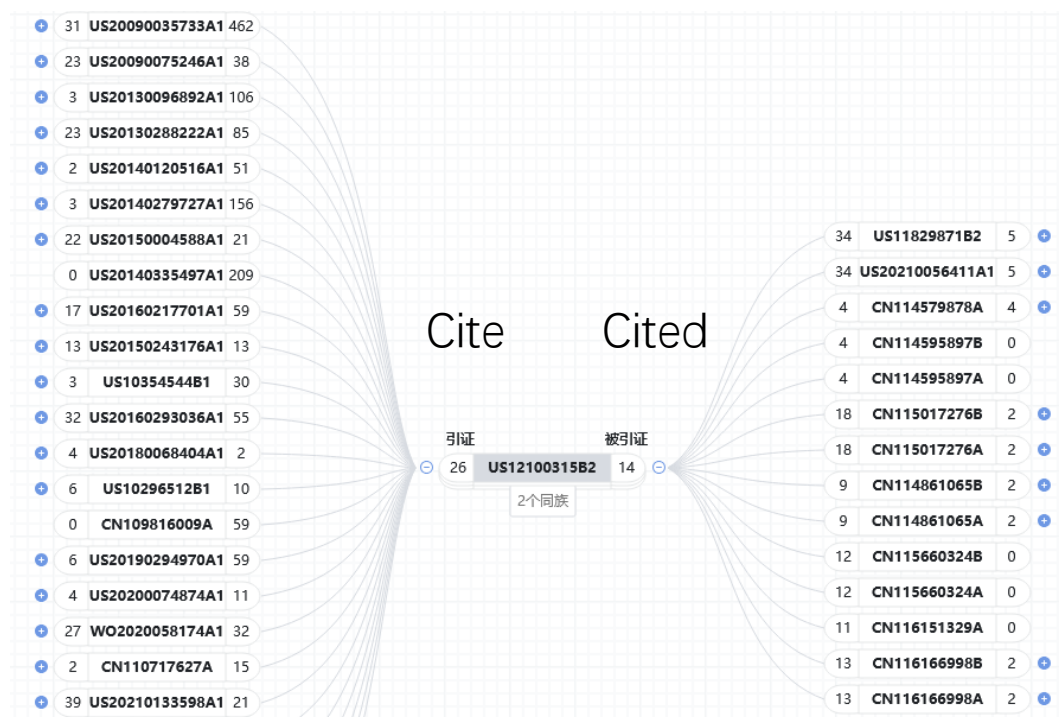
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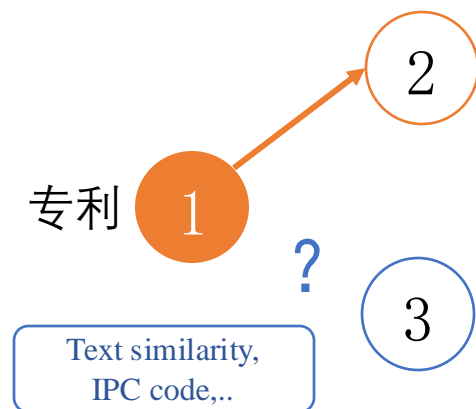
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Heng-Tze Cheng et al. "Wide & deep learning for recommender systems." Deep Learning for Recommender Systems, 2016, pp. 7-10.
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Primary Examiner — Jack Yip
(74) *Attorney, Agent, or Firm* — Idea Intellectual Limited; Margaret A. Burke; Sam T. Yip

(57) **ABSTRACT**
A method for predicting student performance in interactive question pools, comprising: a data processing and feature extraction module for: extracting from historical score data records statistical student features reflecting the students' past performances on the questions; and statistical question features indicating a question popularity of each question and the average students' scores on each question; and extracting from the pointing device movement data records a plurality of interactive edge features representing the



