BTP - 2

CNN for Boundary Value Prediction

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Experiment 1

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Motivation

- Before we use any complicated machinery such as PINNs, it would be helpful to first check how something like a vanilla Convolutional Network performs on the task of boundary value prediction.
- This would give us a benchmark which we can use to compare and analyse how much of an improvement more complicated models are providing.
- A CNN is applicable to this problem, since we want to predict the temperature values at the boundaries by taking the whole image as an input.

Experiment

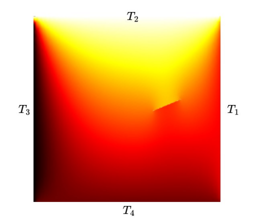

Figure 1: Thermal profiles produced with temperature BCs on edges

- Here, the input being fed to the CNN is the thermal profile.
- We want it to predict the outputs T_2/T_1, T_3/T_1, T_4/T_1. We are predicting non-dimensional ratios instead of actual temperatures because the ~~thermal profile is invariant under an affine transformation globally~~. pixel values will stay almost same under scaling of BCs by a constant value
- Also, we are using ReLU activations for hidden layers and Linear activation for the output layer

Dataset

- The dataset was generated by modifying the MATLAB code to also store the boundary conditions.
- The temperatures for each image are then saved in a pandas Dataframe
- The dataset used was 120 images during training and 30 during testing

	Image	Right	Top	Left	Bottom	RK	TK	LK	BK	T_by_R	L_by_R	B_by_R
0	image_a_1_1.png	-86	-58	-28	-15	187	215	245	258	1.149733	1.310160	1.379679
1	image_a_1_10.png	8	-20	51	67	281	253	324	340	0.900356	1.153025	1.209964
2	image_a_1_11.png	-15	53	49	74	258	326	322	347	1.263566	1.248062	1.344961
3	image_a_1_12.png	-85	-40	-79	41	188	233	194	314	1.239362	1.031915	1.670213
4	image_a_1_13.png	-35	77	-18	0	238	350	255	273	1.470588	1.071429	1.147059

Figure 2: Ratios of kelvin temperatures

Results

- The model was able to perform well and we achieved a test loss of 0.0896 and test MAE of 0.2233 which is good enough, but there is scope for improvement

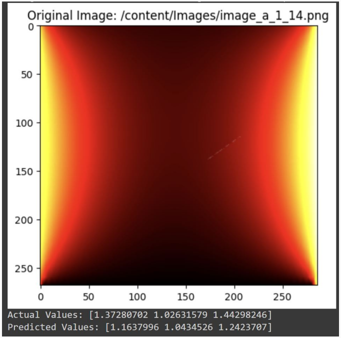

Figure 3: Model Prediction. In this instance, the model predicted (1.16, 1.04, 1.24) whereas the true prediction was (1.37, 1.02, 1.44)

Conclusion and Future Work

- The model is performing well without giving any input other than the image.
- This is very good as it means that the model is generalizing well and thus inferring on its own.
- Thus, we can also hopefully train it to detect temperature boundary conditions on internal edges such as cracks
- We have used temperature ratios, but we can also try to see what happens with temperature differences.
- In presence of more data, it is very likely that the model will perform better