Topic 1: How artificial intelligence can improve the management of large projects?

Background

Even though the impact of artificial intelligence, predictive analytics and machine learning has proved to be significant in different areas of automation and engineering, there is a lack of research on their effect on project management.

Research Questions

- How artificial intelligence can improve the management of large projects?
- What aspects in project management can be improved through AI?
- Which factors influence the willingness of projects/project managers to adopt AI?
- How are the correlations of those factors?

Tasks

- Systematic and comparative literature review on the applications of AI and machine learning in project management
- Identification of aspects/factors in project management that can be improved through AI.
- Identification of factors influencing the willingness of project managers/teams to adopt AI
- Survey
- Statistical analysis of survey results to identify the correlations

Starting References

https://medium.com/the-project-office/artificial-intelligence-in-project-management-68ddf2ad91d7

https://www.liquidplanner.com/blog/seven-future-trends-in-project-management/

Topic 2: Managing interoperability in circular economy

Background

The circular economy concept involves collaborations of different human actors and information systems throughout the supply chain. Those different actors and systems need to share reliable data and innovative solutions with each other to improve decision makings and process efficiency. In other domains like healthcare [1], and inter-organization collaboration, ontologies and standards are used to define common understanding on a semantical level.

Those ontologies and standards provide agreed vocabularies that represent entities, processes, and resources in the whole system

Research Questions

- What are typical actors, systems, and solutions involved in the circular economy?
- What vocabularies and relation models are required to facilitate the interoperability of those entities?

Tasks

- Systematic and comparative literature review
- Identification of actors, systems, and exchanged information and solutions between actors/systems
- Identification of common vocabularies to facilitate interoperability
- Development of relation model representing the vocabularies and their relations

Starting References

[1] https://www.sciencedirect.com/science/article/pii/S1877050912004024

[2] https://link.springer.com/chapter/10.1007/978-3-642-15961-9_86

[3] http://ceur-ws.org/Vol-2044/paper10/paper10.html

Topic 3: Handling interoperability in dynamic electricity market

Background

The dynamic electricity market is characterized by the introduction of dynamic electricity price that changes depending on electricity supply and demand. To estimate the electricity price, the involvements of different systems and actors, e.g. electricity provider, consumer, network operator, etc. are required. In order to improve the efficiency of the collaboration between those actors/systems, an approach to facilitate interoperability is required.

Research Questions

- What are typical actors, systems, and solutions involved in the dynamic electricity market?
- What vocabularies and relation models are required to facilitate the interoperability of those entities?
- Which existing vocabularies should be used and how to integrate them?
- How to calculate the dynamic price? Which data are required?

Tasks

- Systematic and comparative literature review
- Identification of actors, systems, and exchanged information and solutions between actors/systems
- Identification of common vocabularies to facilitate interoperability
- Development of relation model representing the vocabularies and their relations
- Development of a calculation model to estimate dynamic price

Starting References

https://energyinformatics.springeropen.com/articles/10.1186/s42162-018-0018-2

Topic 4: The impacts of dynamic electricity price on production planning and control

Background

The introduction of dynamic electricity prices in the manufacturing (energy consumer) requires the production planners to consider the price fluctuation in their production planning and controls. The production processes have to be shifted to the time points where the electricity price is low.

Research questions

- What activities in production planning and control will be influenced by the dynamic electricity price?
- What objectives, variables, and constraints are required to be changed compared to conventional production planning and control?
- How can the production planning and control be optimized?

Tasks

- Systematic and comparative literature review
- Analysis of different dynamic price models and their impacts on planning time horizon
- Identification objectives, variables, and constraints for the optimization
- Development of optimization model

Solving the optimization model using tools, eg. using linear programming, ant colony optimization, etc.

Starting References

https://www.sciencedirect.com/science/article/pii/S2212827116001281

https://publikationen.bibliothek.kit.edu/1000060882

Topic 5: Systematic Literature Review of reference model of Smart Manufacturing standards

Background

Several smart manufacturing architectures, reference models and standard frameworks have been developed by different institutions or standard development organizations (SDOs). Which one is best for which?

Research Questions

- What criteria are suitable to compare Industry 4.0 and smart manufacturing architectures, reference models and standards framework systematically?
- What are the strengths and weaknesses of the standards?
- In which contexts should those standards be applied?

