

EE520, Bollt,

Proj 3, Data-Driven Forecasting, DMD, due F Nov 7.

1. Now we will perform POD analysis of the spatiotemporal data from the Kuramoto-Sivashinsky PDE solution provided in the matlab .mlx code.

By perform a POD analysis we mean:

- a) Show the power spectrum plot (the singular values as a function of mode number k) and decide how many modes are enough for a good representation. (State this number you will use).
 - b) Plot each of those first k - modes.
 - c) Show how well these modes reproduce the dynamics – that is with this k - low rank approximation, show the reproduced estimate of the solution.
 - d) Plot a time-series of each of the time varying projections of the solution onto each of those k -modes. You can show these modes all in one plot.
2. Now we will perform DMD-Koopman analysis of the spatiotemporal data from the Kuramoto-Sivashinsky PDE solution provided in the matlab .mlx code. We will do what is called “exact DMD,” and there are now many variants. I will provide more direction on this one shortly.

By perform a POD analysis we mean:

- a) Develop the computation in terms of A_r and then A the low rank and then high rank relationship for DMD, in terms of POD modes.
 - b) Compute the eigenvalues of A_r and discuss how these relate to A . Plot these eigenvalues in the complex plane and discuss how their positions relative to the unit 1 modulus circle relate to the dynamics.
 - c) Compute the Van der Monde matrix presentation of the data matrix X .
 - d) Use the result of X to show the low rank approximation of the data X . Then use this to forecast for a short time into the future.
 - e) Now repeat a-d for 90% of the data, and show forecasts into the future for the 10% half – and therefore you can also produce an error plot. This is cross validation.
3. Now we will perform a reservoir computing – random neural network - analysis of the spatiotemporal data from the Kuramoto-Sivashinsky PDE solution provided in the matlab .mlx code. We train the method and then use it for forecasting these spatiotemporal patterns.

Build a reservoir computer to forecast the KS equations.

- a) Split the data again into 90%/10% and use your forecaster to forecast KS solutions into the future, and so you can make an error plot for the 10%.
- b) Hint – it may be simpler if you do forecasting for the time-varying mode amplitudes time-series – and use those to rebuild the spatiotemporal signal, rather than the spatiotemporal signal directly.

4. Now you will use the built in commands of matlab to build a fully trained deep feedforward neural network to perform forecasting of the spatiotemporal data from the Kuramoto-Sivashinsky PDE solution provided in the matlab .mlx code. You will likely want to modify the code provide that already does a similar task for the chaotic Lorenz equations.

Repeat a) and b) as you did in #3 above but now for a fully trained and feedforward ANN.

Format – Please include statement of question, presentation of solutions with any included mathematical equations, inequalities and descriptive words/narrative AND your interpretation of what you are observing. Include figures, with figure captions and these should also be referred to from within the text. Include any tables, again with captions, and also any code you produced or modified to work these problems. In other words, standard presentation technical writing for technical results.