様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科学研究費助成事業　　研究成果報告書

令和　６ 年　 ６ 月 １４ 日現在

機関番号：１３３０２
研究種目：若手研究
研究期間：2021～2023
課題番号：２１Ｋ１７８１６

研究課題名（和文）Temporal Knowledge Graph Construction from Text

研究課題名（英文）Temporal Knowledge Graph Construction from Text

研究代表者
Ｋ.　Ｎａｔｔｈａｗｕｔ（Kertkeidkachorn, Natthawut）

北陸先端科学技術大学院大学・先端科学技術研究科・講師

研究者番号：４０８１８１００

交付決定額（研究期間全体）：（直接経費）　　2,700,000円

研究成果の概要（和文）：本研究の成果には、金融分野における時系列知識グラフの開発が含まれる。具体的には、テキストから有用な知識を抽出するために、意味論的および統語論的特徴の両方を利用する知識抽出フレームワークを提案した。また、金融分野の時系列知識グラフであるFinKGとFinKG-JPを構築した。報告書の詳細や株価を含む時系列情報は、金融オントロジーテンプレートを使用して抽出し、知識グラフのエッジにエンコードされた。FinKGのアプリケーションは、知識検索と株価予測の2つのアプリケーションで研究が行われた。

研究成果の学術的意義や社会的意義
このプロジェクトでは、金融分野における時系列知識グラフであるFinKGとFinKG-JPの構築および開発方法を提案した。これらの時系列知識グラフは、金融分野における時間認識型AIアプリケーションの開発に貢献することができる。本研究の科学的意義は、時系列知識グラフの構築方法を進展させることであり、これは金融における予測分析や意思決定プロセスの向上に不可欠である。

研究成果の概要（英文）：The project outcomes include both the research methods and the development of temporal knowledge graphs in the financial domain. Specifically, we proposed a knowledge extraction framework that uses both semantic and syntactic features to extract useful knowledge from text, ensuring high-quality knowledge graphs. We constructed FinKG and FinKG-JP, temporal knowledge graphs in the financial domain. Temporal information, including report details and stock prices, was extracted using our financial ontology template and encoded at the edges of the knowledge graphs. We demonstrated the usefulness of FinKG in two applications: knowledge retrieval and stock price prediction.

研究分野：知能情報学関連

キーワード：Temporal Knowledge Graph　Financial KGs　Knowledge Representation　Relation Extraction

様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９（共通）

１．研究開始当初の背景

Knowledge Graphs are structured knowledge bases that store the relationships between real-world entities in the form of directed graphs. In a Knowledge Graph, a node represents a real-world entity, while an edge expresses a relationship between entities. In many modern Artificial Intelligence (AI) applications, such as question-answering systems, entity resolution systems, and information retrieval systems, Knowledge Graphs have been widely used as rich knowledge resources.

Nevertheless, current Knowledge Graphs are designed to curate static knowledge. As a result, temporal clues (such as timestamps, events, etc.), which describe when knowledge is valid, are not taken into account. In practice, temporal clues are valuable because they help us understand the relationships between entities on the real-world timeline and their valid periods. Without temporal clues, AI applications using Knowledge Graphs may not perform precisely due to the lack of essential information.

２．研究の目的

The objective of this research is to study and develop temporal knowledge graphs, which incorporate temporal information such as timestamps and events to represent time and change within a knowledge graph. Temporal knowledge graphs aim to capture the dynamic nature of real-world information, allowing for more accurate and time-aware AI applications. This research focuses on extracting and representing temporal information from various data sources, ensuring that dynamic aspects of knowledge are appropriately preserved within the knowledge graph.

To achieve this, the research involves several key areas. Firstly, we develop algorithms and methodologies to accurately extract relevant temporal information from text resources and other data formats. Secondly, we create models to effectively represent this temporal information within a knowledge graph, defining the structure of temporal nodes and edges and encoding temporal relationships. The integration of these temporal clues into existing knowledge graphs will also be a focus, ensuring that the temporal context of relationships between entities is preserved.

Additionally, the research focuses on developing real-world applications to apply temporal knowledge graphs for time-aware AI applications. Case studies will be conducted to demonstrate the advantages of temporal knowledge graphs in various contexts, such as tracking historical changes in data. Through these efforts, the research aims to provide a comprehensive understanding of temporal knowledge graphs and pave the way for more accurate, dynamic, and time-aware AI applications.

３．研究の方法

The research methods for each fiscal year are as follows:

FY2021: We proposed a knowledge extraction framework that utilizes both semantic and syntactic features to extract useful knowledge from text, ensuring the quality of the knowledge graph. Our framework showed up to a 20% improvement compared to state-of-the-art methods. Additionally, we manually built the temporal knowledge graph data and prepared a dataset for extracting temporal information in the financial domain. We chose the financial domain for this study because financial data is highly sensitive to temporal information.

