This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 957402.

TEAMING.AI 4TH PRESS RELEASE

October 2022

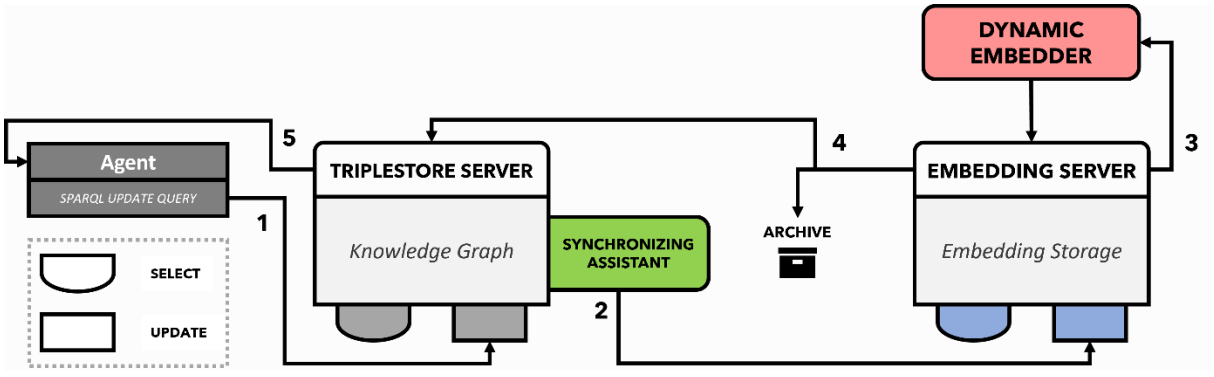
TEAMING.AI Wisdom Engine: Can a shadow cast another shadow?

Knowledge graphs and successive machine learning models represent a topic that has been gaining popularity in recent research. It has been already stated in TEAMING.AI's previous press release that the project will rely on knowledge graphs to conceptualise shared mental models for the collaboration of humans and AI services. In this way, so-called digital shadows of manufacturing domains are created, which are usually applied for managing the corresponding data and to standardize it across the domain.

One step further is to utilise knowledge graphs in combination with relational machine learning techniques for downstream tasks such as question answering or process optimization as well. Such methods are based on knowledge graph embeddings, i.e. numerical representations of the information within the graph, which first have to be learned in a very time- and resource-intensive way. Based on the domain's digital shadow, these representations then provide an additional numerical shadow in the form of feature vectors which can be used directly in statistical analyses or machine learning models.

In fact, this is a very natural approach to decision making, as it resembles human intuition. In order to integrate this intuitive way of thinking into our AI systems, the embeddings need to adapt quickly to dynamic changes in the knowledge graph, which is not feasible with state of the art embedding approaches as they are designed exclusively for stationary knowledge graphs.

For this reason, the consortium in charge of this task has been working intensively over the last few months to determine how the envisioned dynamic knowledge graph can be extended by dynamic embeddings as an associated intuitive shadow without relearning the embeddings after each update to the graph. The architecture of the so-called wisdom engine is depicted in the figure below.



1) The dynamic knowledge graph receives an update request from an agent (human/machine).
2) A synchronizing assistant extracts the actual facts to be inserted and deleted.
3) Based on the updated facts, the embeddings are adapted by a dynamic embedder tool.
4) If the update was successful, the updated facts are added to an archive.
5) The knowledge graph is updated and a response is forwarded to the agent.

In this context, the dynamics of knowledge graph embeddings are insufficiently addressed in the literature and that this topic is often treated as being equivalent to so-called temporal knowledge graph extensions which deal with the deployment of time-related metadata for stationary edges in the graph. Therefore, it was decided to write a position paper[1] on time-awarenes in knowledge graphs which was eventually well received by the Semantic Web community and won the best scientific paper award at this year's SEMANTiCS conference in Vienna.

Further, to achieve dynamic wisdom as a combination of dynamic knowledge and sound judgements via dynamic embeddings, two novel components of the Teaming Engine are being developed.

First, update queries, no matter how complex, need to be transformed in such a way that the facts actually deleted and added become apparent. This is achieved this by transforming contextual data into binary adjacency matrices which can be stored efficiently via sparse representations. Thus, updates in the graph are replaced by simple additions and subtractions of the respective arrays. A prototype has already been developed for some common triplestore frameworks such as Apache Jena Fuseki.

Second, the update matrices are meant to be used for adjusting existing embeddings with regard to evolving environments. Within the wisdom engine's architecture, the dynamic embedder is responsible for this task. It receives the update matrices and the current embeddings as input in order to adapt them accordingly. To ensure that this adaptation can proceed as quickly as possible, the Navi Approach[2] was developed and presented at this year's Extended Semantic Web Conference. This approach provides a surrogate model that reconstructs embeddings independently of themselves but rather based on the embeddings of adjacent nodes. The reconstructions only need to be trained once and can then be applied on-the-fly to dynamically address evolutions in the graph.

In summary, the wisdom engine will ensure that the information encoded within the knowledge graph is extended by dynamic embeddings as intuitive representations. Thus, via continuous observations, the AI systems will be enriched by an experience component which in combination with the encoded knowledge will provide the foundation of wisdom in Teaming.AI.

For additional information please contact

Project Coordinator: Software Competence Center Hagenberg GMBH (SCCH)

Bernhard Moser bernhard.moser@scch.at

Mario Pichler Mario.Pichler@scch.at

Communication and Dissemination Manager: Core Innovation

Ilia Kantartzi ikantartzi@core-innovation.com

[1] https://ebooks.iospress.nl/doi/10.3233/SSW220010
[2] https://doi.org/10.1007/978-3-031-11609-4_36

This project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 957402.

Connect with us