

# Graph Element Networks for Wind Nowcasting

*EE-452 – project*

Arnaud Pannatier

May 30, 2022

## 1 Introduction

Air Traffic Controllers (ATC) need to have access to reliable wind speed forecasts to organize the airspace efficiently. However, at cruising altitudes, the only measures that one has access to are measured by airplanes that record the wind along their trajectories. Therefore, air traffic controllers need to have very short-term forecasts of about 30 minutes. In that range, called nowcasting, one gets the most accurate forecast by extrapolating from the latest measures available rather than trying to solve expensive numerical equations solvers. It is in that range that deep learning methods can offer a lot, as meteorological data is often highly available, and deep learning methods thrive in that environment.

## 2 Related works

### 2.1 Finite Element Networks

Traditional PDEs solvers model the domain using regular grids, but this has some drawbacks as some part of the space might be more complicated to model than the other. One way of dealing with this problem is to use a Finite Element method approach [Hughes, 2012], which uses a non-regular graph that can be denser in the more complex regions and coarser in the smoother regions.

### 2.2 Graph Element Networks (GENs)

Graph Element Networks [Alet et al., 2019] aim to model SFTs using a non-regular graphs with nodes in the underlying space  $\mathbb{X}$ . Each measurement  $(x, i)$  is encoded using a small MLP and contributes to the neighbouring nodes values. The model then process this latent variable using  $T \in \mathbb{N}$  steps of message passing, the exact formulation of its message passing scheme can be found in the appendix. In order to predict at a new query position, the model linearly extrapolates in latent space, and decodes using a small MLP modelling the transformation from latent to output space.

## 3 Exploration

- We want our graph to represent the state of the space

- Features : field values
- Edge features : derivatives ?
- Setting up the graph : Kmeans + nearest neighbors // scale free network based on the variation of the field
- Connected graph
- Expect local connections but ablation
- comment on diameter and degree distribution
- display visualization of the two networks
- Compare with traditional Finite Element method

## 4 Exploitation

Here the node features is the most informative, maybe the edge features depending on the exploitation of 1.

Have a good baseline.

## 5 Communication

- Good report
- Github
- Streamlit

## References

[Alet et al., 2019] Alet, F., Jeewajee, A. K., Villalonga, M. B., Rodriguez, A., Lozano-Perez, T., and Kaelbling, L. (2019). Graph element networks: adaptive, structured computation and memory. In Chaudhuri, K. and Salakhutdinov, R., editors, *Proceedings of the 36th International Conference on Machine Learning*, volume 97 of *Proceedings of Machine Learning Research*, pages 212–222. PMLR.

[Hughes, 2012] Hughes, T. J. (2012). *The finite element method: linear static and dynamic finite element analysis*. Courier Corporation.