Tasks

- Analysis of requirements criteria to implement smart manufacturing and industry 4.0 standards
- Comparative analysis of the following industry 4.0 and smart manufacturing standards based on identified criteria (entities, processes, resources, architecture, etc.). Standards to be compared:
    - Smart Manufacturing ecosystem (SME), developed by NIST;
    - Reference Architecture Model Industrie 4.0 (RAMI4.0), developed by Industrie 4.0;
    - Intelligent Manufacturing System Architecture (IMSA), developed by MIIT and SAC;
    - Industrial Value Chain Reference Architecture (IVRA), developed by IVI;
    - Industrial Internet Reference Architecture (IIRA), developed by industrial internet consortium (IIC);
    - Framework for Cyber-Physical Systems (F-CPS), developed by Cyber-Physical Systems Public Working Group, Smart Grid and Cyber-Physical Systems Program Office, and Engineering Laboratory, published by NIST;
    - Internet of Things Architectural Reference Model (IoT-ARM), developed by IoT-A project
- Visualization of review results, e.g. using vosviewer, Bibliometrix, etc.
- Critical analysis on weaknesses, strengths and application contexts

Starting references

[1] https://www.sciencedirect.com/science/article/pii/S0166361517302075

[2] https://www.elsevier.com/__data/promis_misc/525444systematicreviewsguide.pdf

Topic 6: Solving interoperability problem in smart manufacturing standards through ontology

Background

There are several standards and scenarios of implementing smart manufacturing for industry 4.0, which involve a lot of entities and resources. The different interpretations of standards may cause the interoperability problem in smart manufacturing.

Research Questions

- What are typical scenarios of implementing smart manufacturing for industry 4.0?
- What causes the interoperability problems in implementing the smart manufacturing?
- What vocabularies and relation models are required to facilitate the interoperability of those entities?

Tasks

- Identification of use cases scenarios in implementation of smart manufacturing for industry 4.0
- Identification of entities, processes, resources involved in smart manufacturing
- Comparative analysis of the following industry 4.0 and smart manufacturing standards based on identified entities, processes, resources, e.g.
    - Smart Manufacturing ecosystem (SME), developed by NIST;
    - Reference Architecture Model Industrie 4.0 (RAMI4.0), developed by Industrie 4.0;
    - Intelligent Manufacturing System Architecture (IMSA), developed by MIIT and SAC;
    - Industrial Value Chain Reference Architecture (IVRA), developed by IVI;
    - Industrial Internet Reference Architecture (IIRA), developed by industrial internet consortium (IIC);
    - Framework for Cyber-Physical Systems (F-CPS), developed by Cyber-Physical Systems Public Working Group, Smart Grid and Cyber-Physical Systems Program Office, and Engineering Laboratory, published by NIST;
    - Internet of Things Architectural Reference Model (IoT-ARM), developed by IoT-A project
- Implementation of interoperability model based on the comparative analysis using ontology. Ontology is a modelling approach to represent entities and relationships similar to ER diagrams.

Starting References

[1] https://www.sciencedirect.com/science/article/pii/S0166361517302075

[2] https://www.tandfonline.com/doi/abs/10.1080/00207543.2014.918287

Topic 7: Managing I4.0 technology interoperability through ontology based database

Background

A lot of new emerging technologies and resources are involved in Industry 4.0, such as IoT, big data, and CPS. The technologies are developed by different vendors with different standards. The differences may cause several issues in the implementation of Industry 4.0 if not well identified, planned and managed. Ontology models have been proven to provide semantic abstraction to address the interoperability.

Research Questions

- What are typical technologies used in industry 4.0?
- What causes the interoperability issues in implementing industry 4.0 technologies?
- What vocabularies, terms, and relations required to provide a common understanding among systems/human actors?
- What model is required to address the interoperability of those entities?

Tasks

- Identification of industry 4.0 components and attributes
- Populate the Industry 4.0 components' database
- Import the database as an ontology
- Mapping of the I4.0 technology resources ontology, , e.g.: mapping of CPS, cloud computing, IoT and big data ontology (with the attributes).