- **Purpose:** predicting the citation relationship between two patents



- Motivation: (1) link prediction is a core task in different complex network data scenarios.
(2) Increased burden in patent management highlights the importance of automation.
- Direct application value: Patent citation recommendation for examiners, technology evolution paths identification
- Indirect application value : Patent value assessment, Forward-looking technology management

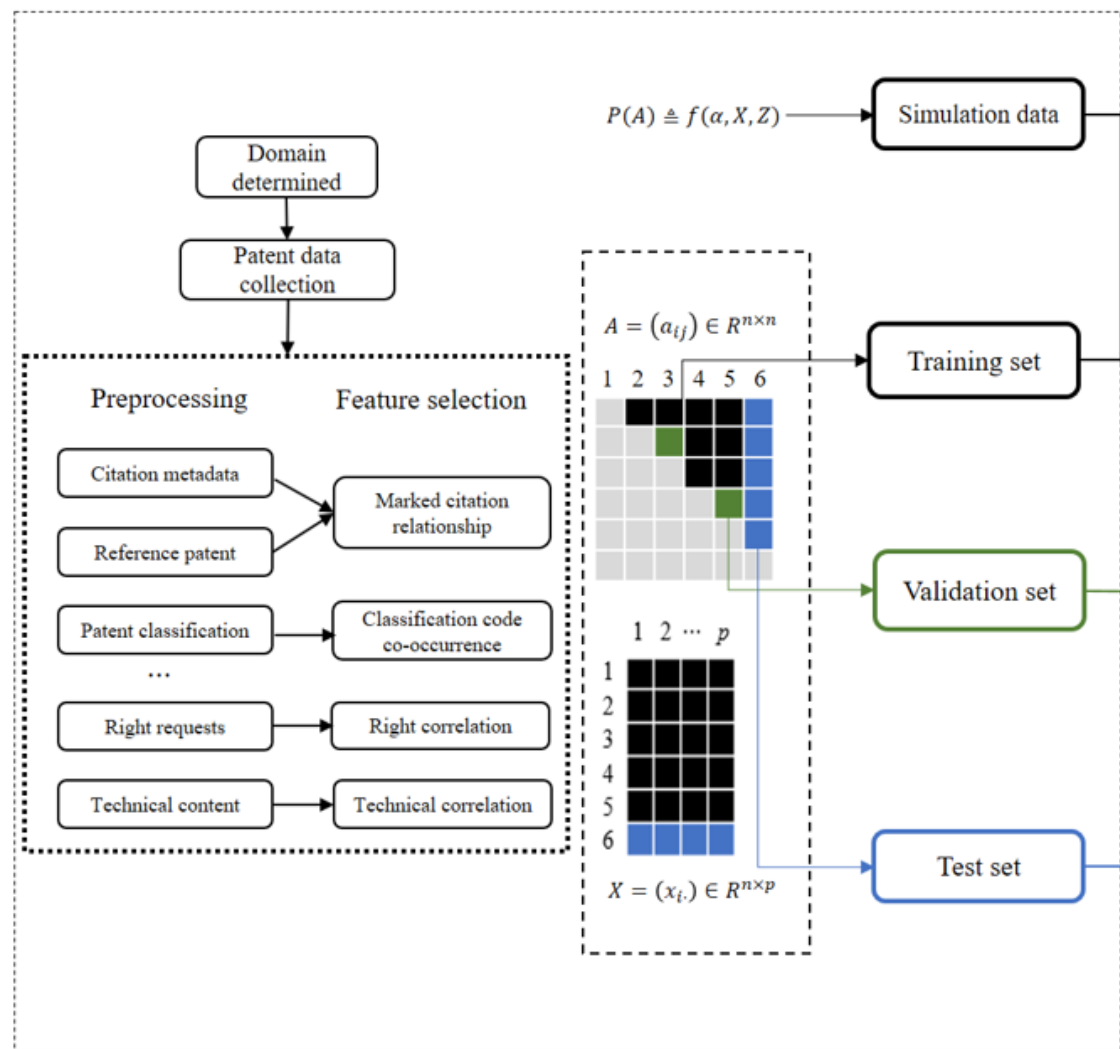


Patent citation link prediction

Database

Quantum Sensing - Non-Imaging

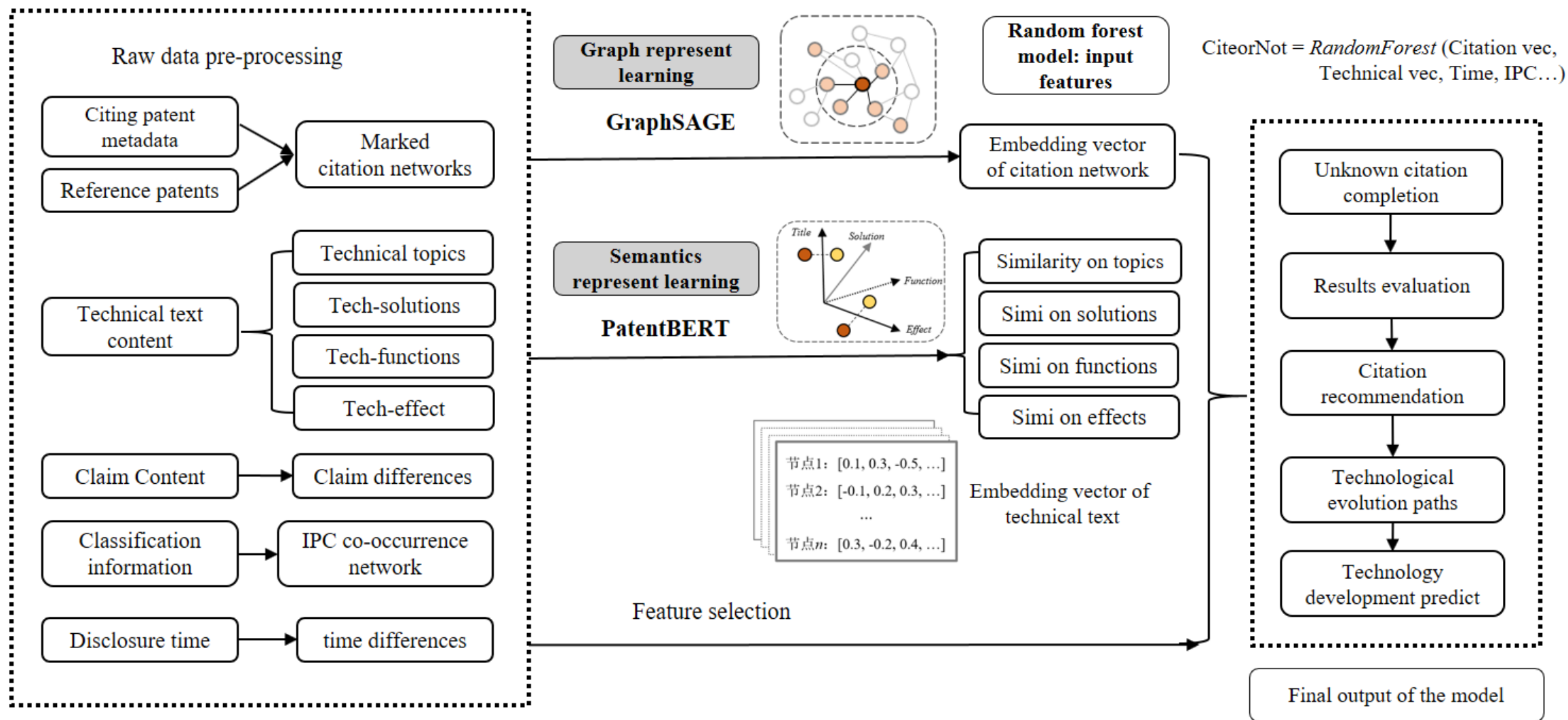
ALL=("quantum sensing" OR "quantum sensor*" OR "quantum metrology" OR "atom interferometry" OR "non state*" OR "atomic sensor*" OR "quantum gyroscope*" OR "quantum accelerometer*" OR "quantum ins" OR "quantum imu" OR "quantum magnetometer*" OR "quantum rf receiver*" OR "cold-atom interferometer*" OR "cold-atom gas interferometer*" OR "heisenberg limit*" OR "standard quantum limit*" OR "quantum inertial sens*" OR "quantum gravimeter*" OR "quantum electrometer*" OR "quantum radio*" OR "quantum receiver*" OR "rydberg atom sensor*" OR "vapor-cell sensor*" OR "defect-based sensor*" OR "scanning quantum dot microscop*" OR "qubit detector*" OR "quantum detector*" OR "quantum detector tomography" OR "quantum tomography" OR "quantum state tomography" OR "microwave bolometer*" OR "microwave bolometer*");



