ASDIE: Adaptive and Sustainable Digital Innovations for Fourth Industrial Revolution Ecosystems

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***Abstract*—At the beginning of the 21st century we experience a transformation of industries due to the usage of Artificial Intelligence (AI), Automation and Digital Ecosystems which is compared by some with the impact the steam engine had on the Industrial Revolution, hence the labeling as 4th Industrial Revolution [1].**
However, simultaneously, the ecological conditions are changing on a global scale caused by global warming. This worsens the life conditions in large potion of the globe and is causing massive interventions in modern days societies [2]. In order to tackle those effects and increase environmental friendliness on a larger scale, today's technologies must be designed to cope with those goals as well. This provides, however, several challenges, which need to be addressed by science and industry alike.
The Special track ASDIE, therefore, focuses on technologies which are taking those factors into account and are of high importance for the academic and industrial community.

Keywords*—*Artificial Intelligence, Automation, Autonomous vehicle, PDDL, Circular Economy, Digital and Sustainable Services.

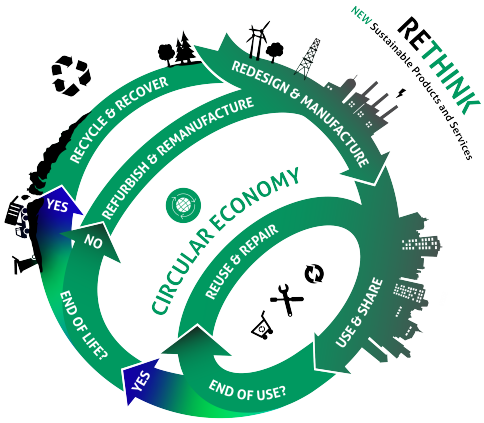

Fig. 1. Circular Economy model for products and goods [4]

I. Introduction

Humankind is facing multiple challenges in the 21st century, caused by rapid developing technology as well as the drastic decline of the quality of life in several parts of the globe caused by global warming and climate change as well as human-caused environmental pollution. In order to tackle the negative effects of this development, innovations and services need to be designed with two additional premises: sustainability and adaptability [3]. Such innovations and services are, therefore, contributing towards a sustainable future and enable the transformation of society as a whole towards a *Circular Economy*, which addresses various fields along a value chain of a product, as shown in Fig. 1.

Especially in the production and logistics industry, innovations can create a major impact in this transition process and enable systems which are highly flexible while also acting as a propellant for a sustainable system transition. Therefore, the aim is to design systems which are both flexible and re-configurable to be applicable in various Use-Cases and simultaneously conceptualize them under the premises to reduce harmful ecological impacts or even mitigate and reduce them [5].

Key technologies, therefore, need to be considered to enable the creation of those innovations and services, of which the most prominent are [6]:

- Artificial Intelligence for designing, assessing, predicting, controlling and planning operations and products
- Cloud-based digital ecosystems for sustainable service development
- Cyber-physical systems enabling the transition from the physical to the digital world

Researchers and companies alike are, therefore, motivated to deal with this interesting and highly relevant topic in order to drive forward the research in this area and enable the design of such solutions. The special track ASDIE is showing exemplary findings, which have been researched in the above-mentioned areas.

II. Contribution

As already stated in the introduction, the contributions are wide-spanning regarding their topics and applications towards adaptive and sustainable systems.

A. Submission no. 1

The first submission, called "Application of a Maneuver-Based Decision-Making Approach for an Autonomous System Using a Learning Approach", is targeted at the area of maneuver-based decision-making in the area of autonomous vehicles. The authors mention the current limitations in classical approaches and state, that learning-based approaches like deep learning (DL) and reinforcement learning (RL) could help tackle the shortcomings of those technologies. These approaches are investigated in an automotive context, namely in the Automatic Emergency Braking (AEB) and the Adaptive Cruise Control (ACC).

