Physical Informed Neural Network

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SUMMARY

This project aims at using Physical Informed Neural Network to solve Burger's Equation.

$$u_t + uu_x = \nu u_{xx}$$

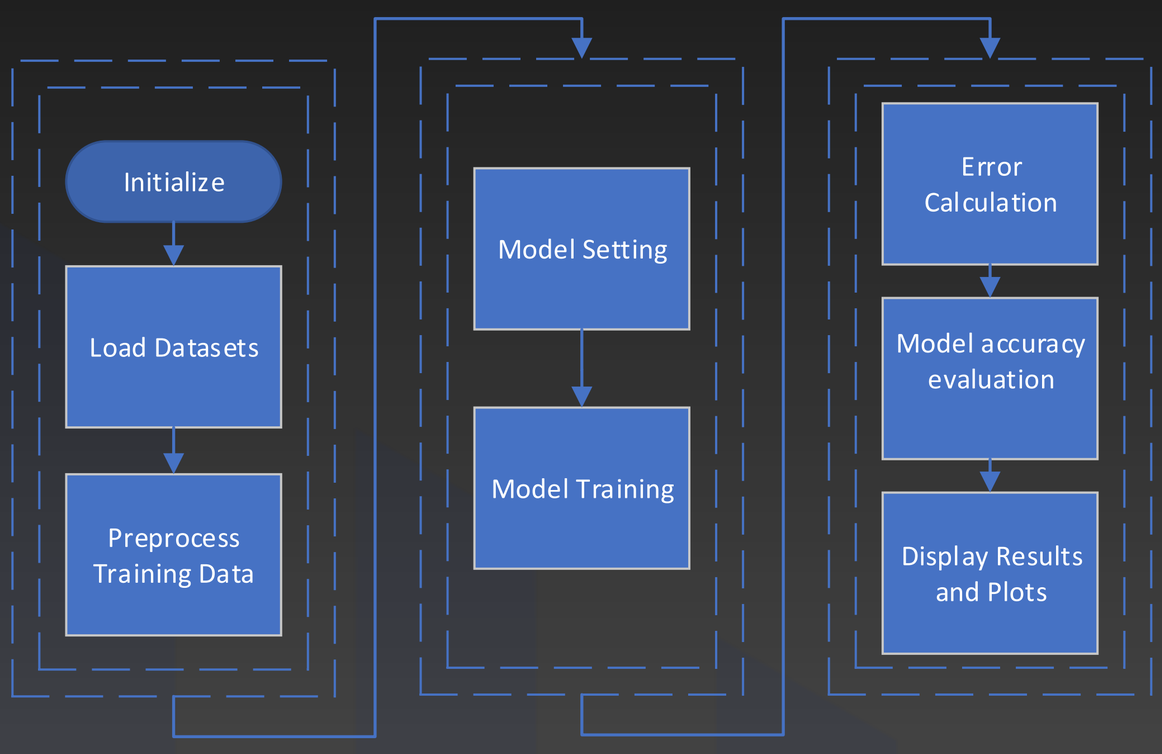
$$\text{BC:} \quad u(-1,t) = u(1,t) = 0$$

$$\text{IC:} \quad u(x,0) = -\sin(\pi x)$$

ADVANTAGE

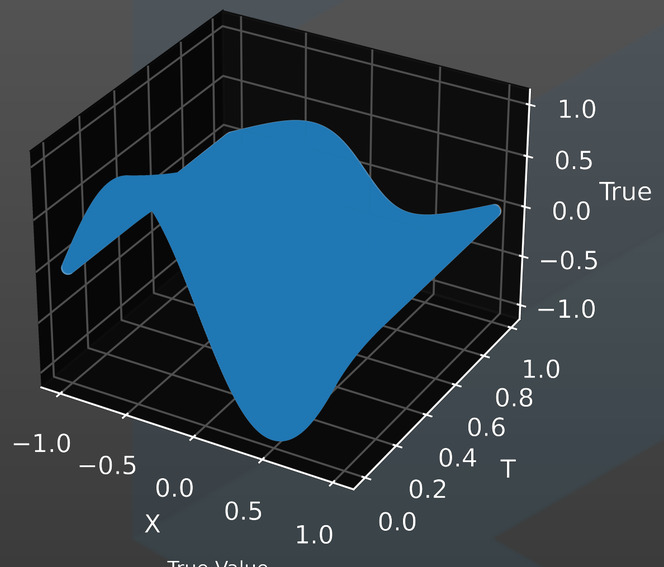
No need to know the specific mathematical or numerical solution, yet we are able to identify the tendency of the PDE solution

