Empty Vehicle Weight Prediction for EVTOL Aircraft

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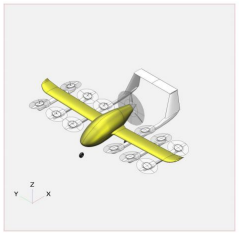
Problem & Prediction

- Analytical methods exist for predicting aircraft weight based on size of various components
- These methods require a full-featured aircraft model within a conceptual design suite
- By training a neural network we can make these predictions without the overhead of the conceptual design suite

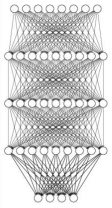
Data Format

- 1E6 data points were generated via uniform random sampling of the design space for aircraft with estimated MTOW from 2E3 to 2E4 kg:

$$\boldsymbol{x}: \begin{bmatrix} MTOW \\ m_B \\ m_{PL} \\ L_F \\ W_F \\ H_F \\ b \\ c \\ t/c \\ w/f \\ N_L \\ N_T \\ B_L \\ B_T \\ R_T \end{bmatrix} \rightarrow \boldsymbol{y}: EVW$$



Models – FCNN



- FCNN as Baseline:
  - 32-128 Hidden Units
  - 3-9 Layers
- Softmax or ReLU Output Layer
- Adam Optimizer
  - α: 1E-4 to 1E-1
  - Batch Size from 32 to 1024
  - Training Epochs from 10 to 10000

Categorical vs. Regressor

- Problem can be posed as either regression using 1-D output w/ MSE Loss or 100-D output w/ CCE Loss:

$$L_{MSE} = \frac{1}{m}\sum_{i=1}^{m}(\hat{y}_i - y_i)^2$$

$$L_{CCE} = \frac{1}{m}\sum_{i=1}^{m}\sum_{j=1}^{n} -\left(y_{ij}\log\hat{y}_{ij} + (1-y_{ij})\log(1-\hat{y}_{ij})\right)$$

Results & Discussion

	Training (95%)	Test (5%)
Categorical	3.6%	1.9%
Regressor	2.7E7	4.5E7

- Overall performance was poor, Regressor errors on the order of 5000 kg, Categorical accuracy only marginally better than random guessing
- Models typically reached this performance in <500 epochs, insensitive to longer training
- Improved with size of dataset, not with size of network (tested with subsets of 1E3 to 1E5 points)

Future Work

- Generate larger dataset, exclude outliers
- Consider wider range of architectures (e.g. HRNN)
- Implement simulated annealing optimizer