Velocity Estimation from Doppler Radar

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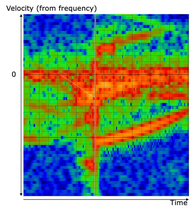
Introduction

Accurate **velocity estimation** of a golf ball is crucial for golf analytics and simulations. Using **Doppler radar** signals and spectrogram analysis, **CNN models** are able to predict velocity with more accuracy than previous methods (refrenca mark/supervisorinn)

The Data

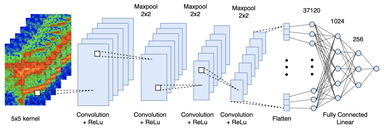
The main data used for training the models are stacked spectrograms, 4 power and 2 phase spectrograms, along with the target radial velocity. It was derived from the Short-Time Fourier Transform.

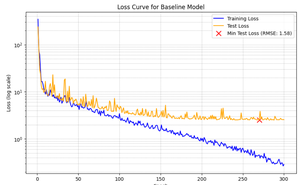


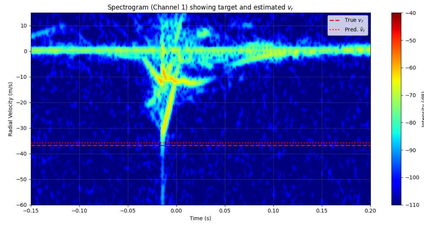
Main Objective

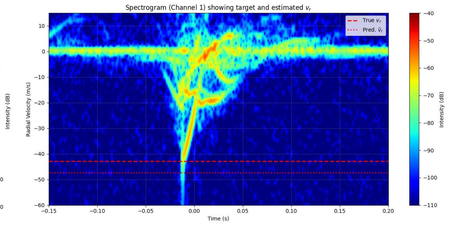
Improve baseline models accuracy with the limitation of **not adding to the model complexity** (total number of model parameters) and/or make it **simpler** (fewer parameters).

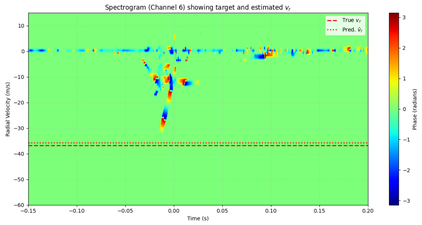
The Baseline Model

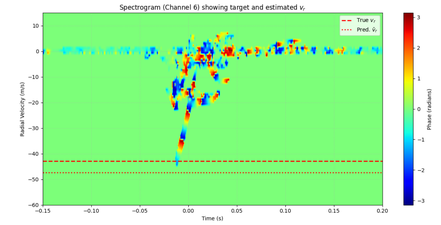












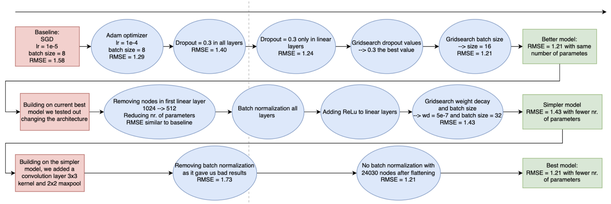
Methods and Model Improvements

The proposed method

- Start out simple, change optimizer, fine tune learning rate → take out layers, fewer nodes…
- Add regularization techniques like **dropout** and **batch normalization** to regularize and stabilize the training
- **Coarse grid search** used in hyperparameter tuning
- Trial and error…

Performance Metrics

- Loss curves
- Statistical tests
  - T-tests
  - Wilcoxon signed-rank test



Results

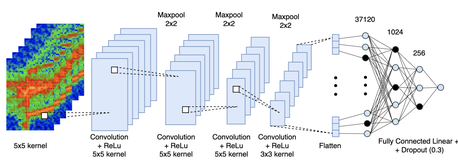
Model	Optimizer	Learning Rate	Batch Size	Batch Norm	Dropout	ReLU	Min RMSE	Total Parameters	Hidden Layers	T-Test (P-value)	Wilcoxon (P-value)
BaseLine	SGD	1e-5	10	No	No	Yes	1.58	38,414,929	6		
Best performing	Adam	1e-4	16	No	0.3	Yes	1.21	38,414,929	6	1.61e-5	4.45e-44
Simpler model	Adam	1e-4	32	Yes	0.3	Yes	1.43	23,081,009	6	2.96e-10	1.57e-21
Last model	Adam	1e-4	16	No	0.3	Yes	1.20	24,292,177	7	5.302e-4	5.11e-41

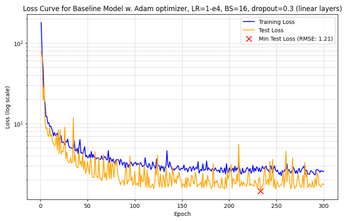
- Succesfully achieved main objective:

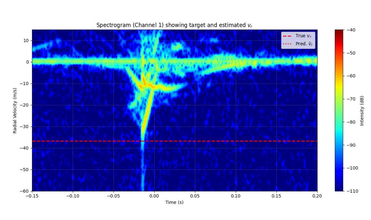
1. Better performing model than the baseline
2. Simpler model with as good or better performance than the baseline
3. Simpler and better model performance than previous models and the baseline

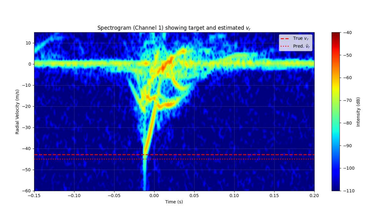
Best Models

Better performing model

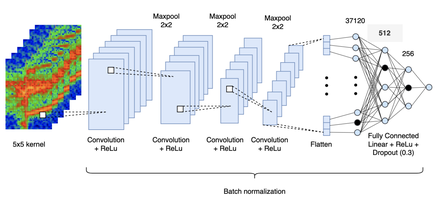


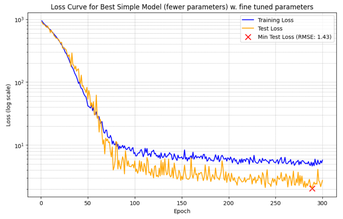


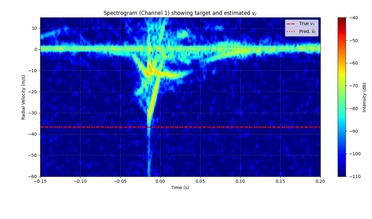


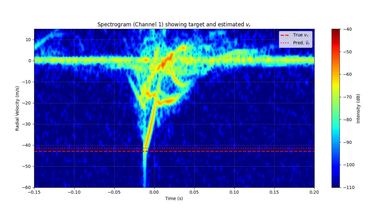


Simpler model









Best model