Linkages among Science, Technology, and Industry

Shuo Xu, Zhen Liu, and Xin An

- Beijing University of Technology
- Speaker: Zhen Liu
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Contents

Part One

Background

1.1 Research Background

- As stated by two-branched model, science and technology act as two strands of DNA to jointly **promote the development of society**.

- As the innovation cycle shortens, **the interactions between science and technology are becoming stronger and stronger**. Ever since the wok by Narin and his co-workers, **extensive studies on the linkages between science and technology** are being conducted in recent years.

- However, in the context of economic globalization, **the development of science and technology is not isolated, but rather is accompanied by the development of industries.**

- In the meanwhile, industry development largely relies on the advances of science and technology. Despite this, **the linkages among science, technology, and industry are largely under-studied.**

1.1 Our Work

To explorer the linkages among articles, patents, and drugs, this paper proposes a framework based on main path analysis:

(1) **Scientific publications, patents and products** are viewed as respective proxies of **scientific research, technological advance and industrial development.**

(2) The **DrugBank database** in pharmaceutical industry is taken as our dataset.

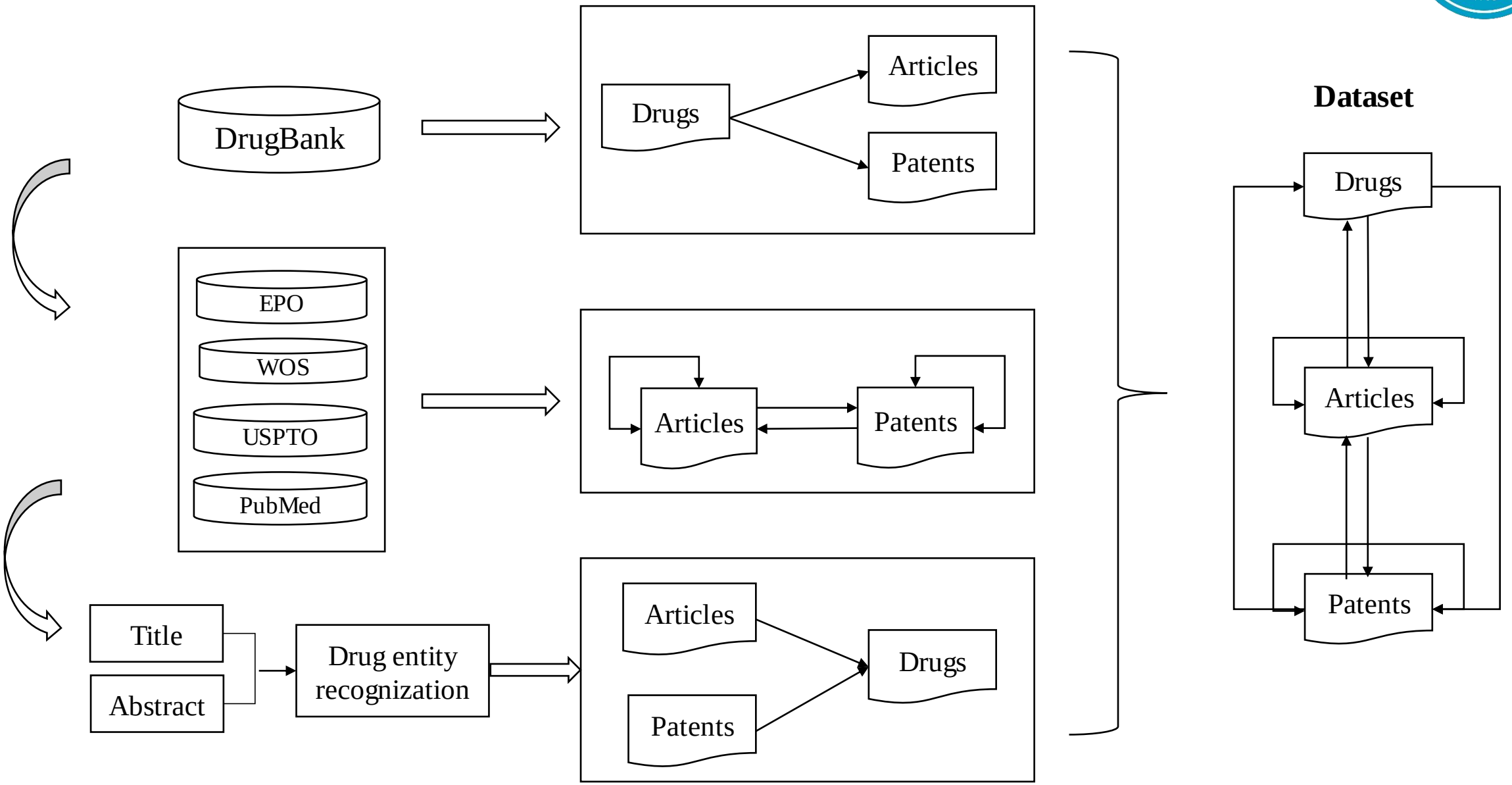
(3) Constructs **a heterogeneous network based on citations among articles, patents, and drugs.**

