**Lecture 1. Enhancing Environment Perception for Autonomous Driving with Quaternion Neural Networks**

**Abstract:**
Autonomous driving relies on an accurate perception of the environment for safety. However, perception systems often need help with adverse weather and suboptimal lighting conditions, which can reduce image contrast and color fidelity. This affects essential computer vision tasks, such as localization, semantic segmentation, and object detection. Traditional image processing techniques are insufficient to cope with weather's adverse effects on critical applications, such as surveillance, navigation, and autonomous vehicle operation. Therefore, more advanced and robust methods are needed to improve image quality and visibility under such conditions. We present Quaternion Neural Networks (QNNs) as an innovative solution. QNNs use quaternion algebra to process complex multidimensional data, such as the color channels in image pixels, which are often affected by adverse environmental conditions. QNNs have several advantages over conventional neural networks, such as reduced computational complexity, enhanced parameter efficiency, and robust defense against overfitting. These advantages are crucial for the high-fidelity interpretation of environmental data. This talk will explain the basic concepts of quaternion algebra applied to convolutional neural networks and the recent advances in QNN transformers. We will demonstrate the application of QNNs in scene perception for autonomous vehicles, especially under difficult visibility conditions like fog, clouds, and rain. The audience will learn how QNNs outperform real-valued networks in tasks such as weather artifact removal, scene segmentation, and object detection, thus enhancing environment perception for safer autonomous driving. We will also discuss the future development roadmap of QNNs for autonomous driving, including defense and attacks using fake weather.

**Lecture 2. Computational Perception for Image Quality Assessment and Optimization: Insights from Human Vision**

**Abstract:** Bio-inspired computer vision aims to create algorithms that mimic the capabilities of human sight. This goal drives the development of image processing systems that simulate and aspire to the complexity of human visual perception. A key aspect of this endeavor is image quality assessment (IQA), which ensures the fidelity of images for subsequent analysis by computer vision algorithms. High-quality input is essential, as even minor distortion can affect algorithmic performance. This talk explores the landscape of IQA, where digital imperfections are common and the quest for precision is constant. We examine both full-reference (FR) and no-reference (NR) assessment methods, which compare images against a reference or gauge quality without one. These methods are useful, for example, in machine vision for mobile robotics, where high-quality frames are crucial. The evolution of IQA is dynamic, tracing its lineage from the Universal Image Quality Index (UIQI) to the Structural Similarity (SSIM) index to the recent "blind EME" methods and their variations. Despite the availability of new databases and deep learning techniques, IQA still faces persistent challenges. Our talk will analyze these challenges, evaluating the vision-inspired metrics that guide our assessments and their implications for robust and efficient vision models, algorithm optimization, and benchmarking practices. Our presentation will showcase our latest research achievements in the IQA field, contrasting them with the current state-of-the-art. We will also offer insights

into how these image-processing tools enhance our understanding of biological visual systems. Looking ahead, we will reveal the trends likely to disrupt the IQA domain, considering their potential to transform commercial landscapes and create new technological opportunities. Participants will gain an enriched perspective on how bio-inspired computing is redefining the assessment and optimization of image quality, paving the way for a new era in visual technology.