FY2022: We constructed FinKG, a temporal knowledge graph in the financial domain, using information reported by the SEC and market exchanges. Temporal information, including report details and stock prices, was extracted using our financial ontology as a template and encoded at the edges of the knowledge graph. FinKG contains over 30 million facts. We demonstrated the usefulness of FinKG with two applications: knowledge retrieval and stock price prediction. Knowledge retrieval reveals complex connections among entities, while aggregated features from FinKG enhance neural models' ability to forecast stock prices.

FY2023:

We developed FinKG-JP, a temporal Japanese knowledge graph in the financial domain, using annual reports provided by the Financial Services Agency via EDINET. Temporal information, including report details and stock prices, was extracted using our financial ontology as a template and encoded at the edges of the knowledge graph. For FinKG-JP, we derived concepts from FinKG and added concepts specific to the Japanese market. FinKG-JP contains over 5 million entities. Additionally, we explored applying temporal knowledge graphs to public transport navigation systems by modeling a bus network as a knowledge graph.

4．研究成果

The project outcomes include both the research methods and the development of temporal knowledge graphs in the financial domain (FinKG and FinKG-JP). Based on our research results, we have published the following papers:

- Esrat Farjana, Natthawut Kertkeidkachorn, Ryutaro Ichise: Competent Triple Identification for Knowledge Graph Completion under the Open-World Assumption, IEICE TRANSACTIONS on Information and Systems
- Natthawut Kertkeidkachorn, Rungsiman Nararatwong, Ziwei Xu, Ryutaro Ichise: FinKG: A Core Financial Knowledge Graph for Financial Analysis, Proceedings of IEEE 17th International Conference on Semantic Computing
- Natthawut Kertkeidkachorn, Rungsiman Nararatwong, Ziwei Xu, Ryutaro Ichise: FinKG-JP: A Japanese Financial Knowledge Graph, **人工知能学会全国大会論文集 第** 37 **回**
- Rathachai Chawuthai, Natthawut Kertkeidkachorn, Teeradaj Racharak: Modelling an RDF Knowledge Graph with Transitivity and Symmetry for Bus Route Path Finding, Proceedings of the 6th Artificial Intelligence and Cloud Computing Conference

５．主な発表論文等

〔雑誌論文〕　計4件（うち査読付論文　3件／うち国際共著　1件／うちオープンアクセス　0件）

１．著者名 Kertkeidkachorn Natthawut、Nararatwong Rungsiman、Xu Ziwei、Ichise Ryutaro	４．巻 -
２．論文標題 FinKG: A Core Financial Knowledge Graph for Financial Analysis	５．発行年 2023年
３．雑誌名 IEEE 17th International Conference on Semantic Computing (ICSC)	６．最初と最後の頁 90-93
掲載論文のDOI（デジタルオブジェクト識別子） 10.1109/ICSC56153.2023.00020	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 FARJANA Esrat、KERTKEIDKACHORN Natthawut、ICHISE Ryutaro	４．巻 E105.D
２．論文標題 Competent Triple Identification for Knowledge Graph Completion under the Open-World Assumption	５．発行年 2022年
３．雑誌名 IEICE Transactions on Information and Systems	６．最初と最後の頁 646～655
掲載論文のDOI（デジタルオブジェクト識別子） 10.1587/transinf.2021EDP7148	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

１．著者名 Chawuthai Rathachai、Kertkeidkachorn Natthawut、Racharak Teeradaj	４．巻 -
２．論文標題 Modelling an RDF Knowledge Graph with Transitivity and Symmetry for Bus Route Path Finding	５．発行年 2023年
３．雑誌名 6th Artificial Intelligence and Cloud Computing Conference	６．最初と最後の頁 126-134
掲載論文のDOI（デジタルオブジェクト識別子） 10.1145/3639592.3639610	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

１．著者名 Kertkeidkachorn Natthawut、Nararatwong Rungsiman、Xu Ziwei、Ichise Ryutaro	４．巻 -
２．論文標題 FinKG-JP: A Japanese Financial Knowledge Graph	５．発行年 2023年
３．雑誌名 人工知能学会全国大会論文集 第 37 回	６．最初と最後の頁 1-3
掲載論文のDOI（デジタルオブジェクト識別子） なし	査読の有無 無
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 －

〔学会発表〕　計3件（うち招待講演　0件／うち国際学会　2件）

1．発表者名 Natthawut Kertkeidkachorn
2．発表標題 FinKG: A Core Financial Knowledge Graph for Financial Analysis
3．学会等名 IEEE 17th International Conference on Semantic Computing（国際学会）
4．発表年 2023年

1．発表者名 Natthawut Kertkeidkachorn
2．発表標題 FinKG-JP: A Japanese Financial Knowledge Graph
3．学会等名 人工知能学会全国大会論文集 第 37 回
4．発表年 2023年

1．発表者名 Rathachai Chawuthai
2．発表標題 Modelling an RDF Knowledge Graph with Transitivity and Symmetry for Bus Route Path Finding
3．学会等名 6th Artificial Intelligence and Cloud Computing Conference（国際学会）
4．発表年 2023年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

―

6．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

7．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関