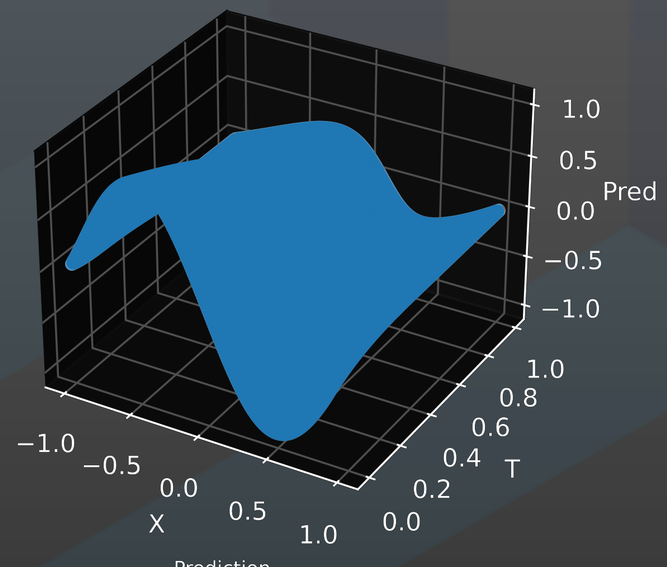
CODING STRUCTURE

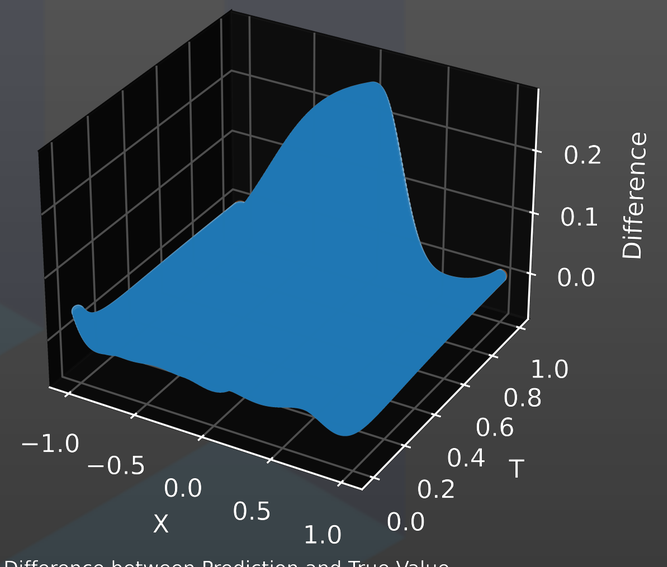


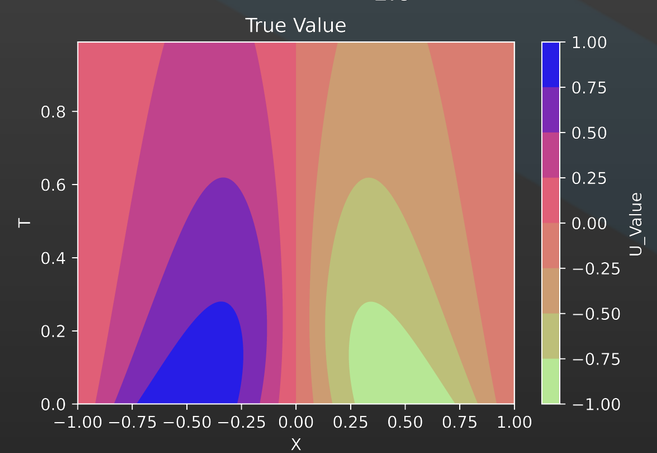
Our Code is mainly consists of three parts: Data preprocessing, Model processing and Model Evaluation. In summary, it is a sequential model

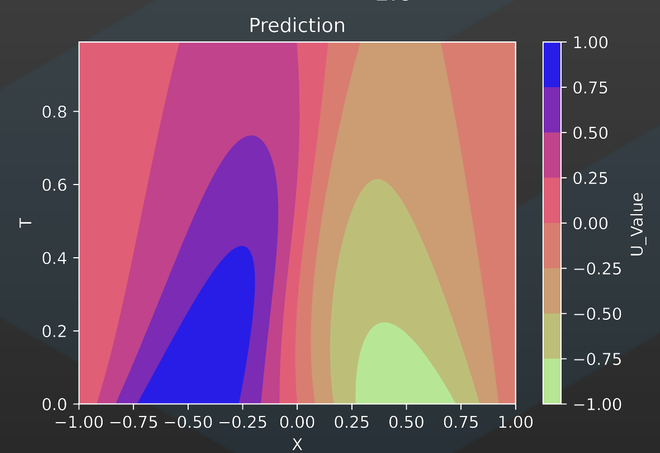
OUTPUT ANALYSIS

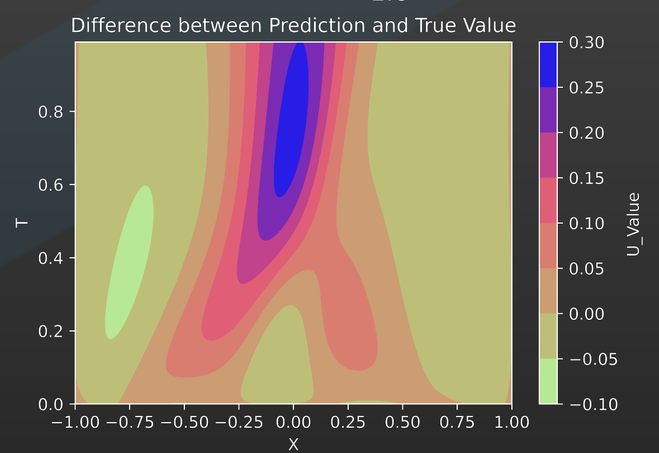












Ground truth (true value) is obtained through numerical method in MATLAB. Here we choose viscosity to be 0.1.

Our neural network is trained with the following configuration: 8 hidden layers with 20 neurons, Adam optimizer, MSE loss and Tanh activation function. The result proves to be quite similar to the ground truth, showcasing the effectiveness of our PINN.

We employ the absolute error metric at each data point to validate our results. The average loss observed is 0.053, which falls below the threshold of 0.06. This level of performance meets our stakeholder's requirements.

FUTURE IMPROVEMENTS

Future PINN improvements should focus on enhancing generalization to solve diverse PDEs and incorporating uncertainty quantification. These steps will make PINNs more adaptable and reliable for complex applications.

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[3] Banerjee, Arindam. "Dummies Guide to Writing a Custom Loss Function in Tensorflow." Analytics Vidhya, 28 Sept. 2022,
[4] S. Alkhadhr and M. Almekkawy, "A Combination of Deep Neural Networks and Physics to Solve the Inverse Problem of Burger's Equation," 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Mexico, 2021, pp. 4465-4468, doi: 10.1109/EMBC46164.2021.9630259.
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