Railway track video Knowledge Base

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Abstract
A video knowledge graph and a corresponding ontology was created based on railway track videos and infrastructure data. It was shown that the heterogeneous and distributed infrastructure and track data in the railway company, enriched with visualisations such as images and videos, implemented as an RDF/OWL graph, fulfill the required use cases and increases business value. These use cases include tasks such as being able to quickly query the graph for a videos in which specific infrastructure elements occur or being able to search for video sequences that start or end with certain elements.

Keywords
knowledge graph, railway track videos, railway infrastructure, RDF graph, OWL ontology

1. Motivation

Our team, as part of a railway company, is responsible for recording, processing, and providing videos of the German railway network. Video processing includes tasks such as anonymizing individuals and license plates appearing in the videos. Additionally, the recordings need to be associated with corresponding train ride data and prepared before being made available for various projects. This process involves working with a variety of data in different formats from different sources, stored independently. The goal of building a knowledge graph is to harmonize the data used within our team and establish connections between information about the infrastructure of the rail network and the recorded railway track videos.

2. Problem Statement

Monitoring the railway infrastructure is an important part of maintenance. So far, it has been possible to use the videos to search for the elements, but it has not been possible to jump directly to the relevant points in the video. Another requirement is the training of train drivers. Here it is very helpful to be able to use video sequences of special constellations, e.g. passing through a station from the entry signal to the exit signal, especially location-related to the stationing of the train driver. To achieve this, the videos must be linked to the elements of the infrastructure, but also to the information of the railway tracks. These heterogeneous data

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sources are usually distributed throughout the railway company. A harmonized graph-based and queryable data view would cover a multitude of use cases beyond those mentioned.

3. Approach

Firstly the ontology was designed based on the various data sources, modeling different entities and relationships such as signals and stations. The ontology was developed by the team itself, instead of using an external ontology, in order to be able to adapt it exactly to the data. The ontology is built up on the data sources mentioned below. For each train ride, we receive data from LeiDis [1] (Leitsystem Disposition), a control system that monitors the current operations on the rail network. That data includes information about the stations visited during the ride, as well as the date and time at which the train arrived at certain stations. Data about infrastructure occurring at specific kilometer marks along each railway track is derived from so called substitute timetables. These timetables include all the necessary information for a train driver, if he needs to drive a railway track without the modern digital version of these information. Furthermore we can determine for every second of the video the precise location of the train on the railway track, in terms of kilometer position. The graph also incorporates various datasets related to tracks and stations. After converting and harmonizing these data within the knowledge graph, complex queries can now be formed using SPARQL.

The modelling and creation of the ontology associated with the Knowledge Graph were implemented using the Protégé software [2] from the Stanford University, which supports the W3C standards of the RDF format and the OWL Web Ontology Language. After no existing ontology could be found for the specific domain we were describing, we had to build one ourselves. This has been accomplished by following the steps described in the ”Ontology Development 101” Guide [1] from the Stanford University and ideas of the ”Generic Ontology Design Patterns” paper [2]. In order to convert the mentioned data into rdf data, a Python module was developed to collect, process and convert the video specific data into the rdf format. GraphDB [3], based on the RDF4J framework, was used as the triple store, providing a SPARQL endpoint and a web interface for working with RDF triples. The architecture of the knowledge graph itself follows a classical approach described in the paper ”Towards a Definition of Knowledge Graphs” [3] by sending rdf data to GraphDB, that holds the ontology and uses it for deriving new knowledge. To interact with the Knowledge Graph, a REST API and a user interface were created using the FastAPI Python package[4]. This additional frontend, in which various use cases are predefined, also allows non-experts to use the information in Knowledge Graph.

