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ITU-T F.748.34 (06/2024)

SERIES F: Non-telephone telecommunication services

Multimedia services

Requirements for the construction of multimedia knowledge graph database structure based on artificial intelligence

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Recommendation ITU-T F.748.34

Requirements for the construction of multimedia knowledge graph database structure based on artificial intelligence

Summary

Recommendation ITU-T F.748.34 specifies the requirements for effectively constructing a knowledge graph database capable of processing multimedia data using artificial intelligence technology. It specifies the framework and requirements for the construction of the multimedia knowledge graph database.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T F.748.34	2024-06-13	16	11.1002/1000/15913

Keywords

Artificial intelligence, entity relationship, knowledge extraction, knowledge graph, multimedia data.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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Requirements for the construction of multimedia knowledge graph database structure based on artificial intelligence

1 Scope

This Recommendation specifies requirements and framework for the construction of multimedia knowledge graph database structure.

The scope of this Recommendation includes:

– Overview;

– Framework for the construction of multimedia knowledge graph database structure;

– Requirements for the construction of multimedia knowledge graph database structure.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 attribute [b-IEEE 2807]: Describable features.

3.1.2 entity [b-IEEE 2807]: An object existed independently in the real world.

3.1.3 event [b-IEEE 2807]: Changes of things or states comprised by one or more actions with the participation of one or more roles, which occurs at a specific point in time or within a specific geographical area or time period.

3.1.4 knowledge [b-IEEE 2807]: Facts, opinions, actions, or skills acquired through learning, practicing, or exploring.

3.1.5 knowledge fusion [b-IEEE 2807]: An activity that integrates knowledge cell(s) to form a knowledge graph with global unified knowledge identifications.

3.1.6 knowledge graph [b-IEEE 2807]: Assemblies of knowledge elements and their relations described in a structured form.

3.1.7 knowledge modelling [b-IEEE 2807]: An activity that constructs ontology of a knowledge graph and its formal expressions.

3.1.8 knowledge storage [b-IEEE 2807]: An activity that designs the storage architecture and conducts knowledge storing, querying, maintaining, and managing by using software and hardware infrastructures.

3.1.9 ontology [b-ITU-T Y.4500.12]: Formal specification of a conceptualization, i.e., defining concepts as objects with their properties and relationships versus other concepts.

3.1.10 relation [b-IEEE 2807]: Connection between entities, entity types, combination of entities, or combination of entity types.

3.1.11 schema [b-IEEE 2807]: Formalized expression of ontology models.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI Artificial Intelligence

API Application Programming Interface

OCR Optical Character Recognition

SQL Structured Query Language

5 Conventions

In this Recommendation:

– The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

– The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement needs not be present to claim conformance.

– The keywords "**can optionally**" and "**may**" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification

6 Overall framework

The knowledge graph is a series of various diagrams that depict the process of knowledge development and its structural relationships. It employs visualization techniques to describe knowledge resources and their carriers, mining, analysing, constructing, drawing, and displaying knowledge and its interconnections.

While the knowledge graph primarily focuses on displaying textual information, it can also present non-textual multimedia data, such as images, audio and video. This variety of data enriches the knowledge graph's expressiveness, enabling users to learn more comprehensively about entities and their relationships through diverse information forms.

The construction of multimedia knowledge graph database goes through stages such as data acquisition, knowledge modelling, knowledge extraction, knowledge fusion, knowledge evaluation and knowledge storage. The overall framework is shown in Figure 1.

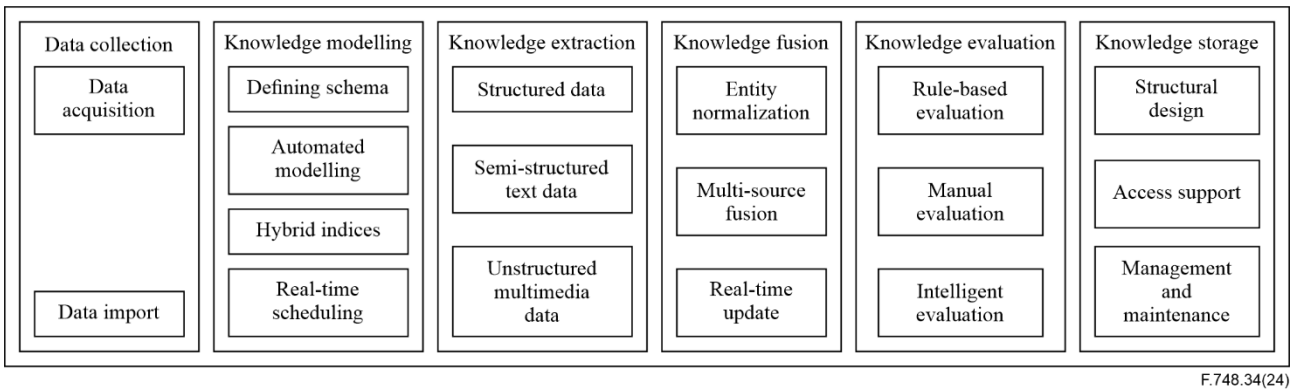

Figure 1 – Overall framework for construction of a multimedia knowledge graph database structure

