CALL FOR PROPOSALS

INNOVATION SCHEMES – CATALOGUE OF CHALLENGES

ENFIELD: EUROPEAN LIGHTHOUSE TO MANIFEST TRUSTWORTHY AND GREEN AI

Co-funded by
the European Union

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INTRODUCTION

This is the first out of two open calls for innovation proposals from legal entities under the ENFIELD[1] (European Lighthouse to Manifest Trustworthy and Green AI) project, co-funded by the European Union. Through the ENFIELD Innovation Scheme open calls and the Financial Support to Third Parties (FSTP) mechanism, the project aims to attract the research/industry partners to conduct applied research related to specific scientific/technological challenges within the sectors of energy, healthcare, manufacturing, and space, contributing to the creation of ENFIELD network and the adoption of AI technologies to boost overall EU.

[1] Grant Agreement nº 101120657, funded by the European Union.

Vertical Healthcare

VH.1 - Enhancing Drug Development Through AI

Keywords: Drug Discovery, Personalized Medicine, Artificial Intelligence, Chemical Data, Biomolecules

STATE-OF-THE-ART

When disease prevention is not possible, there is a need for drug usage to reduce symptoms and/or treat the disease until a healthy state. Inventing new drugs that are better and/or more affordable than current options is a difficult challenge for scientists and industry because of complex process of synthesis, purification, assessment of ADMET properties and clinical testing. The increasing growth of the amount of data that is shared through various databases and the networking of scientists has enabled the ever-better application of artificial intelligence, which provides new and different insights from the point of view of machine learning models.

SCIENTIFIC CHALLENGES

Even though the healthcare sector transforms rapidly and tries to cope with the on-going trends in technology to enhance disease prevention, there is still massive need for drug treatment and personalized medicine. Use of artificial intelligence accomplished to contribute to having more rapid and cost-effective drug development. Apart from drug development which includes inventing the new structures and defining synthesis mechanisms, there are many applications of artificial intelligence in detecting biomolecules in human samples as a way of early detection or an alert for certain diseases. By analysing large amount of genetic data there are more insights available, and treatment can be personalised and improved. Artificial intelligence can detect subtle patterns and those can be used in the development of personalized drugs and treatment with personalized concentration and intake.

EXPECTED RESULTS

With the use of artificial intelligence, together with chemical and biochemical data, this innovation aims to overcome barriers related to drug development in a way that is faster, more efficient, greener, less toxic, and cost-effective. The goal is to **develop and test new algorithms with which an improvement in drug development can be made**, be it in laboratory conditions where trials and errors can be minimized in the process of new drug development, or in the application of personalized medicine with the choosing of proper drugs and treatment based on the individual's data, where all the guidelines of data protection need to be followed.

POSSIBLE OWNER/MENTOR INSTITUTION

Know Center (https://www.know-center.at/en/)

Vertical Healthcare

VH.2 - Enhancing Healthcare Accessibility Through AI-Driven Telemedicine

Keywords: Telemedicine, Diagnostic methods, Information and Communication technologies, Predictive Modelling, Edge Computing

STATE-OF-THE-ART

Current telemedicine encompasses a wide variety of applications such as telemonitoring or teleconferencing. Such provision or support of healthcare services with the help of information and communication technologies is dealing the connection between patient and healthcare service providers or between healthcare providers directly. A barrier often is the secure transmission of medical data for the prevention, diagnosis, or treatment. Telemedicine offers potential for fast high-quality and low-cost provision and support of healthcare services.

SCIENTIFIC CHALLENGES

Most often telemedicine takes place in the field of chronic diseases such as cardiovascular diseases and diabetes. Traditional pain management methods mostly rely on medication, and there is more and more need for innovative and non-pharmacological approach to address pain, especially in chronic conditions. Virtual reality can be used for pain management in a way to distract the patient from the pain. Current diagnostic methods may be resource-intensive and not readily available, particularly in regions with limited access to specialized medical infrastructure. Key elements include the development of strategies for efficient data exploration and the use of AI capabilities for improved decision support. These challenges require interdisciplinary collaboration and the development of methodologies to realize AI in telemedicine.