Patent citation link prediction



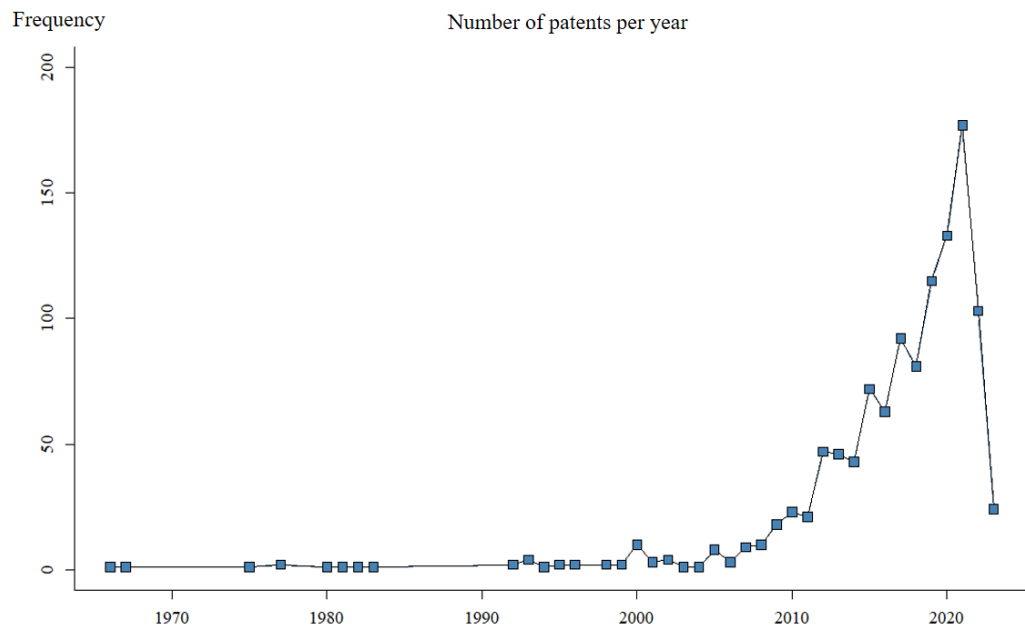
Graph-PatentBERT-RF model



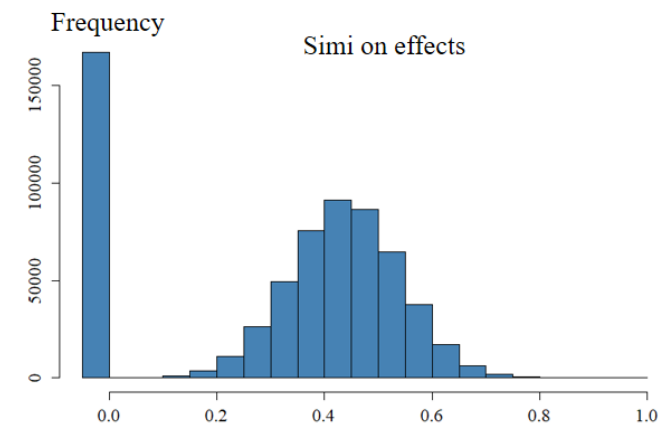