Starting References

https://www.tandfonline.com/doi/abs/10.1080/00207543.2014.918287

Topic 8: Comparative Analysis on ESG ratings assessment methods and criteria

Background

The sustainability performance of a company can be measured using different methods and KPIs developed/issued by ESG ratings providers. It may cause several issues, e.g. inconsistency of ESG ratings, when assessed by different ESG rating providers.

Research Questions

- What are typical methods and scenarios of measuring ESG performance?
- What KPIs are commonly used? Can the KPIs be structured in a taxonomy?
- What vocabularies are required to facilitate the gaps between ESG ratings provided by various providers?

Tasks

- Collecting ESG assessment results information.
- Identification of ESG ratings methods and criteria.
- Comparative analysis of ESG ratings methods and criteria.
- Building the vocabulary and taxonomy of ESG KPIs
- Populate the ESG taxonomy

Starting References

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3438533

Topic 9: Energy consumption and cost prediction of customized products using data analytics or machine learning

Background

To improve the competitiveness in the market, companies transform their business by providing customized product. A stainless steel manufacturing SME, who is currently the leader in a niche market of stainless steel application in the oil and gas industry, provides customized steel products that allow customers to configure the material, size, shape, heat treatment, etc. However, it leads to challenges in estimating the price and energy consumption of the customer configured products individually.

Research Questions

- What variables influence the energy consumption and costs?
- Which data analytics/machine learning methods can be applied to estimate the energy consumption and costs? Which method is the best?
- What would be the actions to save the energy consumption and costs after predicting them?

Tasks

- Comparative literature review
- Data collection, pre-processing, exploratory data analytics
- Building machine learning models
- Evaluation of the models
- Critical analysis of results and actions required to achieve energy and cost-saving

Starting References

https://publikationen.bibliothek.kit.edu/1000060882

Topic 10: NLP framework to analyze sustainability (ESG) reports

Background

The sustainability performance of a company can be measured using different methods and KPIs developed/issued by ESG ratings providers. Those KPIs should be organized in a taxonomy to allow transparent and structured analysis of companies' sustainability performance. The KPIs are mostly presented in companies' annual reports.

Research Questions

- What KPIs should be included for the sustainability performance measurements and how should they be organized?
- What are the keywords and terms in reports that describe the KPIs?
- How to extract the KPI from the reports and populate the taxonomy?

Tasks

- Comparative literature review
- Build the KPI taxonomy
- Collect the NLP corpus from company annual reports
- KPI extraction from the report texts
- Critical analysis of the results

Starting References

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3438533

Topic 11: Forecasting of energy-mix balance in the region of Rheinland Palatine (Rheinland Pfalz) incl. export-import

Background

Dynamic real-time pricing is a method used by electricity providers to promote the use of electricity from renewable energy sources in manufacturing. The electricity price is updated every 15 minutes following the electricity market situation based on electricity supply and demand. To estimate the proper price in the next minutes, hours, and days, an electricity provider needs a forecast of the supply of electricity from renewable sources, including local generation and imports.

Research Questions

- What variables influence the amount of available electricity from renewable sources?
- What data are required to perform forecasting?
- Which forecast method is the best?

Tasks

- Comparative literature review to analyze related works
- Data collection
- Explorative data analysis
- Forecast model building
- Evaluation of the forecast models
- Critical analysis

Starting References

https://link.springer.com/article/10.1057/s41274-016-0149-4

https://www.sciencedirect.com/science/article/pii/S1364032119301807

Topic 12: How to optimize routes in sustainable collaborative city logistics?

Background

Collaborative city logistics integrates different transportation means, e.g. public transports (trams, buses), trucks, bikes, drones, etc., through the collaboration between various city stakeholders, e.g. logistics companies, public transport service providers, individual citizens. The thesis goal is to study the goods movement involving those transportation means, aiming to determine the optimal route from its origin station to its destination station on the designed

network. The optimal route can be determined by lowest costs, shortest time, and lowest CO2 emission.

Research Questions

What would be the best mathematical model to express the optimization of sustainable collaborative city logistics and how to solve it?