EXPECTED RESULTS

With the use of telemedicine this innovation aims to overcome barriers related to access to specialized medical infrastructure, especially in regions with limited resources. Remote consultations and care delivery between professionals and patients in telemedicine can overcome the lack of healthcare services in underserved areas and improve quality of life. Within this innovation the goal is to **develop strategies for efficient exploration of medical data** by using artificial intelligence for analysing large datasets and information extraction. This could help optimize and speed up decision-making processes in healthcare by providing healthcare professionals improved guidance and recommendations for diagnosis, treatment plan and patient care management. All of this can lead to more accurate and timely interventions ultimately improving patient outcomes. Addressing all the challenges in telemedicine requires interdisciplinary collaboration. By bringing together experts from various fields such as medicine, technology, data science, and engineering, the project aims to **develop comprehensive solutions that effectively integrate innovation into healthcare delivery**. Vital aspects when deploying artificial intelligence in healthcare are implementing ethical practices and ensuring patient privacy and consent.

POSSIBLE OWNER/MENTOR INSTITUTION

Know Center (https://www.know-center.at/en/)

VE.1 - Defining Physical Parameters of the Electrical Grid
Keywords: Low-voltage observability, network topology, Grid management, Edge processing, short-circuit impedance
STATE-OF-THE-ART
Low-voltage network observability presents one of the hot topics in grid management. Research work in enhancing network observability led to the emergence of several solutions, currently available on the market, which primarily rely on smart meter data for conducting analysis. Some companies integrate additional data sources, such as GIS, to their solutions. These solutions are targeting the low-voltage grid with the goal of providing maximum insight through direct data processing and digital modelling (digital twins). These solutions largely converge on a shared methodology of harnessing available smart meter data and conducting analyses based on it, but none of them tackle the absence of high-fidelity measurements with high time resolution.
SCIENTIFIC CHALLENGES
Low-voltage network observability presents an important area within the green transition. Real-world information is merged with digital twin simulations to increase observability and awareness of the electrical grid. To produce meaningful outputs, digital twins require a consistent and robust flow of valid metering data (provided). Simplifications must be introduced to the otherwise complex grid model to enable reasonable calculation times, e.g., using theoretical values for short-circuit line impedance. These limit the digital twin precision which results in inconsistent simulation outcomes. One of the main challenges the utility companies have is insufficient frequency and volume of data transfer. Edge processing (provided) would significantly decrease the needed communication traffic between the devices and backend and would increase data fidelity. This would widen the spectrum of obtainable information about the network and its topology, and provide the means to identify power theft, high-impedance faults and estimate technical losses.
EXPECTED RESULTS
The goals are to (i) utilize the edge processing capacity of metering devices by embedding a portion of the required analysis directly within them, and (ii) to **develop AI/ML based algorithms** to achieve a more granular understanding of the network, including estimation of network topology, i.e., phases, feeder connections and short-circuit impedance estimation, and improved fault detection. The **expected outcome are algorithms and methods to be applied to edge devices on smart energy meters** to address the following issues: Using smart meter data to calculate physical grid short-circuit impedance, AI to detect grid faults, tempering and other anomaly detection, federated learning to constantly improve and evaluate the short circuit impedance values.
POSSIBLE OWNER/MENTOR INSTITUTION
Iskraemeco d.d. (https://iskraemeco.com/)

