MEng Innovation by Design

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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PREDICTION OF TURBULENT FLOW BEHAVIOUR USING MACHINE INTELLIGENCE

ABSTRACT

Turbulence is one of the most complex phenomena observed, particularly in the industry. Despite tremendous progress in the field of Computational Fluid Dynamics (CFD) that has given rise to various models and theories that attempt to explain turbulence, they fall short due to various shortcomings in each individual methods.

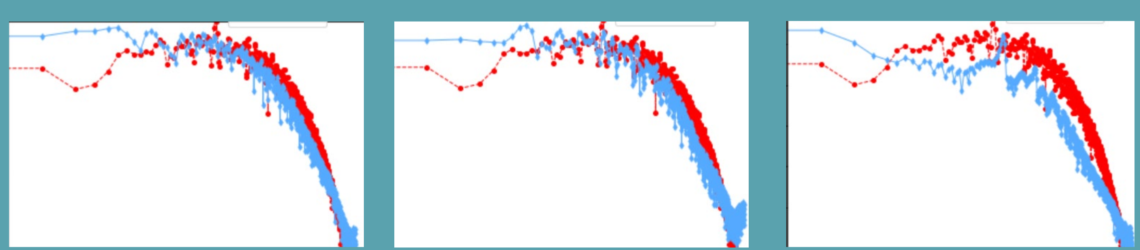
With the advent of Big Data, rapid advances in the field of Machine Learning and rise in the usage of data driven models and learning algorithms, it has now become feasible to develop frameworks of learning models that can be custom-tailored to better understand and resolve turbulence.

The aim of this research is to use advanced neural networks, a machine learning approach, in order to enhance and facilitate the computation of turbulent fluid flows so that it would pave the way in the development of a system that would yield results at acceptable tolerance range, optimal resolutions at low computational cost and time required.

RESULTS

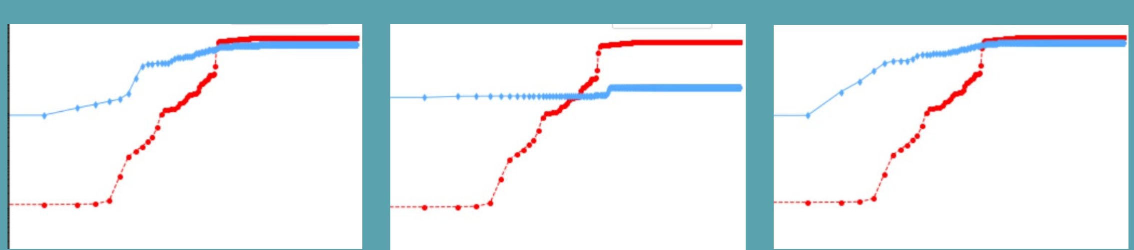
The learning models when executed provide the plot of both the power spectral density and cumulative power spectral density against angular frequency.

The parameter that was varied was the skipsize, with values 30, 40 and 50.



(a) (b) (c)

Power Spectral Density plot at (a) skipsize = 30 (b) skipsize = 40 (c) skipsize = 50

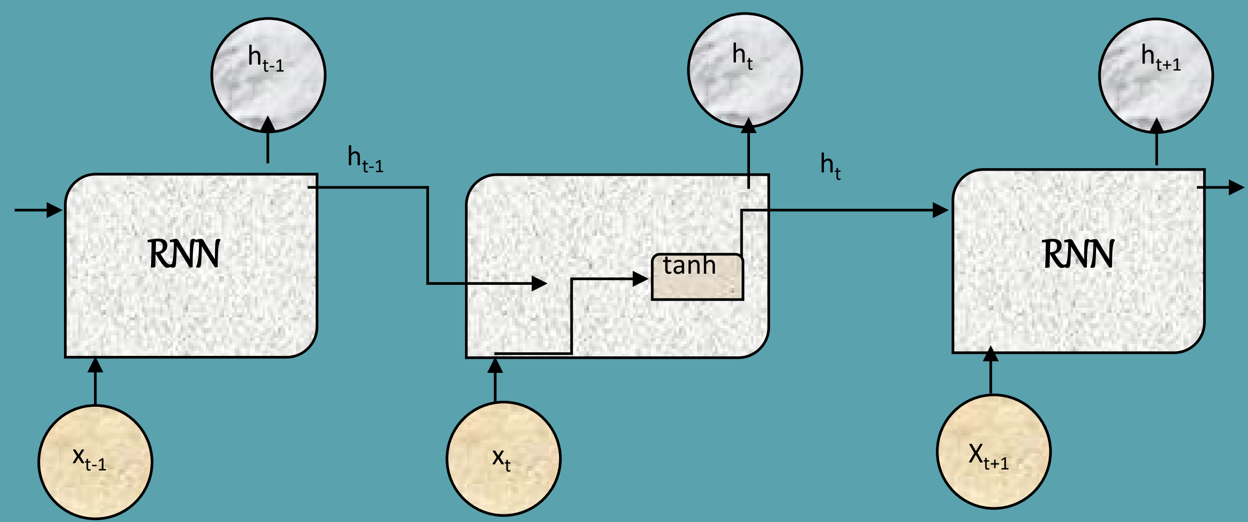


(d) (e) (f)

