MSc Applied Computational Science and Engineering/CfAE Workshop

Preparation for the live workshop on Monday 14 June 14:00-15:30

This document contains links to all the input materials for this workshop. The input has been developed in collaboration with your department to support you in writing your Independent Research Project (IRP) report. Your department has specified that your IRP report should simulate a real research paper (see guidelines provided by your department) and it is therefore important to familiarise yourself with the conventions of research writing and aim for clear and effective written communication of your research.

Key writing strategies for effective research communication covered in the input materials include:

- Showing the impact/value of your research
- Reducing ambiguity/improving clarity
- Using explicit linking (not just 'and')
- Replacing prepositions with alternatives (where necessary)
- Showing clear ownership (where to use agentless passives/we)
- Using reference pronouns and summary nouns: This + noun
- Using consistent terminology to help your reader track key concepts
- Adding a narrative wrap/scaffold to guide your reader
- Choosing the most effective tense to show your position/stance

Before the workshop, please watch and **make notes on** the 3-part video input hyperlinked below. During the workshop, you will be given the opportunity to apply the concepts taught in the videos.

1. Reverse engineering successful reports (35 minutes)
2. Analysing effective and ineffective IRP report writing (15 minutes)
3. Writing tips for writing clearly and effectively (25 minutes)

The texts we will be analysing in the live workshop session on Monday 14 June are included on the following pages. Read these five abstracts from previous students' IRP reports before the workshop to familiarise yourself with the content. In the workshop, we will analyse the effectiveness of these abstracts and explain how to write a clear, reader-friendly and effective IRP report.

Abstract 1

In this project, I develop a new convolutional auto-encoder for compressing the number of fluid flow variables solved for on unstructured finite element or control-volume meshes. This is developed within the OPAL toolbox. OPAL is an open-source software written in Python, used for Reduced Order Modeling of fluid flows and geothermal applications. It provides a set of compression and predicting methods which are needed in order to construct Reduced Order Models (ROMs). This work implements into OPAL (for the first time) a non-linear machine learning method for compressing fluid flow solution variables. In some cases, the convolutional auto-encoder in Reduced Order Modelling shows better performance than traditional methods such as POD. The ultimate aim is to reduce the number of solution variables down from many millions, that are solved for each time step, to perhaps a few hundred. Furthermore to perform this reduction in variables on an unstructured mesh. We use interpolation methods to interpolate unstructured mesh solution variables onto structured meshes so that it is possible to apply standard convolution methods designed for compressing images. In addition, we apply domain decomposition methods in which we split the solution domain into several regions or subdomains with similar resolution within each subdomain. This enables the auto-encoder to be applied at a number of different length scales. We demonstrate our model on some illustrative examples, each, highlighting the models performance in the prediction of flows.

Abstract 2

Reduced order modelling is a powerful technique for rapidly modelling high dimensional fluid dynamics systems. Its speed could enable real-time decision making and operational modelling. Using a Long Short Term Memory (LSTM) neural network to train the data in the reduced space can obtain excellent predictions in a short time. Gaussian Process Regression (GPR) and domain decomposition GPR are also used to train the data in reduced space, which also give accurate results. The full process of reduced order modelling is integrated and implemented in both 2D and 3D problems governed by the Navier-Stokes equations.

Abstract 3

A Python package was developed to produce a generative adversarial model capable of generating realistic time-series sensory data. The model was trained on the MotionSense dataset. This dataset consists of sensory data from twelve different features, captured when the test subjects were performing one of six activities. The features used for this project were limited to only accelerometer data, along three orthogonal axes. A generative adversarial network, consisting of deep convolutional discriminator and generator networks was used for the data generation.
When visualised, the data generated appears to resemble that from the dataset, and when passed through the classification model provided by the authors of MotionSense, the best class (data associated with jogging) obtained an accuracy of 95 %, while other classes scored poorly

Abstract 4

Identifying failures and damage (anomalous behaviour) in remote mechanical assets such as compressors is of great importance to many industries. As the number and complexity of such machinery increases, automated methods that can make inferences from the multivariate time-series produced by sensor readings from these assets are required. Here we show that LSTM (Long Short-Term Memory) auto-encoders are able to prepare intervals of these multivariate time-series for classification into anomalous and normal behaviour, and are able to use the easily-interpretable nature of this model to identify sets of features which contribute to anomalous behaviour. Additionally, we demonstrate that LSGANs (LeastSquares Generative Adversarial Networks) are able to learn the static (non-time dependent) marginal distributions of the time-series and samples can be drawn from this to generate synthetic data.

Abstract 5

In the oil industry, seismic surveys have been used for decades to investigate the structure of sedimentary basins and localise potential hydrocarbon reservoirs. In marine environments, seismic surveys can be conducted with ships towing airguns, generating mechanical waves, and receivers, recording the waves reflected by geological structures. In order to obtain better data quality and save on acquisition costs, the multi-shooting technique consists in firing multiple sources simultaneously in the same acquisition area. The data so obtained is characterised by interferences between signals coming from different sources. In order to be properly processed, the signals generated by the sources have to be untangled, an operation known as signal de-blending. This is conducted with algorithms requiring long computational time and massive hardware resources. The goal of the project is to develop and test artificial neural networks (ANNs) capable of performing good quality de-blending, while requiring a fraction of the computational time needed by standard algorithms. I developed a number of ANNs, featuring an encoding and decoding sides, and trained them to perform de-blending using the outputs of standard algorithms as training examples. Having been able to obtain networks capable of producing good quality results, I compared their outputs with those computed with standard algorithms, highlighting the limitations of the networks results and offering possible solutions. I thoroughly explored how the ANNs performance is influenced by various kinds of architectural modifications. In addition, I carried out an analysis of how the size and features of the training dataset impacts the performance of the networks. The results of the project show the feasibility of employing ANNs in performing signal de-blending, with a significant saving in terms of computational time, from dozens to only a couple of hours, for the processing of one seismic acquisition line.

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