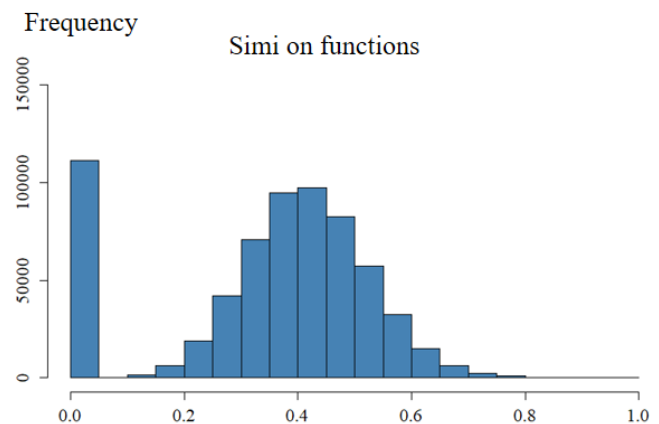
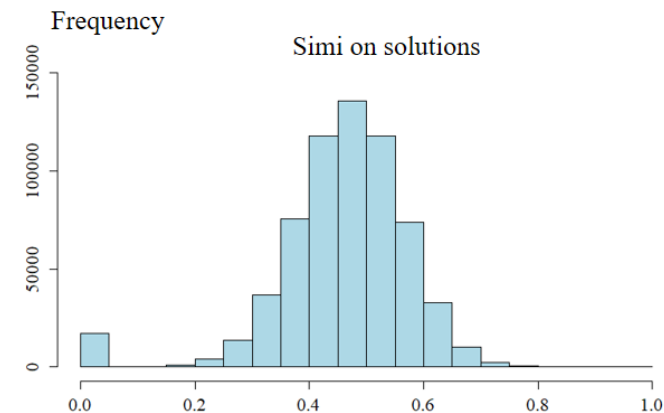
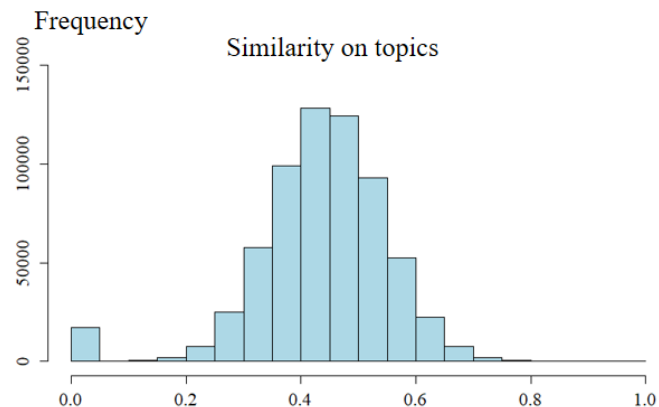
Patent citation link prediction



