Hypersensitive Problem

# Using PINN:

Analysis to be performed:

1. Error on training time data points
2. Error on new (10k) time points - test data
3. How does the depth of the network affects the performance
4. LBFGS vs ADAM
5. Plot x vs t | u vs t

| **1. Error on training data (t = 100 points bw 0 and 1)**  Layers: [1, 100, 2]  Adam  10000 epochs  Absolute error:  Iter 10000, Total\_loss: 0.00017691055836621672, Loss\_f: 0.0001696035615168512, Loss0: 1.2030682228214573e-06, Loss1: 6.103926352807321e-06  CPU times: user 1min 41s, sys: 8.41 s, total: 1min 49s  Wall time: 1min 49s  Test error (training and test dataset are the same in this case)  error x: 5.571379006141797e-06  error p: 5.226259531809774e-07 |
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| **2. Error on new test points (10k points bw 0 and 1)**  error x: 5.566505933529697e-06  error p: 5.277214540910791e-07 |
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| **3. LBFGS vs ADAM**  LBFGS:  Iter 3357, Total\_loss: 2.593597673694603e-05, Loss\_f: 2.593172757769935e-05, Loss0: 1.6575540939811617e-10, Loss1: 4.082721716258675e-09  CPU times: user 38 s, sys: 2.86 s, total: 40.9 s  Wall time: 38.3 s  error x: 6.828220477927971e-08  error p: 8.653672267655566e-08  ADAM:  Iter 10000, Total\_loss: 0.00017691055836621672, Loss\_f: 0.0001696035615168512, Loss0: 1.2030682228214573e-06, Loss1: 6.103926352807321e-06  CPU times: user 1min 41s, sys: 8.41 s, total: 1min 49s  Wall time: 1min 49s  error x: 5.566505933529697e-06  error p: 5.277214540910791e-07 |
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| **4. Deep vs Shallow Layer**  **Layers = [1, 25, 25, 25, 25, 2]**  error x: 2.537348109399318e-10  error p: 7.253574130228202e-11 |
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**OCP X-TFC Hypersensitive Problem**:

| X-TFC  Nf = 11  Layers = [1, 25, 25, 25, 25, 2]  LBFGS  Iter 4086, Total\_loss: 8.04173623691895e-07, Loss\_f: 8.04173623691895e-07  CPU times: user 51.9 s, sys: 3.26 s, total: 55.1 s  Wall time: 53.3 s  error x: 8.653591621055057e-09  error p: 3.239437385005317e-09 |
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| X-TFC  Nf = 101  Layers = [1, 25, 25, 25, 25, 2]  LBFGS  Iter 3056, Total\_loss: 1.1112821994174737e-05, Loss\_f: 1.1112821994174737e-05  CPU times: user 38.8 s, sys: 2.35 s, total: 41.2 s  Wall time: 39.7 s  error x: 1.3066783211002075e-08  error p: 5.82072772203901e-08 |
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| X-TFC  Nf = 11  Layers = [1, 100, 2]  LBFGS  Iter 3129, Total\_loss: 1.7765072698239237e-05, Loss\_f: 1.7765072698239237e-05  CPU times: user 32.1 s, sys: 2.38 s, total: 34.5 s  Wall time: 32.8 s  error x: 1.1721655113205998e-07  error p: 7.783147992768136e-08 |
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Bugs fixed:

1. The initial approach was not really training the network. This was because of the following two reasons:
   1. In the SIMO case, when the single neuron value is taken, it was giving a 1D tensor. Therefore to convert it to a 2D tensor do - ***“.unsqueeze(0).T”***

x\_pred, p\_pred = out[:, 0].unsqueeze(0).T, out[:, 1].unsqueeze(0).T

* 1. In the step, f\_pred1 = dx\_dt + x\_pred + p\_pred “dx\_dt” and “x\_pred” are of shape [101, 1] and [101]. Therefore, f\_pred1 was turning out to be of shape [101, 101]