Quantum Implicit Neural Representations for 3D Scene Reconstruction and Novel View Synthesis

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Implicit neural representations have transformed 3D scene reconstruction and novel view synthesis, with Neural Radiance Fields (NeRF) becoming a dominant paradigm for continuous volumetric scene modelling [1]. However, classical multilayer perceptrons exhibit spectral bias, limiting their ability to reproduce high-frequency geometric and view-dependant details [2]. In this work, we introduce Q-NeRF, the first hybrid quantum-classical neural radiance field framework that integrates Quantum Implicit Representation Networks (QIREN) [3] into the Nerfacto pipeline [4]. As illustrated in Figure 1, the proposed approach preserves the efficient volumetric rendering and hierarchical sampling strategies of modern NeRF architectures while replacing selected density and radiance prediction components with parametrized quantum circuits. Three hybrid configurations are systematically evaluated: quantum colour prediction, quantum density prediction, and both colour and density quantum radiance field prediction. Experimental results on indoor multi-view scenes show that compact quantum modules achieve competitive reconstruction quality while using substantially fewer parameters than classical counterparts. In particular, the hybrid configuration using classical density and quantum RGB prediction provides the best trade-off between fidelity and parameter efficiency reaching reconstruction quality around 30-31 dB PSNR with fewer than 500 parameters in the quantum colour branch, while maintaining strong SSIM and LPIPS scores. Qualitative analysis further demonstrates sharper texture preservation and improved fine-detail reconstruction compared with similarly sized classical predictors. These findings establish the feasibility of integrating parametrised quantum circuits into neural rendering pipelines and suggest that quantum feature encoding may serve as efficient high-frequency function approximators for compact 3D scene. This work provides a foundational benchmark for future quantum-enabled neural rendering systems and opens new directions towards scalable hybrid implicit representations for 3D vision.

References

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[2] M. Tancik et al., *Fourier Features Let Networks Learn High Frequency Functions in Low Dimensional Domains*, NeurIPS (2020)
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Figures

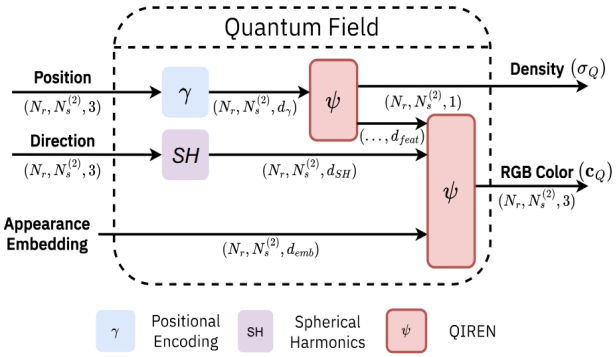

Figure 1: Architecture of our proposed Q-NeRF hybrid quantum field.