VE.2 - Heed on Early Signs of Energy Poverty
Keywords: energy; poverty; efficiency; welfare; people centric
STATE-OF-THE-ART
AI techniques have increasingly been applied to Energy Poverty alleviation, yet there is not a high number of works that apply to the subject as a multidimensional phenomenon. It was found that Neural Networks models were the most used for low-income, energy price and poor energy efficiency characterizations. Support Vector Machines-based algorithms were most popular applied on energy consumption problems. Deep learning was the most used for detecting energy billing irregularities and unpaid bills. Advances, mainly predicting which families will go into Energy Poverty will help governments and utilities prepare adequate economic strategies. The main barrier is handling personal data.
SCIENTIFIC CHALLENGES
Regressive AI models can easily help on the process but, for a wide and fair application, these models need to commit to Green, Human-Centric, and Trustworthy AI, as defined on ENFIELD. Green AI algorithms use should be made applicable, since it is to be used in several entities (Regulators, Utilities, Municipalities, NGO, etc.) where low processing power is available. Privacy should always be respected, and social bias avoided, or the model will fail its trustworthy targets. Federated reinforcement learning may be applied to the case, so that higher improvement rates may be accomplished in less time but respecting the human-centric approach. A Data Space reference architecture approach is preferred to the application of this use case, so that data can be kept at its original place. Besides predicting if a family will run into a stage of Energy Poverty, the models should help deciding if Social Tariff could be applied already.
EXPECTED RESULTS
Energy poverty occurs when a household must reduce its energy consumption to a degree that negatively impacts the inhabitants' health and wellbeing[1]. By addressing the problem from the prediction perspective, based on data, ENFIELD is addressing the EC policies regarding *Social Welfare* and *Clean Energy for all*, leveraging Economy through Data Science and technology. The effectiveness of this aim will be visible from the **success of replication of the model(s) to other European geographies** by the organizations abovementioned. The model(s) will work as a base for fair government decisions, taking on ENFIELD pillars of Green, Human-Centric, and Trustworthy AI use.
POSSIBLE OWNER/MENTOR INSTITUTION
EDP CNET (https://www.edp.com/en/innovation/NEW)

VE.3 - Smart Management of an Electrical Factory (micro-grids) of Modern Ship
Keywords: Energy management; Ship micro-grids; multi-objectives optimization; Hybrid energy Storage System; Decision making tool.
STATE-OF-THE-ART
The advancement in energy management encompasses a multifaceted approach, embracing a blend of fossil and renewable energy sources alongside decentralized energy production methodologies in factories, combining heat and power systems (CHP), photovoltaic systems (PV) and energy oriented PPC (Production Planning and Control). Central to this framework is an Energy Management System responsible for the comprehensive collection, processing, visualization, and archival of energy data. By leveraging conventional techniques like MINLP and MILP (Mixed Integer Non/linear Programming), and Fuzzy Logic, alongside multi-criteria optimization approaches and heuristic algorithms, the system minimizes power generation costs while maximizing equipment longevity. Additionally, investigation of machine learning methods (e.g.., RBF NN, RNN, MLP and reinforcement learning) has shown promise in simulation environments, but real-world testing is necessary to validate their efficacy and uncover potential limitations.
SCIENTIFIC CHALLENGES
Electrical technologies are becoming increasingly popular in the transport sector. After the tremendous developments for the electric vehicle sector, these technologies start to rise for the maritime transport, as they offer a promising solution for improving energy efficiency and reducing CO2 emissions. Thus, an increasing number of ships are now equipped with variable speed drives for loads such as pumps, fans, thrusters, propellers, and so on, known as ship microgrids. Microgrids have the advantages of being flexible, environmentally friendly, and self-sufficient and can improve the power system performance metrics such as resiliency and reliability. However, their design and implementation are always faced with different challenges considering the uncertainties associated with loads and renewable energy resources (RERs), sudden load variations, energy management of several energy resources, etc. Therefore, it is required to employ such rapid and accurate methods, as artificial intelligence (AI) techniques, to address these challenges and improve the MG's efficiency, stability, security, and reliability.
EXPECTED RESULTS
This use case aims to investigate innovative AI-based approaches to perform smart management of the energy use for a given ship, and to be able to predict and manage the use of consumers and recharges as effectively as possible. The work will focus on **optimization processes when dealing with complex hybridization of energy resources** (electric, hydrogen, fuel…), which is often used as a mix in modern ships. This may include improvements in the energy system modelling, new strategies for load sharing and load-shedding, the optimization of energy storage strategies and battery use. The goal is to **develop algorithms that are highly reliable, time-critical, and computationally not very complex**. Terrestrial microgrids have similar requirements in terms of communications and thus, similar methods, developed for terrestrial microgrids, can be adopted for ship microgrids. For instance: • AI-based solutions to design, manufacture, develop, and operate new generations of industrial systems efficiently, reliably, and durably as possible. • Propulsion energy sizing tool, coupled with multi-objective algorithms that can be used to propose a pre-optimized design. • The shipboard HESS that can shift the peak load demand into different time-intervals allowing onboard generation that can operate in an economic and environmental way. • A decision-making tool such as digital twin that supports the operator in to switching to the best energy source use as a function of the current configuration: speed, weather conditions, suggested time of arrival.
POSSIBLE OWNER/MENTOR INSTITUTION
Predict – iQANTO (https://www.snef.fr/iqanto/en/)

Vertical Manufacturing

VM.1 - Low-Volume Training Dataset for Computer Vision

Keywords: Computer Vision; YOLO; quality control; defect detection; object classification.