(4) **The main path analysis** is used to extract **the developmental paths** from the network

Part Two

Methodology

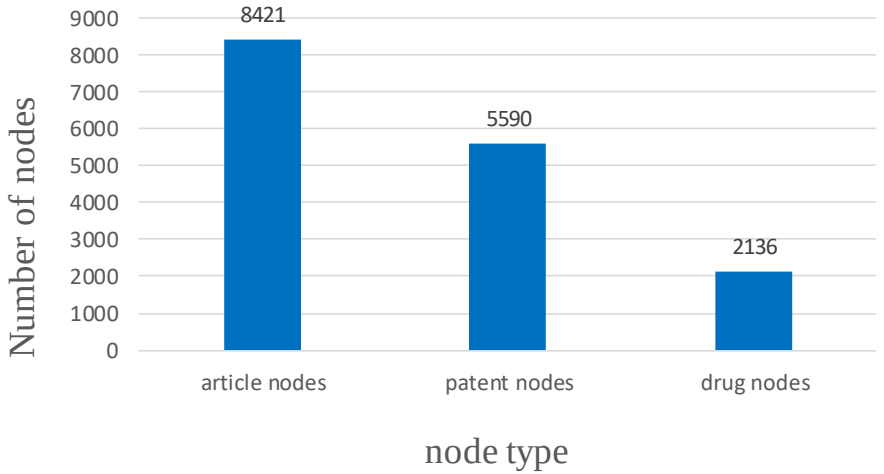
2.1 Dataset


DrugBank
Drugs
Articles
Patents
EPO
WOS
USPTO
PubMed
Articles
Patents
Title
Abstract
Drug entity recognization
Articles
Patents
Drugs
Dataset
Drugs
Articles
Patents

2.2 Preprocessing

- **A heterogeneous network** among articles, patents, and drugs is constructed. This network describes **the flow of knowledge** among articles, patents, and drugs.
- Due to the addition of the citations from articles to drugs and from patents to drugs, **a large number of cycles are generated** in the heterogeneous network.
- We further estimated **the likely time of drug development** based on the citations from drugs to articles and from drugs to patents. According to this time, we **eliminated the citations that did not meet the time requirement** in the citations from articles to drugs and from patents to drugs.
- In the preprocessed network, **we extracted the largest weakly connected component.**

type	#of citations	type	#of citations
citations between articles	4,880 (11.84%)	citations from patents to articles	1,179 (2.86%)
citations from articles to patents	9 (0.02%)	citations from patents to drugs	278 (0.67%)
citations from articles to drugs	2,371 (5.75%)	citations from drugs to articles	8,993 (21.83%)
citations between patents	15,955 (38.73%)	citations from drugs to patents	7,535 (18.29%)



2.3 Methods

- **Key-route main path** is employed to explore the linkages among science, technology and industry.

