Collaborative Research: FW-HTF-P: IntelEUI: Artificial Intelligence and Extended Reality to Enhance Workforce Productivity for the Energy and Utilities Industry

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GOALS

- Design an innovative framework for efficient & effective industrial training by integrating artificial intelligence (AI) with extended reality (XR) and implement a basic prototype of the framework.
- Collect, explore, and analyze systems' failure and maintenance data from stakeholders to design and implement a robust predictive maintenance framework using a machine learning approach.
- Evaluate training framework design and its prototype along with social and economic impact.

RESEARCH QUESTIONS

- Does the training framework prototype of IntelEUI improve the training experience in EUIs compared to traditional approaches?
- Is the predictive maintenance framework explainable? Does it improve stakeholders' confidence in decision-making for equipment maintenance?

WORK CONTEXT

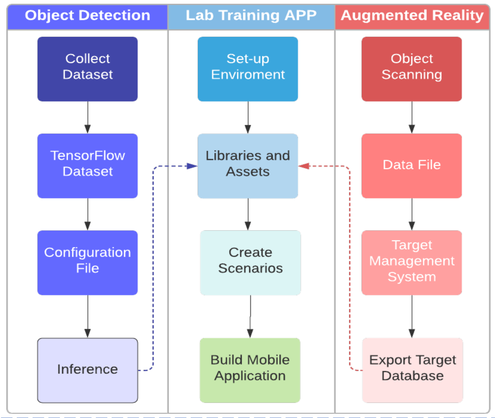
Energy and Utilities industries (EUIs) involve in generation, transmission, and distribution of electricity and natural gas.

- Future Technology: new methodologies devised and emerging technologies integrated to enhance workforce productivity in EUIs to smart and efficient energy distribution and management.
- Future Workers: advanced workforce development by improving training through integrating XR and AI to minimize operational costs, improve safety, and broaden the types of services offered in EUIs.
- Future Work: an ML based smart predictive maintenance framework for EUIs that can address challenges such as data scarcity, lack of machine failure data, and limited feature engineering.

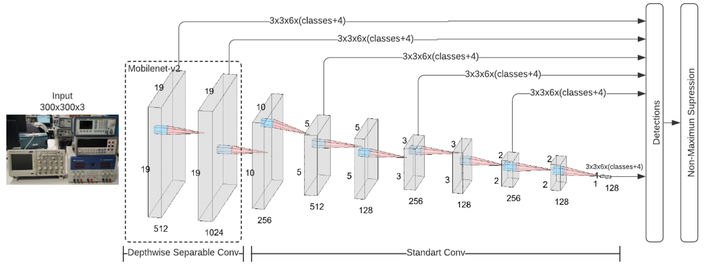
METHODOLOGY

Implemented a prototype of an AI integrated augmented reality (AR), and built a superimposition-based AR app tutorial of lab equipment.

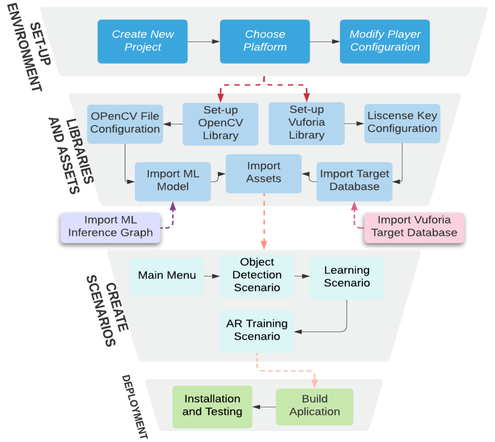
- Built AI-powered smart framework that can automatically identify machines/devices from images/videos in real-time, and provide interactive operational tutorial by incorporating novel deep learning and XR technologies.
- MobileNet-SSD based deep learning technique is employed to perform real-time object detection task, and Progressively Expanded Deep Neural Network is being embedded to improve detection accuracy.
- Developed a Convolutional Long Short-Term Memory based few short learning model and applied it to a publicly available dataset, with successful results.
- A survey is developed to measure outcomes of the XR training tool on the user experience, including usability, engagement, trust of the system, satisfaction, user mental workload and cognitive fatigue, and open-ended questions regarding suggestions for system improvement.



Framework Design of AR Training Mobile Application

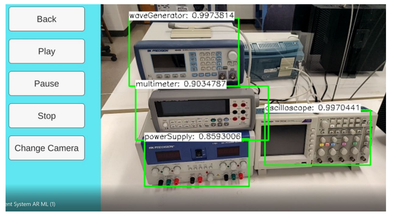


MobileNet- SSD based Deep Neural Network Architecture

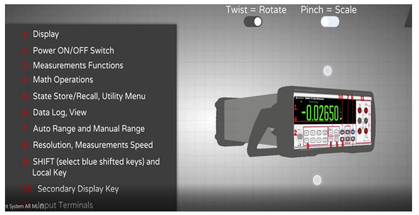


Equipment Tutorial Application Framework

RESULTS



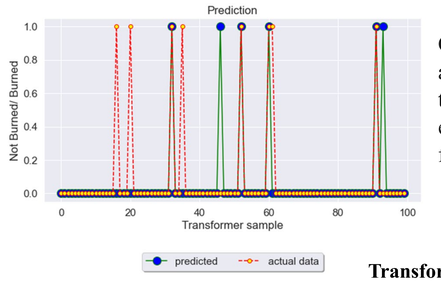
Equipment Detection



Learning Interactive Scenario

AI Integrated AR Training Scenario

3D model is superimposed on top of the physical object in the mobile app. It will also include a GUI for the user to interact with, allowing them to understand and explore the physical object, while the mobile application provides additional information in the form of holograms.



Transformers Failure Prediction

Our developed deep learning model achieved 96% accuracy for transformer failure prediction. More equipment is being added to the model for predictive maintenance.

CONCLUSION / FUTURE WORK

- Identified needs from Northern Indiana Public Service Company (NIPSCO), and collected data.
- Developed an interactive multimeter tutorial using deep learning and AR.
- ConvLSTM based few short learning model was developed. The preliminary results shows 96% predication accuracy to classify burned/non-burned transformers.
- In our future work, we will incorporate transfer learning modules to more accurately predict machine maintenance in advance. Data volume sensitivity as well as machine learning model explainability will be also conducted.
- Human effectiveness and cognitive workload will be also further analyzed.