Meetings Notes

# Time Series Prediction with AI Methods for Fluid Flow

Tianyi Zhao

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# March 18

Hi Tianyi

Thanks for talking to us today. Here are some links to some papers:

<https://arxiv.org/abs/2102.02664> gives an idea of how to use GANs for time prediction. Again, you could skip some of the description of the modified SEIRS model used here (for virus modelling).

<https://arxiv.org/abs/1406.2661> Goodfellow's original GAN paper

<https://arxiv.org/abs/1511.05644> a follow up paper which we could possibly use to do the time prediction with GAN

<https://www.sciencedirect.com/science/article/pii/S0021999119305364> for a time stepping procedure we could use (although they don't use GANs)

[https://www.sciencedirect.com/science/article/abs/pii/S0360132318306607](https://www.sciencedirect.com/science/article/abs/pii/S0360132318306607" \t "_blank) a general description of non-intrusive reduced order modelling (NIROM), which is broadly what you'd be doing

<https://www.sciencedirect.com/science/article/abs/pii/S0045793019300350> for a paper on domain decomposition applied to NIROM (don't get bogged down in the details)

These papers will be quite hard to read - don't worry about this - just try to get the main idea. Also google things such as GAN, WGAN, autoencoder and variational autoencoder and you should see some blogs and tutorials on these.

Best wishes

Claire

# June 2

### This week

1. GAN, from paper and books and some tutorials. Theory, application scenarios, what do we need to pay attention to when training
2. Get the basic idea of how to use GAN to predicting time series

### Next week

Here is my plan for next week.

To do:

1. Using Python to prototype MLP to predict next time level given the current time level.
2. Understanding the time stepping procedure in this paper:

<https://www.sciencedirect.com/science/article/pii/S0021999119305364>

as well as source code if it can be found.

(more stable)

Additions:

1. Using Python to prototype MLP to predict the time derivative given the current time level.
2. Understanding domain decomposition with ROMs from these 2 papers:

<https://www.sciencedirect.com/science/article/abs/pii/S0360132318306607>

<https://www.sciencedirect.com/science/article/abs/pii/S0045793019300350>

Dependencies:

1. Old/new FPC data and POD coefficients

# June 9

### This week

1. Prototype MLP to predict next time level given the current time level with COVID data.
2. Understanding the time stepping procedure in paper ‘Machine learning for fast and reliable solution of time-dependent differential equations’.

### Next week

Here is my plan for next week.

To do:

1. Prototype MLP to predict next time level given the current time level with FPC data.
2. Prototype MLP to predict the time derivative given the current time level with FPC data.

Additions:

1. Understanding domain decomposition with ROMs from these 2 papers:

<https://www.sciencedirect.com/science/article/abs/pii/S0360132318306607>

<https://www.sciencedirect.com/science/article/abs/pii/S0045793019300350>

1. Start to write the project plan.

# June 16

### This week

1. Understand ROM and POD by talk given by Claire.
2. Prototype POD-MLP with old FPC data.
3. Prototype POD-MLP-deriv with old FPC data.

### Next week

Here is my plan for next week.

1. Write the project plan.
2. Reading and doing literature review.
3. Understand how to use GAN to predict next time level (POD-GAN).

# June 23

### This week

1. Write the project plan.
2. Visualize the FPC results.

### Next week

Here is my plan for next week.

1. Training MLP with new FPC data. Try to follow Claire’s suggestions and do more training.
2. Start working on GAN with Vinicious’s GAN and corporate with Jon.

# June 30

### This week

1. Training MLP with new FPC data. Try to follow Claire’s suggestions and do more training.
2. Started working on GAN with Vinicious’s GAN and corporate with Jon.

### Next week

Here is my plan for next week.

1. Make DCGAN work.
2. Continue to train with MLP.

# July 7

### This week

1. Make DCGAN work.
2. Continue to train with MLP.

### Next week

Here is my plan for next week.

1. Understand PredGAN and use it to predict with DCGAN trained.
2. Finished training with MLP.

# July 14

### This week

1. Understand PredGAN and use it to predict with DCGAN trained.
2. Finished training with MLP.

### Next week

Here is my plan for next week.

1. Apply 2-order time derivative method to MLP.
2. Apply time derivative method to DCGAN.
3. Figure out why the multiple-point prediction performs not well. Fullset and some text!

# July 21

### This week

1. Applied 2-order time derivative method to MLP.
2. Applied time derivative method to DCGAN.
3. Figured out why the multiple-point prediction performed not well.

### Next week

Here is my plan for next week.

1. Do optimization to PredGAN architecture.
2. Do post-processing with DCGAN results and visualization.

# July 28

### This week

1. Do optimization to PredGAN architecture.
2. Do post-processing with DCGAN results and visualization.

### Next week

Here is my plan for next week.

1. Subtract the mean before adding pod.
2. Try more derivatives (>5).

# Aug 4

### This week

1. Subtract the mean before adding pod.
2. Try more derivatives (3, 4, 5, 6).

### Next week

Here is my plan for next week.

1. Do parameter optimization with wandb.
2. Trying to apply AAE.

# Aug 11

### This week

1. Do parameter optimization with wandb.
2. Trying to apply AAE.

### Next week

1. Write final report.
2. Get final results for AAE.

# Aug 18

### This week

1. Write final report.
2. Get final results for AAE.

### Next week

1. Do proofreading of final report.
2. Add fig, eqn and other part of final report.

# Aug 25

### This week

1. See suggestions from Claire and Chris and continue to do revision of final reports.