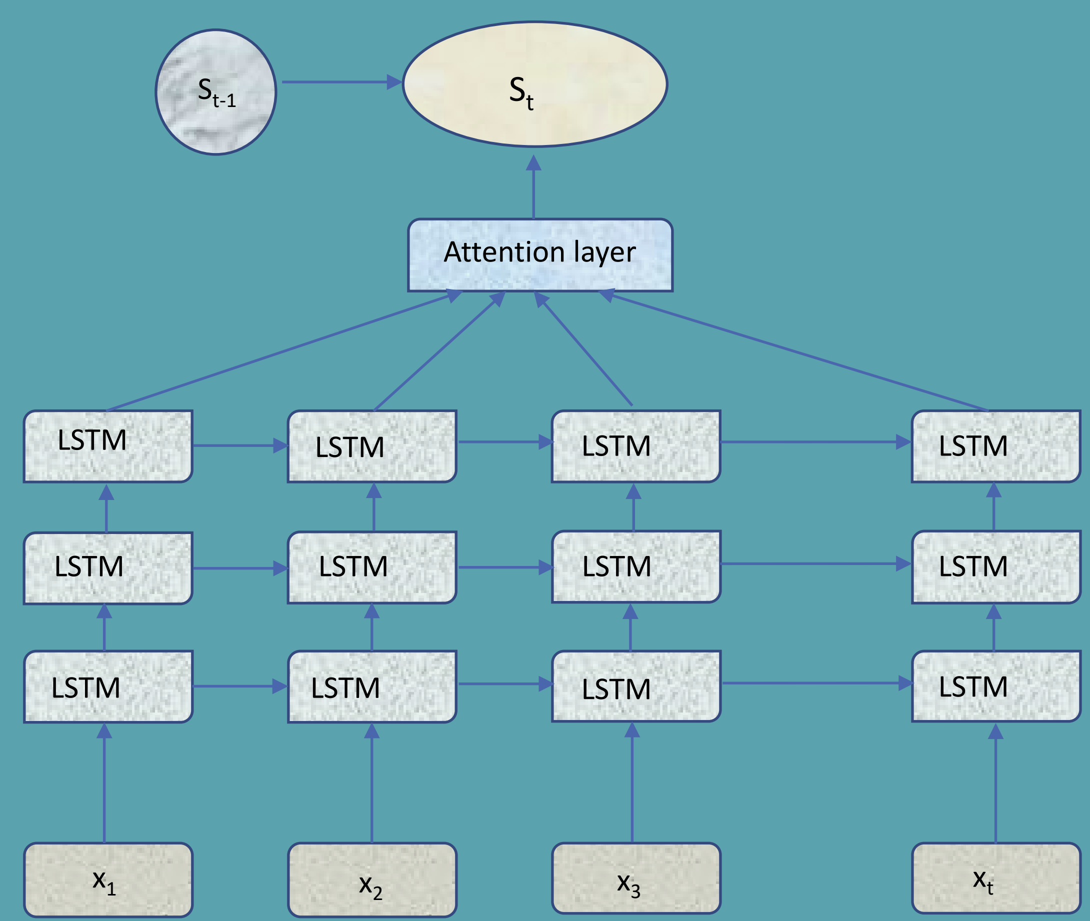
Cumulative Power Spectral Density plot at (d) skipsize = 30 (e) skipsize = 40 (f) skipsize = 50

METHODOLOGY

Recurrent Neural Network is an NN architecture characterized by a feedback loop. This finds application especially in time-series analysis, since the state of the output at a given timestamp t is influenced by the state of the output at previous timestamp t-1.



The LSTM algorithm acts as a gating mechanism that maintains the state of the previous output which helps in proper data transmission. The keras attention layer is used here. The attention layer facilitates the interdependence between the output and the input states and also within the input states.



FUTURE WORKS

The learning model will now be tested by varying other factors such as learning rate, attention layers, etc., to determine the right set of parameters that would ensure that the outputs predicted have the highest level of accuracy possible.

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