Automatic Detection of Nuclear Spins at Arbitrary Magnetic Fields via Signal-to-Image AI Model [1]

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Abstract

Quantum sensors leverage matter's quantum properties to enable measurements with unprecedented spatial and spectral resolution. Among these sensors, those utilizing nitrogen-vacancy (NV) centers in diamond offer the distinct advantage of operating at room temperature [2, 3]. Nevertheless, signals received from NV centers are often complex, making interpretation challenging [4]. This is especially relevant in low magnetic field scenarios, where standard approximations for modeling the system fail. Additionally, NV signals feature a prominent noise component. In this work, we present a signal-to-image deep learning model capable to automatically infer the number of nuclear spins surrounding an NV sensor and the hyperfine couplings between the sensor and the nuclear spins. Our model is trained to operate effectively across various magnetic field scenarios, requires no prior knowledge of the involved nuclei, and is designed to handle noisy signals, leading to fast characterization of nuclear environments in real experimental conditions. With detailed numerical simulations, we test the performance of our model in scenarios involving varying numbers of nuclei, achieving an average error of less than $2\,\mathrm{kHz}$ in the estimated hyperfine constants.

Figures

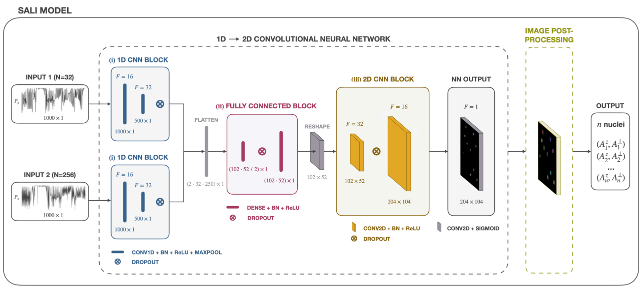

Figure 1: Schematic representation of SALI model, composed of a 1D → 2D Convolutional Neural Network (CNN) module for processing 1D string data of NV measurements into a 2D image output, along with an image post-processing module.

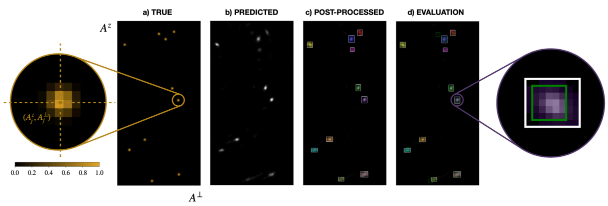

Figure 2: (a) True output of the neural network. (b) Output predicted by the neural network. (c) Output after the image post-processing. (d) Evaluation of the post-processed output.

References

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