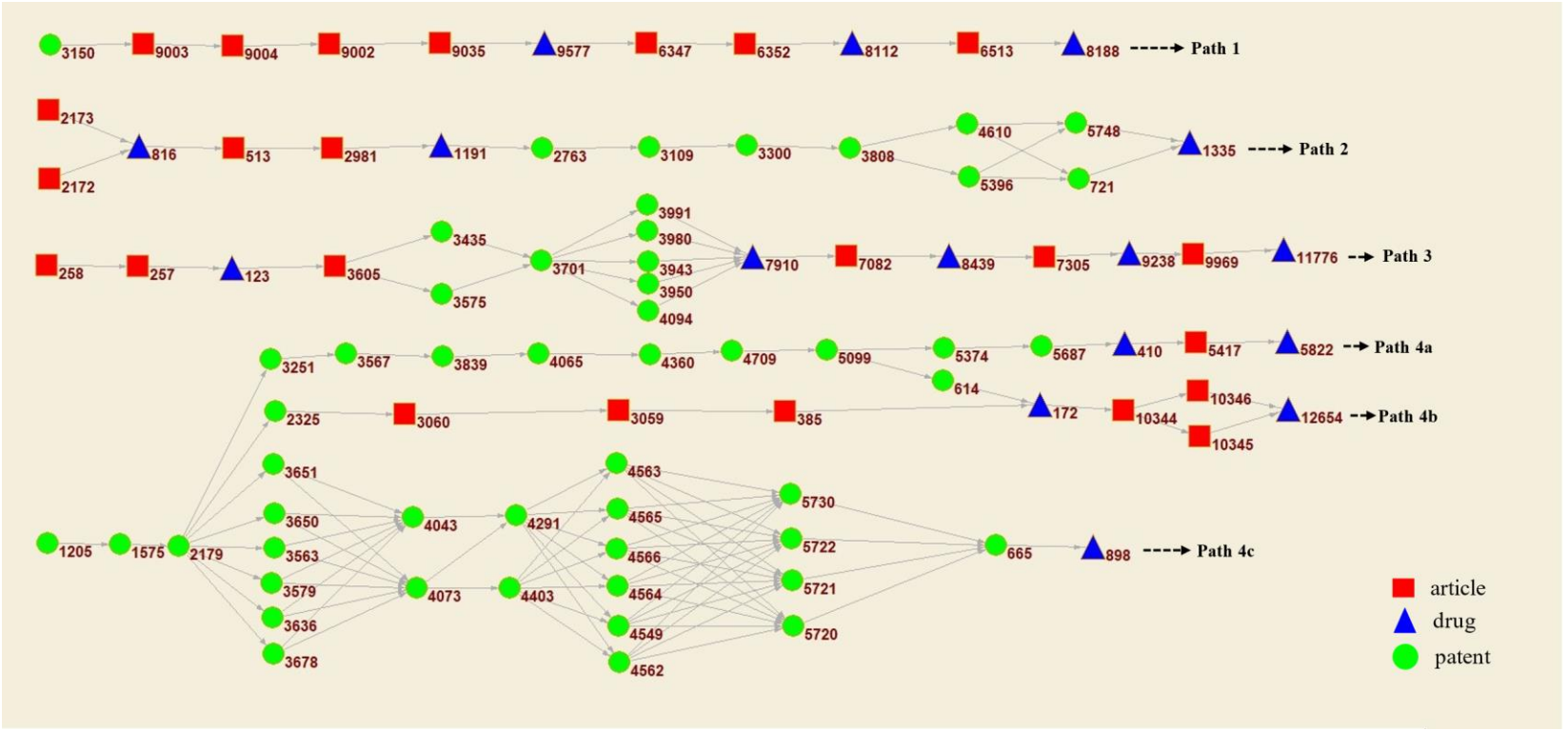
- **Search Path Link Count (SPLC)** is utilized to measure the importance of each edge.

- To highlight the linkages between science, technology, and industry, the following ten edges are fixed to our key routes:
  - **top two edges with the largest weight** from patents to articles and those from articles to patents;
  - **top one edge with the largest weight** for the citations with the other types.

Part Three

Results and analysis

03 Results and analysis



- The results include **four developmental paths**. Moreover, the fourth path **evolved into three sub-paths**.
- The result reveals three main development modes: **(a) pushed simultaneously by science and technology; (b) pushed by science; (c) pushed by technology**.
- The drugs can help **enhance knowledge exchanges** between science and technology.

Part Four

Conclusions & Discussions

4.1 Conclusion

- The discovered development paths indeed **encode the linkages among science, technology and industry**;
- The development modes of the pharmaceutical industry are mainly divided into three types: **the mode promoted by only science, only technology, and science and technology simultaneously**;
- The drugs can **promote knowledge exchanges** between science and technology.

4.2 Discussion

Limitations

- This paper proposes a research framework for exploring the linkages among science, technology and industry, and has carried out a preliminary application in the pharmaceutical industry. **But the framework has not been validated in other areas, and we hope that this initial attempt will encourage further exploration of this topic.**

Future work

- The results of this paper are **further expanded** to explore more information about the linkages among science, technology and industry.
- In the future work, the research framework of this paper **will be applied to more fields to further verify its reliability.**

THANK YOU

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