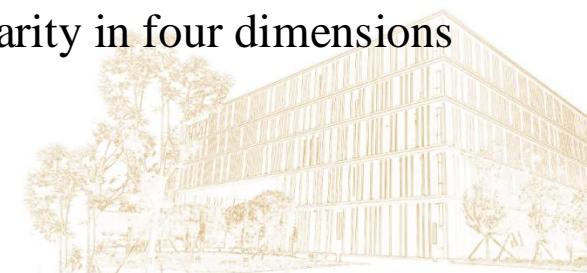
Data description



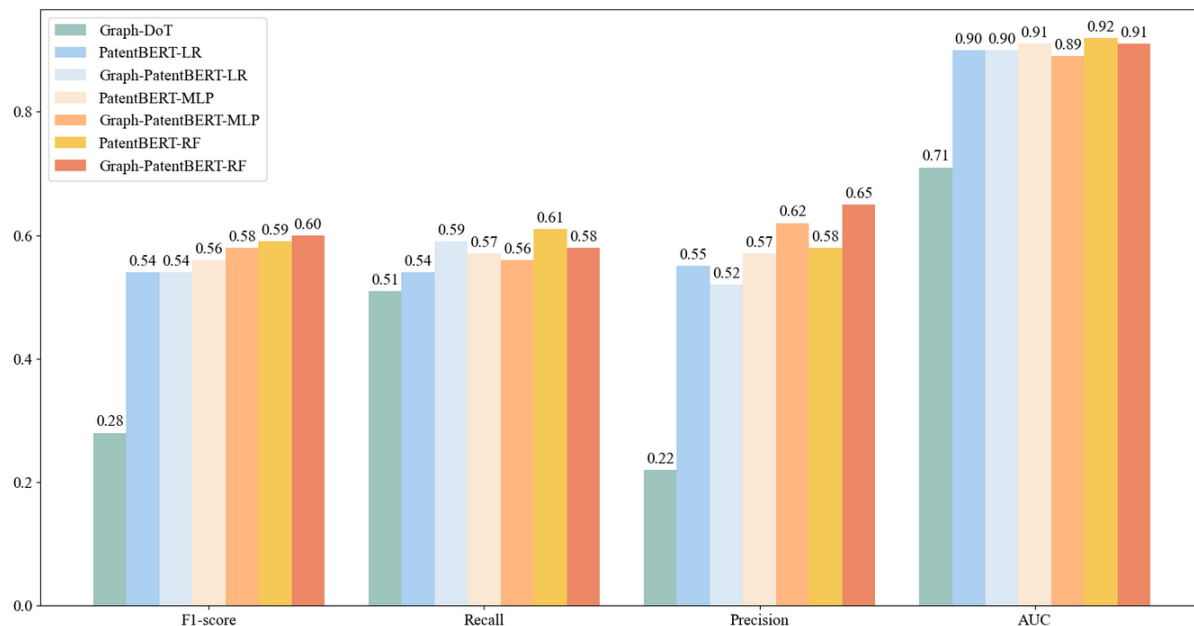
Annual distribution of the number of patents in the field of quantum sensing (1966-2023)



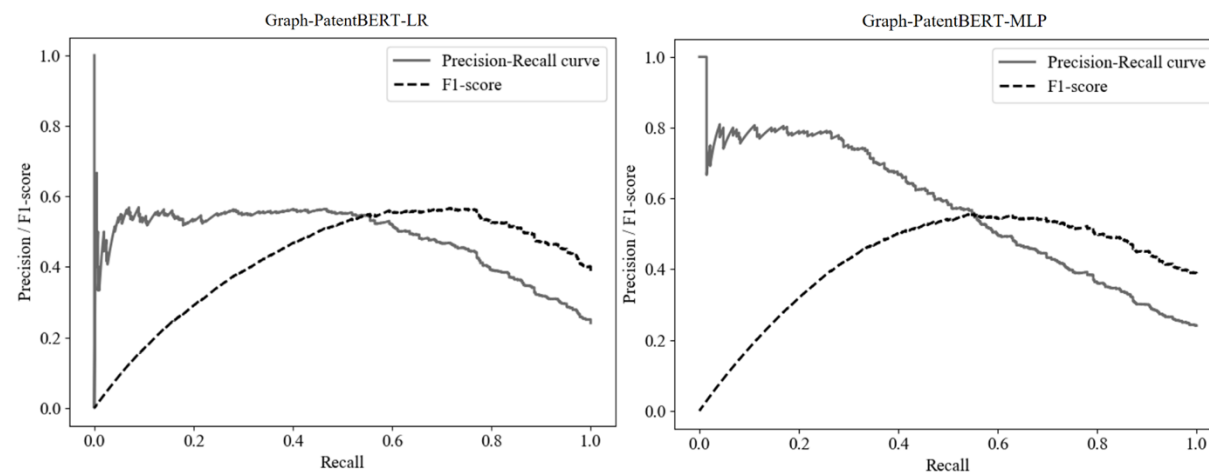
The distribution of technical similarity in four dimensions