STATE-OF-THE-ART

CNNs, notably YOLO algorithms, enhance defect detection, enabling object identification, as simultaneous detection and classification, reducing computational load. Advancements in Faster R-CNN and SSD improve accuracy and speed by leveraging ResNet and MobileNet for feature extraction. Transfer learning, via pre-training on datasets like ImageNet, mitigates data scarcity challenges. Explainable AI methods like Grad-CAM enhance transparency in decision-making, aiding human oversight. In summary, CNNs, transfer learning, and explainable AI, including YOLO algorithms, significantly elevate computer vision-based quality control in manufacturing.

SCIENTIFIC CHALLENGES

In low-volume manufacturing or niche product lines, acquiring labelled data for training neural network models can be challenging, leading to overfitting and limited performance. Ensuring diverse and representative training data is crucial for reliable computer vision models. Biases or gaps in data can hinder defect detection, causing false results in quality control. Updating training datasets to match evolving manufacturing processes and defect types is essential. Collaboration between engineers, data scientists, and experts is vital for developing robust methods and enhancing computer vision systems. This includes improving data collection, annotation, and leveraging techniques like transfer learning for scalable quality control in low-volume manufacturing.

EXPECTED RESULTS

Development of an algorithm able to recognise defected parts and to classify the defects, starting from a limited size database (~1000 total samples). Samples available from demanufactured PCB components or from real manufactured mechanical parts. A comparative analysis of different algorithms and methodologies used is also supposed to be delivered as **a peer-reviewed publication**.

POSSIBLE OWNER/MENTOR INSTITUTION

Politecnico di Milano (https://www.som.polimi.it/)

Vertical Space

VS.1 - AI Satellite On-Board Processing Model for Cloud and Cloud Shadow Masking on Hyperspectral Images with a Metadata Perspective
Keywords: Artificial Intelligence, hyperspectral images, cloud masking, on-board processing, Green AI
STATE-OF-THE-ART
Currently, industry employs components-of-the-shelf (COTS) for on-board processing such as VPUs, FPGAs and GPU-based processing platforms. Each of those COTS offers different capabilities with different power consumption requirements. To ensure no loss of features satellites are keeping raw image files in-memory, which results in greater needs in terms of computational power when processing. Model-wise, SVM-based hardware accelerators, spatial enhanced Random Forest and lite architectures of deep neural networks are widely used.
SCIENTIFIC CHALLENGES
Satellite on-board processing often requires high power consumption or lacks in terms of computational power for AI tasks. Optical sensors, since their dawn, are suffering from cloud coverage resulting in unusable raster images. Cloud masking and Cloud shadow masking is a procedure enhancing the provision of Analysis Ready Data (ARD) to users. In addition, hyperspectral sensors are adding more complexity in detecting/classifying clouds and cloud shadows due to their high dimensionality regarding number of available bands (features). The main objective of this ENFIELD use case is the development of a lite AI model for the delivery of ARD hyperspectral data directly from the hyperspectral satellites by generating on-board cloud and cloud shadow masks accompanied by metadata for easier utilization in different applications.
EXPECTED RESULTS
This use case aims to **investigate innovative AI-based approaches** and feature selection approaches to reduce the dimensionality of hyperspectral images. The combination of novel AI with feature selection will contribute with an innovative lite on-board AI model for hyperspectral images pre-processing, in concern to Green AI. At the end of this use case, the following must be accomplished: 1) A **comprehensive evaluation of different Feature Selection methodologies** to find the most appropriate for this specific task. 2) A **lite AI model** with the combination of feature selection 3) Potentially a journal publication.
POSSIBLE OWNER/MENTOR INSTITUTION
ERATOSTHENES Centre of Excellence – EcoE (https://www.eratosthenes.org.cy/)