C.1. Artificial Intelligence and Machine Learning

Artificial Intelligence , Machine Learning and SE processes. Projects involving machine learning, or more broadly AI are becoming ubiquitous. Lifecycle models have been developed specifically for "Data Science" projects. This stream invites presentations on what can we learn from Systems Engineering to applications and lead to successful AI projects.

Lead: Andrew Madry, Jawahar Bhalla
Domains: Digital Engineering, All domains welcome

Submissions Summary:

1. Scalable AI-Based Chiller Optimization System for Enhanced Energy Performance (Full Paper)
2. Application of Large Language Model - requirement management and system assurance on major infrastructure projects (Panels and Workshops)
3. Binary classification of mine-like-objects within side scan sonar images using deep learning algorithms. (Paperless Presentations)
4. A Framework for the Assurance of Simulated Environments Supporting Assurance Certification of Autonomous Systems (Full Paper)

21181 Scalable AI-Based Chiller Optimization System for Enhanced Energy Performance

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Keywords: Artificial Intelligence,Neural Networks,Air-conditioning,Genetic Algorithm,Evolutionary Computation

Type: Full Paper
Stream submitted: C.1. Artificial Intelligence and Machine Learning

Overview Chiller plants in buildings consume the greatest electrical power in Air-conditioning system, playing a pivotal role in our journey towards carbon neutrality. Chiller plants have conventionally been controlled using traditional rule-based strategies, resulting in energy inefficiency and limiting system adaptability to environmental changes. This paper reveals the success of implementing Artificial Intelligence-based model for large-scale real-time monitoring and control of chiller plant which seizes every opportunity to enhance building energy performance. Context With the introduction of modern high-efficiency chillers and a central Regional Digital Control Centre, there is an opportunity to implement control strategies to achieve energy saving by varying Coefficient of Performance under different part-load and ambient weather conditions. To acquire optimized chiller parameters, there were past trials using Genetic Algorithm (GA), Particle Swarm Optimisation (PSO), or combination of both in achieving optimisation of engineering systems. Purpose This study aims to develop a scalable system, code-named ChillStream, based on the novelty in Artificial Intelligence (AI) chiller optimisation. Artificial Neural Networks were trained using historical plant data and weather data to predict power consumption and cooling load for individual chillers. In an attempt to combine the merits of evolutionary algorithm and swarm intelligence, a hybrid GA-PSO Algorithm was developed to calculate optimised setpoints at regular time intervals. Approach The developed AI control strategy was successfully deployed in a chiller plant with a significant cooling capacity installed in a clinical laboratory building in Hong Kong. Compared to the conventional rule-based system control, the chiller plants overall energy consumption was prominently reduced by 8% in autumn/winter 2023. Insights Through the autonomy of ChillStream to operate the chiller plant, considerable manpower resources are saved. This optimisation control strategy can be readily replicated and adjusted to accommodate the unique configurations of chiller plants in various buildings, resulting in substantial energy savings.

20898 Application of Large Language Model - requirement management and system assurance on major infrastructure projects

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Keywords:

Type: Panels and Workshops
Stream submitted: C.1. Artificial Intelligence and Machine Learning

A key challenge of major infrastructure delivery is the sheer volume of requirements that resides across multiple contract documentation, scope of works technical criteria, guidelines, standards, specifications and drawings. A lot of these requirements are project, proponent and/or jurisdictional specific. As an example North East Link (NEL) requirements covers multiple asset owners: VicTrack, Department of Justice and Community Services (DJCS), Department of Transport and Planning(DTP); and NEL Central Package (Spark Consortium); and State Tollroad Corporation (STC) With advancement in cloud infrastructure and Artificial Intelligence (AI) cost effective Large Language Model (LLM) services are now readily available in the market e.g. Open AI, Google, Microsoft, Facebook, Amazon. This workshop provides the target audience a hands on guide to how to apply different availableLLM as "co-pilot for system assurance/requirement management activities. This workshop will use current transport infrastructure examples to illustrate the pros and cons(key limitations) against various system assurance use cases. The workshop will conclude with targeted "hands on" LLM tutorial enabling participant toexperience the LLM on an example set ofpre-canned system assurance scenarios and get insight on how this can benefit their day to day SE&A activities.

20894 Binary classification of mine-like-objects within side scan sonar images using deep learning algorithms.

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Keywords:

Type: Paperless Presentations
Stream submitted: C.1. Artificial Intelligence and Machine Learning

The interpretation of imagery produced by autonomous underwater vehicle side scanning sonar system used for locating anti-shipping mines is a crucial operation for naval safety. Deep learning algorithms have shown potential to identify mine like objects within sonar imagery at a rapid pace with consistent results and with minimal human operator interaction. Traditional methods involved the technical operator manually scanning through a large dataset of sonar imagery. Increasingly, the Navy are looking to employ autonomous underwater vehicles fitted with side scanning sonar to perform remote sensing in the search for mines. The fact that side scanning sonar imagery is not available for inspection by the operators until after the mission has concluded and the vehicle has returned, add to onerous nature of this task. The purpose of this exercise was to perform a binary classification task to classify images as either containing a mine like object or not. Are deep learning algorithms more efficient at analysing sonar images and what are the limitations facing these algorithms now. The Convolution Neural Network model would be trained using sonar images that either contain a mine like object or none, the model would then be evaluated on its ability to classify images with mine like objects within a separate dataset. The results were then compared with a real-world operator attempting to manually complete the same task. Within the scope of testing conducted, the Convolution Neural Network tended to be more liberal in its classifications, as it displayed a higher false positive rate in comparison to the human classifier. Overall, the Convolution Neural Network showed good potential for operational use. Predictably, the performance of the Convolution Neural Network appeared to improve as the quality and quantity of training images increased.

20608 A Framework for the Assurance of Simulated Environments Supporting Assurance Certification of Autonomous Systems

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Keywords: Autonomous Systems,Verification Validation and Accreditation,AI/ML,Modelling and Simulation,AS4AI

Type: Full Paper
Stream submitted: C.2. Autonomy

The burgeoning adoption of Robotic and Autonomous Systems with Artificial Intelligence (RAS-AI) necessitates standardized approaches for Systems Engineering of AI-intensive systems (SE4AI) and Assurance of AI-intensive systems (As4AI). There is an increasing recognition of the need to employ simulated environments in an As4AI context, which in turn necessitates standardized approaches for the Systems Engineering of simulated environments (SE4SimE) and Assurance of Simulated Environments (As4SimE). This paper outlines a conceptual framework and methodology for the assurance of simulated environments (As4SimE) used in the assurance certification of (maritime) autonomous systems. It does this by first contextualizing As4AI in a (maritime) autonomous systems context, to highlight the need for simulated environments, and in the need for an associated As4SimE framework. This is followed by a literature and market review to identify enabling concepts and to identify gaps in available assurance capabilities. The core of the paper builds on these concepts to propose a generic As4SimE framework that can encapsulate all the aspects necessary for the certification of a simulated environment that may be employed to demonstrate compliance against a specific set of regulatory requirements in an As4AI context, supporting the conduct of a set of selected operational scenarios.The primary outcome from this As4SimE activity is a Certified Simulated Environment (C-SimE) that can then be selected (from a list of C-SimEs) to form a MAS Assurance Plan (MAP), that through the conduct of supported scenarios, in associated C-SimEs, collectively enable a compliance demonstration activity for a specific autonomous system. This includes associated processes, tools, techniques, and curation of reference technical data and assurance reports. The paper concludes with a summary and suggestions for future research.