The functions of each part are as follows:

a) Data collection: Identify the sources of data needed to build the knowledge graph, prepare relevant data, import it, or crawl for it using crawlers and similar tools.

b) Knowledge modelling: Define the entity categories and entity relationship categories in the knowledge graph.

c) Knowledge extraction: Extract knowledge information from structured data, semi-structured data and unstructured multimedia data.

d) Knowledge fusion: Integrate knowledge through the dynamic evolution of multi-source heterogeneous semantics. This process includes conflict detection, consistency checks and knowledge reasoning to determine the accuracy of knowledge, which is then organized into the knowledge base through alignment, association and entity linking, facilitating comprehensive knowledge sharing.

e) Knowledge evaluation: Employ methods to guarantee the quality of knowledge when new knowledge is added to the knowledge graph.

f) Knowledge storage: Store extracted knowledge in a database.

7 Functional requirements

7.1 Data collection

During data collection, it is essential to clearly identify the sources of data for constructing the knowledge graph database. Appropriate acquisition strategies should be developed for different data sources, and data should be collected accordingly. This step sets the foundation for the subsequent construction process, which involves data acquisition and import.

The functional requirements are as follows:

a) It is required to clearly determine the data sources necessary for constructing the knowledge graph, such as unstructured data from literature and books, structured data from databases, and non-text data like images, audio and video.

b) It is required to use de-identification techniques for the organization's internal data before utilization.

c) It is required to acquire data from external partners either through application programming interfaces (APIs) or by data file transfers.

d) It is recommended to import the collected data into databases or storage systems for further analysis.

7.2 Knowledge modelling

During knowledge modelling, business knowledge is first transformed into a graph-based representation. This transformation completes the modelling from structured data to semantic, logic-based knowledge and builds the content of the knowledge graph.

Knowledge modelling includes defining the schema, automating the modelling process, creating hybrid indices and implementing real-time scheduling.

The functional requirements for knowledge modelling are as follows:

a) It is required to support the capability to abstract business domain knowledge into the entities, relationships, attributes and constraints of a graph through the graph's schema modelling ability.

b) It is required to support operations such as the addition, deletion, modification and querying of schema.

c) It is required to support automated knowledge modelling services.

d) It is required to support the capability of index configuration for querying and recall abilities for text, vectors and spatial indices.

e) It is recommended to support knowledge construction through both top-down and bottom-up approaches.

f) It is recommended to support the referencing of existing relationships, entity definitions, etc., from other domains.

g) It is recommended to support multi-person online collaborative editing with real-time updates.

7.3 Knowledge extraction

7.3.1 Structured data

Knowledge extraction of structured data is mainly carried out from relational databases.

It is recommended to map the data directly into the knowledge graph by database tables, fields, Structured Query Language (SQL) queries, and views. If the field corresponds to a foreign key, replace its value with the value corresponding to the foreign key.

7.3.2 Semi-structured text data

Knowledge extraction of semi-unstructured text data is mainly oriented to open linked data, and usually the typical input is natural language or multimedia documents.

Knowledge extraction is generally divided into entity extraction, relation extraction and attribute extraction. Through automatic or semi-automatic technology, available entities, relations and attributes are extracted to form a series of high-quality expression of facts, which lays the foundation for the construction of the upper layer.

The requirements for knowledge extraction for semi-structured text data are as follows:

a) It is recommended to support entity extraction, including Time class, Entity class, and Number class, such as person, place name, organization name, date, time, currency, percentage, etc.

b) It is recommended to support entity disambiguation to solve the situation that entities with multiple meanings can express different meanings in the same document.

c) It is recommended to support entity unification to determine whether multiple entities belong to the same entity.

d) It is recommended to support reference resolution, so that different references representing the same entity can be divided into an equivalent set.

e) It is recommended to support relation extraction, which can extract the relation between entities from the correlative corpus.

7.3.3 Unstructured multimedia data

Knowledge extraction of unstructured multimedia data refers to extracting knowledge from multimedia data such as images, audio and video.

For image data, it is recommended to use optical character recognition (OCR) to recognize the text information in images and extract knowledge according to the above-mentioned knowledge extraction method for text. For some applications, deep learning algorithms can be used to automatically generate text descriptions of images, and then extract knowledge from the description text.

