Real-Time Perception Pipeline Compression for Edge XR Devices in Mixed Reality Environments

Background

The deployment of mixed reality (XR) and 3D telepresence systems on edge or wearable devices requires neural perceptual pipelines that are highly efficient. Model compression techniques such as pruning, quantization and knowledge distillation are well studied for 2D vision tasks, but fewer works focus on 3D/immersive pipelines.

Problem Description

The goal is to develop a **compressed perception pipeline** (e.g., for view synthesis, 3D reconstruction or segmentation) targeted for XR edge devices. The project will investigate how to adapt compression methods (quantization, pruning, structured sparsity) for 3D/light-field neural networks while maintaining inference speed and perceptual quality.

Milestones and Extensions

- Review literature on model compression, efficient neural networks, XR edge constraints.
- Profile a baseline 3D/light-field network (e.g., view-synthesis or reconstruction) on edge hardware.
- Apply compression techniques: pruning, quantization, distillation.
- Evaluate performance: FPS, memory footprint, perceptual quality (LPIPS, MOS).
- **Extension:** integrate runtime adaptation (e.g., dynamic bit-depth) depending on hardware conditions.

  Tools, Qualifications, and Outcomes
- Skills: Python, PyTorch, knowledge of model compression, embedded/edge deployment.
- Tools: PyTorch, ONNX/TensorRT, edge hardware (e.g., laptop GPU or embedded board), light-field/3D datasets.
- Outcome: A compressed XR-perception pipeline ready for edge deployment, with benchmark results and publication potential.

Relevant Articles and Resources

- Han, S., Mao, H. and Dally, W.J., 2015. Deep compression: Compressing deep neural networks with pruning, trained quantization and huffman coding. *arXiv preprint arXiv:1510.00149*.

- Jacob, B., Kligys, S., Chen, B., Zhu, M., Tang, M., Howard, A., Adam, H. and Kalenichenko, D., 2018. Quantization and training of neural networks for efficient integer-arithmetic-only inference. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 2704-2713).

- Li, K., Masuda, M., Schmidt, S. and Mori, S., 2025. Radiance Fields in XR: A Survey on How Radiance Fields are Envisioned and Addressed for XR Research. *IEEE Transactions on Visualization and Computer Graphics*.