DiMAT

Holistic digital transformation of the SMEs manufacturing industry

Leveraging Knowledge Graphs for Data Representation in Material Manufacturing SMEs

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SMEs operating in the manufacturing domain handle various types of data for their processes. These data pertain to the employed materials defining details such as physical properties, material state, and stock availability as well as the particulars of each step of the manufacturing process, such as device configurations, desired states, order of operation, etc. In addition, during the manufacturing process more data are generated as the end product is produced (e.g., sensor measurements, product properties).

These data are interconnected but this interconnection is oftentimes not evident to the material experts working in SMEs due to outdated formats of data storage and analysis. Understanding this interconnection and developing useful analytic functions can offer valuable insights. These insights can aid the company in organizing more efficiently its operation. Moreover, helpful visualisations can aid in the onboarding process of new personnel by providing intuitive ways of exploring the stored information. Aiming to alleviate the obstacles faced by SMEs we propose the development of various functionalities around a Knowledge Graph database that acts as the storage point of all types of data related to the manufacturing processes.

Knowledge graph databases are NoSQL databases that provide a manner of storing heterogeneous data that highlights their interdependency. In the manufacturing domain there have been some attempts in recent years to represent the acquired knowledge with this particular format.

Organising the data in a graph format, common analytics of graph theory such as community detection and similarity extraction can serve as a foundation for even more complex purposes such as recommender systems. In addition, material ontologies such as the EMMO offer structured ways of referring and representing elements of the manufacturing process enabling interoperability with other systems that are semantically aligned.

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As part of our work in DiMAT project we seek to develop software that will aid SMEs in entering the Industry 4.0 era and overcome common barriers such as resistance to change and inexperienced personnel in the field of computer science. The DiMAT Knowledge Acquisition Framework (DiKAF) is an open-source toolkit with a graph database as a centrepiece. DiKAF goes a step forward compared to other approaches by representing in the same knowledge graph data about materials and industrial business processes, capturing in this way intricate interconnections among materials, devices and steps of the manufacturing process. Around this graph database various functionalities are developed in collaboration with the DiMAT Pilots that provide necessary feedback.

Access to dashboards and visualisations helps DiKAF's users understand the inherent interconnections among various components that affect the business processes. For example, the users can track the available materials and check which products can be produced with the current inventory or they can focus on a specific material and see its properties or other associated information. Moreover, incorporating cutting edge developments in the field of Large Language Models (LLMs), DiKAF offers a chatbot service with which the users can interact and ask questions about the stored information, alleviating the need of knowing the querying language of the database (e.g., Cypher).

Going one step beyond data exploration, DiKAF offers the capability of similarity calculation among the manufactured materials, enabling the users to select the desired properties they want to base their similarity calculation on as well as assign specific weights.

All in all, by introducing DiKAF we aspire to bring the benefits of structured semantic knowledge closer to SMEs in order to help them face the competition and produce products of high quality. This transition to Knowledge Graph representation instead of outdated formats such as Excel datasheets or simple SQL tables can significantly improve SME's data handling and decision making. The developed functionalities can aid the users in understanding complex interdependencies among their data and also extract useful insights. By providing our software as open-source we hope for it to be adopted by various stakeholders active in this domain.

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