For audio data, it is recommended to use audio-to-text technology to convert audio to text and extract knowledge from the text.

For video data, it is recommended to extract knowledge after obtaining text information from video images and audio data by combining the above methods for image and audio data processing.

7.4 Knowledge fusion

The functional requirements for the knowledge fusion includes entity normalization, multi-source fusion and real-time update.

The requirements are as follows:

a) It is recommended that each entity have unique instances in a homogeneous environment.

b) It is recommended to support fusion of heterogeneous multi-source entities and homogeneous entities under different graph.

c) It is recommended to support the fusion of multi-source knowledge subgraphs by enabling subgraph reduction, graph embedding, and subgraph similarity.

d) It is recommended to support the hierarchical inheritance ability of relation to facilitate concept management.

e) It is recommended to support multilingual knowledge fusion.

f) It is recommended to support the fusion of new knowledge in real time.

7.5 Knowledge evaluation

The knowledge evaluation is used to ensure the quality of knowledge newly added to the knowledge graph. It mainly includes three methods: rule-based evaluation, manual evaluation and intelligent evaluation.

Knowledge evaluation requires the following aspects:

a) It is recommended to utilize rule-based evaluation in conjunction with external interface calls to assess the correctness of knowledge, or to depend on system rules for evaluating aspects such as the timeliness and coverage of knowledge.

b) It is recommended to ensure seamless integration between manual evaluations and the knowledge annotation platform.

c) It is recommended to support unbiased sampling of entities, properties and relationships under certain conditions, facilitating the automatic integration of outsourcing and crowdsourcing evaluations to continuously monitor the quality of knowledge.

d) It is recommended to incorporate intelligent evaluation with algorithmic models for assessing the correctness and structural stability of knowledge.

7.6 Knowledge storage

Knowledge storage is to store the concept layer and data layer of the knowledge graph in a format that can be recognized by the computer. Knowledge storage is a storage method designed for knowledge graph, which can store all kinds of knowledge to support the effective management and calculation of large-scale graph data.

The storage of the knowledge graph does not have to rely on a specific underlying structure, and the general practice is to adopt different underlying storage according to the needs of data and applications. It mainly includes three aspects: structural design, access support, management and maintenance.

The functional requirements for the knowledge storage components of the knowledge graph system are as follows:

a) It is recommended to support scalability to adapt to the growing demands of knowledge over time.

b) It is recommended to support querying, reading, calculating, and applying requirements to facilitate interaction with various storage and computing components.

c) It is recommended to support security, reliability, maintenance, and management by implementing role-based access control, encryption, multi-user capabilities, high availability, and backup and restore functions.

8 Non-functional requirements

8.1 Scalability requirements

The scalability requirements for the AI-based multimedia knowledge graph database structure are as follows:

a) It is recommended to support expansion and contraction at any time according to business needs.

b) It is recommended to support a trusted channel management scheme with an automatic scaling mechanism, thereby achieving the purpose of simple and efficient management of trusted computing channels.

8.2 Reliability requirements

The reliability requirements for the AI-based multimedia knowledge graph database structure are as follows:

a) It is recommended to ensure that data can only be used as agreed upon, to avoid misuse of data.

b) It is recommended to support a multi-data centre coordination mechanism to solve the problem of cross-data centre disaster recovery.

8.3 Compatibility requirements

The compatibility requirements for the AI-based multimedia knowledge graph database structure are as follows:

a) It is recommended to ensure compatibility with mainstream graph query languages and graph analysis tools.

b) It is recommended to operate smoothly on mainstream hardware in the industry.

c) It is recommended to support batch data import and update from multiple data sources.

d) It is recommended to support compatibility with mainstream commercial and open-source community edition operating systems.

8.4 Performance requirements

The performance requirements for the AI-based multimedia knowledge graph database structure are as follows:

a) It is recommended to support solving problems like load balancing, failover and dynamic scaling in online services through a clustering solution.

b) It can optionally support second-level queries for data scales of billions or more.

8.5 Security requirements

The security requirements for the AI-based knowledge graph system are as follows:

a) It is recommended to support encryption transmission and storage of sensitive data in the knowledge graph (such as personal information, business data, etc.), supporting access control to data through encryption and decryption methods.

b) It is recommended to support restricting the transmission of data in the knowledge graph among specific authorized entities.

c) It is recommended to ensure the confidentiality, integrity and availability of knowledge graph data.

d) It is recommended to ensure the confidentiality and integrity of input data and output results of the knowledge graph, ensuring they are not obtained by unauthorized users.

Bibliography

[b-ITU-T Y.4500.12] Recommendation ITU-T Y.4500.12 (2018), *oneM2M base ontology*.

[b-IEEE 2807] IEEE Standard 2807-2022, *IEEE Standard for Framework of Knowledge Graphs.*

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