[1]Leitsystem Disposition
[2]Protégé
[3]GraphDB
[4]FastAPI

4. Results

The knowledge graph enables us to quickly execute powerful queries based on the combination of data from the railway track network infrastructure and our videos. For example, a simple query can list the various infrastructure elements occurring in a specific video. This allows us to search for specific types of signals and list videos with timestamps containing those elements. By referring to the timestamp in the video, the corresponding element in the video can be found and visualised, see figure 1. By querying the knowledge graph for videos of a particular element and sorting the results based on the video recording dates, we can also analyze the infrastructure over a specific period. Searching for videos with specific elements or passages through specific stations is particularly useful, especially for training purposes. Additionally, since GPS data about infrastructure elements are also included in the graph, it is possible to search for elements within a certain radius of a position.

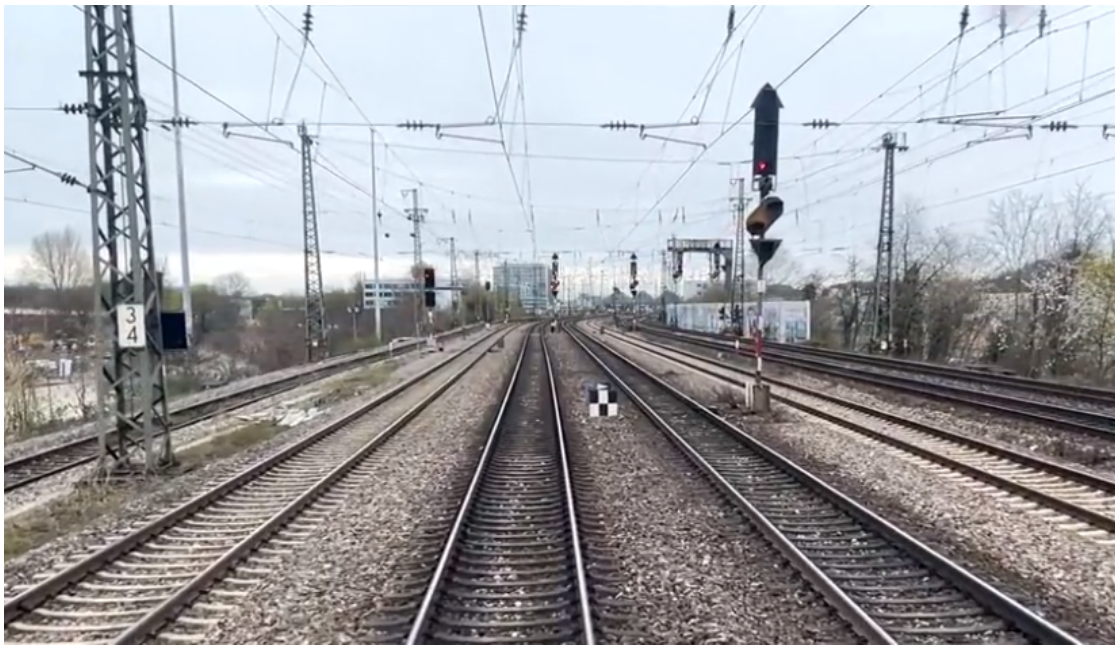

Figure 1: Entry signal in a video, which was found with a query on the knowledge graph.

5. Conclusions

This knowledge graph, developed as part of a bachelor's thesis, offers significant potential, particularly due to the underlying RDF data format and the ease of expanding the graph, extending far beyond its sole use within our team. The graph allows the aggregation of different data from different sources in the rail sector. In addition the corresponding SPARQL endpoint allows us to easily publish the data for others. A possible future improvement to the knowledge graph could be not to use the aforementioned substitute timetables to determine the infrastructure elements in a video, but rather to use AI-based recognition mechanisms to extract the timestamp and position of these elements from the video itself.

The corresponding presentation will be focused on how we used semantic technology to solve a problem, that would have been difficult to implement with traditional tools like a relational database and how we are now able to easily extend the gathered knowledge with more data.

References

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A. Online Resources

- Protégé
- GraphDB
- FastAPI
- LeiDis