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Machine learning–enabled missile system characterisation

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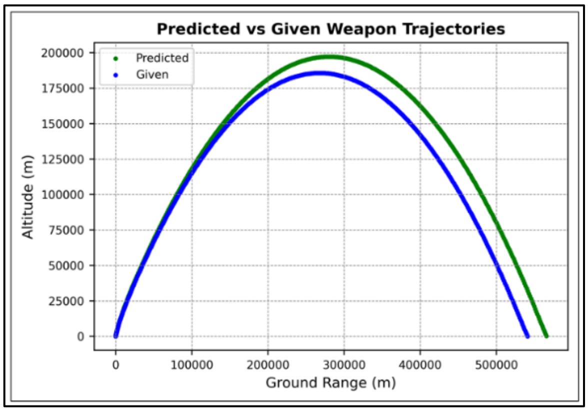
Abstract: Missile system analysts frequently work with incomplete data and are faced with the problem of building physically realistic models with these uncertainties. Knowledge of the parameters that give rise to a missile's trajectory are important for accurately modelling threat systems. Skilled analysts may be able to accurately reconstruct vehicle trajectories based on incomplete data, but there are inherent speed and extensibility limitations and biases associated with this approach. This approach also relies on deep subject matter and modelling tool expertise, knowledge which can be time consuming to disseminate. In this study, an alternative approach to reconstructing missile systems using a multilayer perceptron (MLP) neural network is proposed. This study explored the feasibility of characterising missile systems using an MLP neural network trained on simulated data. A simulated dataset of 8000 ballistic missile trajectories was generated using a custom developed Python script. This dataset was split into a testing and training subset and each trajectory (samples of speed, latitude, longitude, and altitude) was processed into an $n \times 1$ dimensional vector. Training was conducted using the TensorFlow machine learning platform (https://www.tensorflow.org/) using an MLP neural network, with hyperparameter tuning used to identify the optimal neural network architecture for this task. The model was verified by analysing the training and validation learning curves over the training duration. It was demonstrated that the trained neural network could infer the relationship between a ballistic trajectory input and weapon system parameters output (Figure 1).



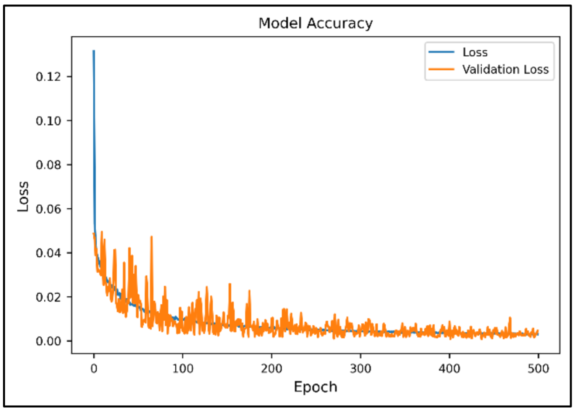


Figure 1. (Left) a comparison of predicted (green) vs given (blue) weapon trajectories with an accurately predicted set of parameters and (right) evidence of the neural network 'learning' to predict missile parameters

Analysis of the relative error values between the predicted and actual missile parameters showed that certain parameters could be predicted with greater accuracy while other parameters proved more difficult. Investigation of these outcomes has revealed that there are some inherent ambiguities associated with machine learning-enabled missile system characterisation. Ongoing work is focused on understanding the limits of this approach, and what influence the given training data inputs has on model prediction accuracy.

Keywords: *Machine learning, missile modelling, missile characterisation*