Research Activities (project : Knowledge For Retail K4R)

The Semantic Digital Twin for the retail shop scenarios.

Being a Researcher at the University of Bremen, I have worked out approaches in artificial intelligence within the scope of retail and service robotics, these approaches help enable a large-scale platform with enormous change potential under the project : Knowledge4Retail.

Digitization of Stationary Retail Participants of stationary retail, such as customers, store personnel, or store managers, demand for added service quality in their respective field of interest. While customers ask for shopping assistance or recommendations similar to online shopping experiences, store personnel want to know the optimal time to restock shelves with products and store managers want to determine the optimal product placement strategy for a store. The core entity in the semantic Digital Twin is the digital representation of a real store including its layout and offered products, augmented with various spatial, semantic as well as relational information.

Semantic Digital Twin: semDT: A semantic Digital Twin is a symbolic representation of robots, human beings, and their environment as physical elements connected to complementary non-physical entities as well as their properties and interrelations, represented by data structures of Virtual Reality scene graphs. Thereby abstract information associated with the entity of interest can be inferred, reasoned about, and visualised through a variety of media to predict current or future conditions. Particularly, actions can be simulated, and hypothetical scenes can be rendered to support and enhance decision-making.

The scene graph holds information about a product location in relation to a shelf, a shelf layer, or other products on the same shelf layer and allows for optimization thereof. On the other hand, the symbolic knowledge base contains product information like 3D models of all objects, a product taxonomy, an ingredient classification as well as additional product information like product brand or awarded labels. Furthermore, the semDT knowledge base can be linked to store specific information like delivery or sales data. This knowledge can be reasoned about, visualised and modified in various environments from web interface to virtual environment, or applied on different platforms for Augmented Reality as well as robotic store assistance.

The main applications of semDTs in retail stores is to support users in their decision processes, and answer questions like “Which products need to be replenished in which quantity?,” “Which products are lactose-free?,” or “How does product placement influence sales data?.” Furthermore, we show the considerable economic potential of a semDT knowledge base in few example use cases: Replenishment Process Based on inventory as well as delivery data and predefined rules store personnel or robotic assistants can determine the adequate time, order, and destination for restocking of products.

A semantic Digital Twin for retail works as a connection of a scene graph and a symbolic knowledge base based on ontologies. This semantic connection of environment information to product information in a semantic Digital Twin is linked to a symbolic knowledge base consisting of interlinked ontologies.

Semantic Digital Twins can contribute to solving various problems, particularly in logistic processes: Store managers are interested in questions such as “Which products need to be replenished in which quantity?” or “Which products are sold out?” at any time. Retail store personnel or robotic store assistants can pose questions such as “Where should this product be sorted?” or “At what time should which product be restocked?.” Customers may want to know “Where can I find the products from my shopping list?” or “Which products are produced economically?.” Marketing specialists can use semDTs to compare and evaluate store layouts and assess how product positioning influences sales figures. Supply chain managers get optimised stock information to abbreviate order and delivery times and minimise warehouse stock. Software developers in the field of robotics can use semDTs to simulate robot behaviour before applying it to the real robot in the store.

The semantic Digital Twin can be described as a Knowledge Representation and Reasoning (KRR) framework, which is a knowledge base that organises information of different knowledge sources from the literature, perception system, historical data as well as forecasts and other open research data services. Given such foundation, the framework allows investigating and mining hypotheses to support queries of retail business actors and Big-Data-enhanced abstract reasoning tools; for instance, retail-relevant concepts, such as “misplaced objects,” can be inferred if differing products are detected in a facing.

Future Research Activities (Planned / Wish to do)

Considering my previous experience, I would like to keep contributing in to working in new Digital Twins for different domains. The ideology of Digital Twins has huge potential in many different domains. Adding real data (business data) in the research is my main thought when I discuss the Digital Twin.

Many sectors like banking, weather forecast, Cloud Robotics or any system which has many parameters to set up, Digital Twin can play a key role and also getting used already in few of them.

I am also interested in the Data Science field, and also wish to explore the possibilities in association rules which I suppose can add some important elements in the Cognitive Robotics which is already dealing with nearly all areas of topics ranging from sensor processing entities to high-level cognitive skills for navigation, adaptation and machine learning. Also Keen in working with cognitive architectures like ACT-R and SOAR.

But, without any hesitation I wish to learn something new or to explore more on the topics which I have scratched in these few years.