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FACTLOG: ENERGY-AWARE FACTORY ANALYTICS FOR PROCESS INDUSTRIES

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Digital Twins (DTs) are playing a crucial role in the development of the Cognitive Factory in the Industry 4.0 era. By creating virtual representations of physical objects and combining information from both the digital and physical worlds, it is now possible to interconnect all aspects of the production process. However, merely having virtual replicas of physical objects interacting with each other in both realms is not enough to achieve true cognition. To accomplish cognition, it is necessary to model not only the physical attributes but also the behaviors of production elements and processes. This can be achieved through the use of Data Analytics and Machine Learning techniques to create data-driven models, resulting in the emergence of Cognitive Digital Twins.

Further expanding the Cognitive Digital Twins, a new concept called the Enhanced Cognitive Twin (ECT) (Eirinakis et al., 2022; Eirinakis et al., 2020), aims to enhance the Cognitive Factory by introducing advanced cognitive capabilities to the DT artifact by also utilizing analytics, simulation and optimization at the core of the DT. The goal of the ECT is to enable DTs to respond to both internal and external stimuli and support decision-making processes. The ECT, similarly to the CDT, can be implemented at various levels of the production process, including sensor, machine, process, employee, or factory level, and can be aggregated to facilitate horizontal and vertical interactions. The proposed ECT concept is specifically relevant in the context of process industries, where cognition is essential due to the continuous, non-linear, and diverse nature of production processes.

Project Outline and Objectives

The FACTLOG (Energy Aware Factory Analytics for Process Industries) project aims to enhance the cognitive capabilities of process industries by developing and introducing the ECTs that perceive and comprehend the current state of the production process (in the realm of situation-aware manufacturing systems), identify disruptions, project them into the future to evaluate their impact, and in turn support informed decision making on appropriate responses as they optimize and reason in the short-, mid-, and long-term. On that account, FACTLOG major objectives include the definition of the Cognitive Factory framework model to encapsulate the ECT concept that will in-turn enhance factory automation, and to design, develop and deploy a set of services (incl. model-driven and data-driven analytics, robust (re-)optimization, process modeling and simulation) in an easy to adopt manner.

Project Partners and their Roles

The FACTLOG project consists of partners from 11 countries including research institutes, universities, SMEs and large companies. The FACTLOG Project partners and respective offerings are: Maggioli acting as the coordinator and Digital Twins platform provider, Athens University of Economics and Business and University of Piraeus offering the optimization toolkit, Swiss Federal Institute of Technology in Lausanne responsible for the knowledge graphs, Qlector, Jozef Stefan Institute and Nissatech offering technologies on advanced analytics, the Technical University of Crete offering the process model tool, Konnekt-able, Domina, Control 2K Limited and Simavi as technology providers, Jems, BRC, Fratelli Piacenza, Continental Automotive Romania and Tupras as pilots and Unparallel, Hanse-Aerospace Wirtschaftsdienst GmbH and Tages for the wide diffusion of the results.

Project Use Cases and Expected Outcomes

Oil Refineries: Oil refineries operate on a continuous 24/7 basis, processing crude oil to produce various petroleum products. Due to the high levels of energy consumption in these refineries, it is crucial to develop a decision support system that is aware of energy consumption and production quality. Specifically, there is a need for early detection and prediction of out-of-spec LPG production and support for recovering to on-spec production in the most energy-efficient manner. The most important KPIs include production efficiency, off-specs LPG production and response-time on off-specs production.

Textile Industry: In the textile industry, in the weaving process, the set-up times can vary significantly based on the characteristics of two consecutive fabrics produced on the same loom. This variation can have a significant impact on the production efficiency of the weaving process and the production schedule of the multi-step, energy-consuming fabric finishing process. In this pilot, the efficacy of ECTs in modeling and optimizing subsequent processes in the fabric production process is evaluated with KPIs relative to production scheduling and the reduction of wasted energy.

Steel Products Manufacturing: This industry has a need to minimize the environmental impact of its operations. To achieve this goal, ECTs employed aim to optimize the operational capacity and maintenance processes of the steel-cutting and bending machinery. Therefore ECTs in this case aim to maximize the throughput from raw materials to finished products per machine used. To enable this, KPIs relative to the percentage of twinned machines and Tonnes per Person Hour are identified as the most important.

Automotive Industry: The automotive industry strives to minimize downtime caused by equipment breakdowns and improve overall equipment efficiency. To achieve this objective, ECTs are utilized to simulate and optimize the complete set of machines and processes involved in production. These ECTs take into consideration potential breakdowns and preemptive maintenance, with the goal of optimizing production efficiency. KPIs in this case include the percentage of machine downtime, the maintenance costs, the energy cost of idling machines and the overall equipment efficiency.

Sustainability and future work

Having completed the FACTLOG project, a European Economic Interest Grouping (EEIG) will be formed to exploit the outcomes of the projects through each partner acting as a focal point. The main offering will be sold through each technical partner in their respective network (or country / market) and all module providers will be providing their technologies on an ad-hoc manner and pertinent to each new client.

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