Mechanical Engineering Dissertation Defense

Uncertainty-Aware Neural Networks for Decision Support and Engineering Risk Assessment

School for Engineering of Matter, Transport and Energy

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Abstract

This dissertation makes novel contributions to uncertainty-aware neural network models using multiples types of data sources, with a focus on industrial and aviation applications. Drawing from seminal works in recent years that have significantly advanced the field, this dissertation develops techniques for incorporating uncertainty estimation and leveraging multi-modality information into neural networks for tasks such as fault detection in industrial processes and environmental perception for decision support systems. The escalating complexity of data in engineering contexts demands models that predict accurately and quantify uncertainty in these predictions. The methods proposed in this presentation utilize various techniques, including Bayesian Deep Learning, multi-task regularization and feature fusion, and efficient use of unlabeled data. Popular methods of uncertainty quantification are analyzed empirically to derive important insights on their use in real world engineering problems. The primary objective is to develop and refine Bayesian neural network models for enhanced predictive accuracy and decision support in engineering. This involves exploring novel architectures, regularization methods, and data fusion techniques. Significant attention is given to data handling challenges in deep learning, particularly in the context of quality inspection systems. The research integrates deep learning with vision systems for engineering risk assessment and decision support tasks, and introduces two novel benchmark datasets designed for semantic segmentation and classification tasks. Additionally, the dissertation delves into RGB-Depth data fusion for pipeline defect detection and the use of semi-supervised learning algorithms for manufacturing inspection tasks with imaging data. The dissertation contributes to bridging the gap between advanced statistical methods and practical engineering applications.

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