Neural Plasma Reconstruction from Diagnostic Imaging

Ekin Ozturk[1], Rob Akers[2], Abhijeet Ghosh[1], Stanislas Pamela[2], Pieter Peers[3], The MAST Team[2]

[1] *Imperial College London, London, United Kingdom*

[2] *Culham Centre for Fusion Energy, Abingdon, United Kingdom*

[3] *College of William & Mary, Williamsburg, VA, USA*

We leverage a neural network to estimate 2D distributions of neutrals, electrons and temperature from images of plasma obtained via cameras inside the MAST vessel. This is achieved by learning the non-linear mapping between images of the plasma emission and the distributions of the neutrals, electrons, and temperature. Our network, composed of an image encoding block followed by a dense layer, is able to achieve a mean relative RMS error on the test set of $14.6\% \pm 5.0\%$, $27.3\% \pm 5.2\%$, and $15.3\% \pm 3.7\%$ for the neutrals density, electrons density and the electron temperature respectively the results of which an example is shown in Figure 1. Crucially, our network is able to predict not only the electron density and temperature parameters, but also the neutrals density parameters, in only $8ms$ and the full 2D distributions with a spatial resolution of $4mm$ in $6s$ on a laptop RTX 3070 GPU.

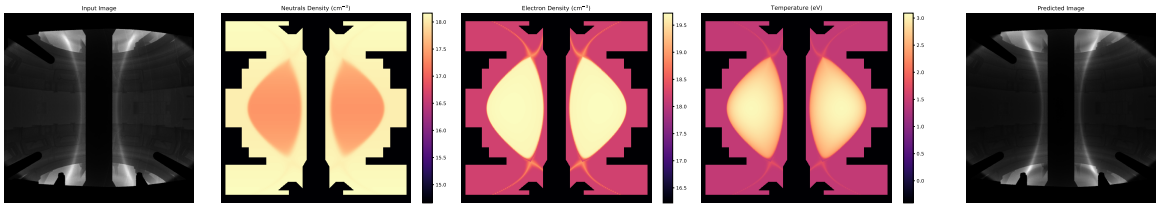

Figure 1: *Input Image (Left), Predicted Cross-Sections (Middle: neutrals density, electron density, temperature), Predicted Image obtained with volume rendering using predicted parameters (Right).*

The success of training a network depends on the richness of the training dataset. Currently, no experimental data exists with a sufficient number of configurations with visually distinct equilibria. To resolve this, we densely sample the space of configuration and simulate the camera image generating process to produce synthetic images of the plasma to train our network.

Our future goal is to further improve the accuracy on simulated data, as well as validate our methods on real diagnostic images. We believe our method has the potential to provide fast feedback of the 2D distributions during physical experiments to improve control.