To do so, the authors formulated their problem as a Partially Observable Markov Decision Process (POMDP), to enable decision processes under not fully observable states. The authors selected for their simulation two policies, the Policy Gradient (PG) method and the Proximal Policy Optimization Clip (PPO Clip) method, which they used in their scenario and outline the results of their test case. The paper closes with an outline of the key findings of both the applied policies in the RL training architecture and outlines the future research direction [7].

B. Submission no. 2

The second contribution, called "You've Got a Plan? A Domain Modelling Approach for Collaborative Product Disassembly Planning with PDDL", deals with the question on how to design an adaptable system for product disassembly in order to enable sustainable and ecological reuse of the former. The authors state, that these processes are carried out nowadays mostly by manual labor, which can be time-consuming, error-prone and costly. However, in order to cope with the high amount of incoming products, the necessity arises for automated systems, which are capable of dealing with a variety of compositions.

As a core of the concept, an intelligent planning system is proposed, which is able to generate a disassembly sequence. The paper, therefore, presents a meta-model that is able to describe the compositional setup of a product and the corresponding actions to disassemble the connections of the same. As a possible solution for the planning system, the model is implemented into the Planning Domain Definition Language (PDDL) and tested and evaluated in two example disassembly cases. The authors are applying the defined PDDL-Domain and the two different PDDL-Problems via a Best First Width Search (BFWS) Planner in combination with a Fast Forward (ff) parser. Further, the contributions of the paper are addressed as well as the limitations and a future outlook of the research [8].

C. Submission no. 3

Contribution number three, called "Automating Benchmarking Process for Multimodal Large Language Models (MLLMs) in the Context of Waste Disposal", presents a possible approach for automated benchmarking for Multimodal Large Language Models (MLLMs). The authors state, that MLLMs although they are capable of taking in several types of inputs and, therefore, are suitable for carrying out classification tasks. They are, however, struggling with generating accurate results on specific prompts, containing, for example, regional conditions since they are trained on general knowledge.

To tackle this circumstance, the authors propose an approach containing a Large Language Model (LLM) monitoring another one. Further, prompting strategies are leveraged by this approach and regional recycling suggestions could be generated accurately in accordance to the input. The authors show in their work the functionality of the overall approach and evaluate the given examples with different models. From the eight evaluated model, the most accurate one was identified based on the answers, although the researchers pointed out the shortcomings regarding the quality of the classification model. The paper closes with a section regarding future research and the conclusion [9].

D. Submission no. 4

The fourth contribution, called "Integrative Development and Evaluation of V2X Communication Architectures to Support Autonomous Driving Systems in 5G Campus Networks", to the special track is presenting an upcoming research project focusing on Cellular Vehicle-to-Everything (C-V2X) for autonomous driving. The project is planned to be conducted via a 5G communication infrastructure located in Wolfenbüttel and aims to investigate different, more complex scenarios, so-called Day-2-Use-Cases for vehicle communication. The authors state, that for those kind of scenarios and data transmission capabilities of 4G communications are lacking the necessary performance. Further, the core research question regarding the quality, impact and applicability of the proposed network are introduced.

The paper contains as well a description of the scenario and addresses the requirements for the autonomous vehicle system communications, including incoming data from other systems in the ecosystem like traffic management as well as outgoing data recorded by the sensor array of the vehicle itself. The authors point out in the conclusion, that 5G communication can leverage interconnected mobility ecosystems on a new level by applying further methods, like Network Slicing, to address stability issues. Thereby, 5G is expected to play a major role in future mobility communications [10].

III. Conclusion

The special track shows examples of the above mentioned research focus in the area of adaptable and sustainable innovations and services and identifies some of the core research

domains in this direction. It, therefore, contains contributions, spanning from digital, sustainable services to innovations in the field of autonomous vehicles. As future research areas, the following directions can be identified:

- Artificial Intelligence proves to be one of the major propellants of this transformation process.
- Digital Ecosystems are building the organisational frame for multiple applications and enable flexible and adaptable systems.
- Data, both historical and real-time is as expected key in various applications.
- Networks and system interconnection will become more and more prominent due to an increasingly connected world.
- System autonomy is one of the key enablers for adaptable systems.

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