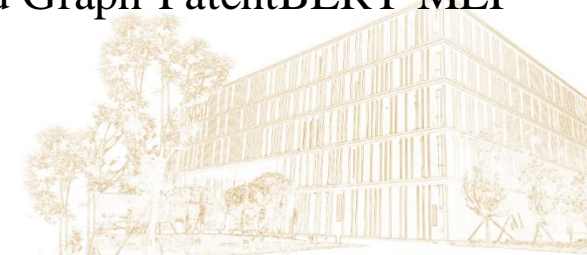
Comparison of link prediction performance of different models



Comparison of prediction results of 7 models under different evaluation indicators



Comprehensive performance of link prediction on Graph-PatentBERT-LR and Graph-PatentBERT-MLP

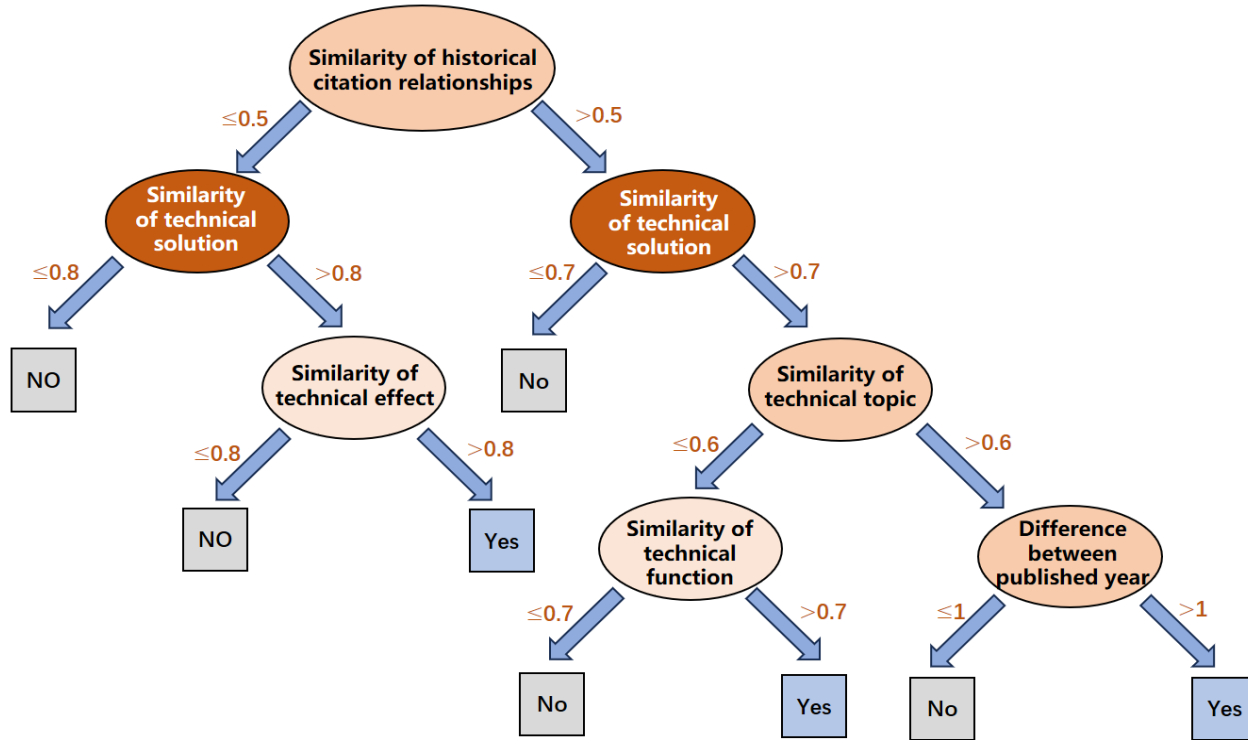


Patent citation link prediction

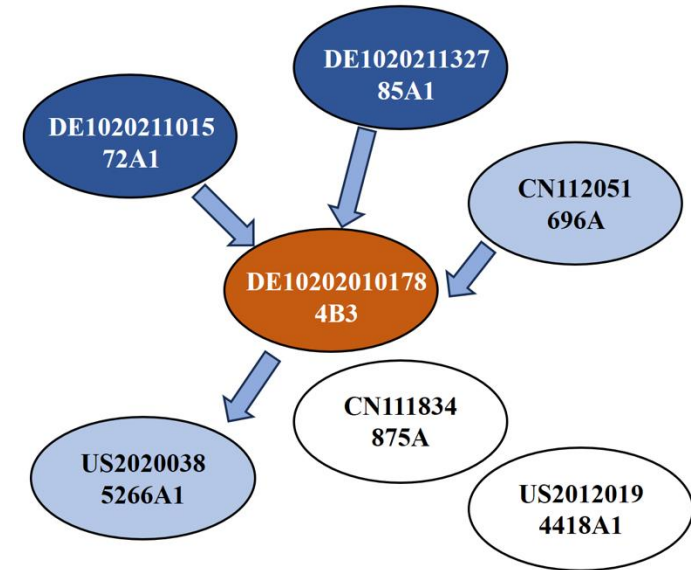


■ Interpretation of prediction rules

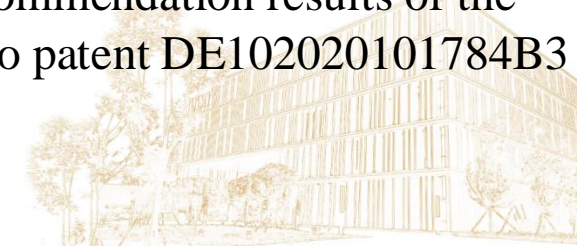
■ Case validation



Decision tree: The probability of generating a patent citation relationship



Schematic diagram of the recommendation results of the model's citation relationship to patent DE102020101784B3



Patent citation link prediction



Some typical technological evolutionary paths

Main path of the citation network **VS** Main path of the link prediction probability value

Table5 Some typical technological evolution paths

Start node	End node	Main path of citation network	Main path of the probability value	Explanation
US328033 6A	DE102020 101784B3	None	US3280336A→CN104677508 A→CN110547964A→ DE102020101784B3	The evolutionary path from the original technology node to the important technology node
DE102020 101784B3	DE102021 101569A1	DE10202010178 4B3→DE102021 101569A1	DE102020101784B3→DE102 019121029A1→US202101573 12A1→DE102021101569A1	Evolutionary paths between important technology nodes
DE102020 101784B3	DE102021 132527A1	None	DE102020101784B3→DE102 019121029A1→US202100336 40A1→ KR2231135B1→ US20210156735A1→DE1020 21132527A1	The evolutionary path from the most important technology node to the latest technology node



■ Conclusion

- We construct a patent citation network link prediction model framework (Graph-PatentBERT-RF) based on graph and semantic representation learning.
- The model makes full use of features such as the citation network representation vector, and the technical semantic representation vector of four topic dimensions.
- The model could improve the accuracy of citation relationship prediction results, further improve the methods of technology diffusion, and provide new tools for practical applications.



Thank you for listening!

Your criticism and suggestions are greatly appreciated!

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Full text of the article is available online:

HU Wei, LI Shuying, ZHANG Xin, Yang Ning. Research on Patent Citation Network Link Prediction Based on Graph and Semantic Representation Learning[J/OL].Data Analysis and Knowledge Discovery,1-19.<http://kns.cnki.net/kcms/detail/10.1478.G2.20240910.1715.002.html>.