Tasks

- Comparative literature review to analyze related works
- Identification of influencing variables
- Definition of objective functions, constraints, and decision variables
- Building the mathematical model
- Solving the mathematical model using solvers, e.g. integer programming, ant colony optimization, genetic algorithm solvers
- Evaluation of the results

Starting References

https://link.springer.com/article/10.1007/s10846-020-01223-y

Topic 13: How COVID-19 give impact to the supply chain of different products (e.g. hygiene, electronics/IT, typical product)? A data analytics approach

Background

The global COVID-19 pandemic has a strong impact to world economy due to the limitation of supply chain activities. The supply chain of certain types of products are negatively affected but not for some other types of product. This thesis focuses on the analysis of the supply chain of different types of products during the global pandemic by analyzing the available data.

Research Questions

- What types of products are strongly affected by the COVID-19 global pandemic?
- How the pandemic affects the supply chain of those products?
- What model can be used to describe the correlations of the pandemic to the supply chain. (note: focus on the different time series models e.g. Holt-Winters, ARIMA, SARIMA, VAR, etc. or regression models, e.g. linear, polynomial, random forest, ridge, etc.)

Tasks

- Comparative literature review to analyze related works
- Identification of supply chain scenarios affected by COVID-19 pandemic
- Data collection
- Exploratory data analysis
- Building the time series and regression models
- Evaluation of the results

Starting References

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7413852/

Topic 14: Opportunities and Challenges of Applying Precision Farming in Global Agriculture Supply Chain: Data analytics approach

Background

Each country in the world has different agricultural characteristics, which is in accordance with the land and soil nature, climate, the crop types, and the social-cultural dimension. An efficient global supply chain can be built by analyzing the country-specific agricultural characteristics and the technological potential such as precision farming.

Research Questions

- Which countries are the sources of which crop types?
- Which countries are the targets of which crop types?
- How is the development of precision farming technologies in those countries?
- How the precision farming technologies can affect the global food supply chain?

Tasks

- Comparative literature review to analyze related works
- Development of general global food supply chain scenarios
- Data collection, e.g. global food agriculture statistics (see the starting references), global economic development, technological potential
- Exploratory data analysis
- Building the data analytics/machine learning models
- Evaluation of the results

Starting References

https://www.kaggle.com/unitednations/global-food-agriculture-statistics

Topic 15: The roles of digital twin in sustainable supply chain

Background

A digital twin can be used as a virtual supply chain replica that consists of hundreds of assets, warehouses, logistics and inventory positions [1]. It is gaining more attention in the industry due to improvements in technical and computational capabilities with operations technology.

Research Questions

- What factors make a supply chain more sustainable?
- What are the requirements for applying digital twins to a supply chain?
- What scenarios in a supply chain can be improved through digital twins?

Tasks

- Comparative literature review on sustainable supply chains and digital twins
- Identification of essential factors in applying digital twins in supply chains
- Development of general sustainable supply chain scenarios
- Two possible methodology
- Cross case analysis: combining literature studies and interview on different supply chain scenarios
- Surveys
- Analysis of literature studies + interview or survey results

Starting References

[1] https://www.supplychaindigital.com/technology/evolution-digital-twins-supply-chain

[2] https://link.springer.com/article/10.1007/s11036-020-01557-9

Other topics (self-defined)

Industry 4.0 Commons

IC01. Readiness vs. willingness to change for industry 4.0
IC02. Industry 4.0 marketplace platform
IC03. Industry 4.0 meets circular economy (self-defined topic)
IC04. Industry 4.0 meets sharing economy (self-defined topic)
IC05. Open Innovation Platform for industry
IC06. Towards Harmonised Characterisation Methodologies and Data Formats
IC07. Industry 4.0 in agriculture – precision farming

Green Manufacturing and Circular Economy

GC01. The role of IoT and big data to green manufacturing
GC02. Materials lifecycle analysis methodology for the circular economy
GC03. Holistic energy-efficient manufacturing system management
GC04. Digital twin applications in sustainable manufacturing

Construction 4.0 and Smart Building

CB01. Industry 4.0 in construction industry (self-defined topic)
CB02. The role of digitization in building retrofitting
CB03. Smart operation of proactive residential buildings needs – challenges in control technologies, predictive maintenance, and data supply for the customer
CB04. Construction by Digital-Twin Reconstruction.