NORTHROP GRUMMAN

ENGINEERING & SCIENCE STUDENT DESIGN SHOWCASE

FLORIDA TECH

Atmospheric Retrieval using Neural Network Methods

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Introduction

- The current growing number of discovered exoplanets via the transit method demands a need to have a quick and accurate way of performing atmospheric retrieval.
- This project investigates the accuracy of neural network (NN) methods of atmosphere retrieval, involving long short-term memory (LSTM) NNs and graph neural networks (GNN) and compares it to preexisting convolutional neural network (CNN) and Bayesian retrieval methods.

Methods

- NASA's Planetary Spectrum Generator (PSG) **[1]** was used to generate synthetic transmission spectra for inputs into the NN models.
- The parameters that the models tried to predict was the temperature, radius, surface gravity, and abundance of H_2O, CO, CO_2, NH_3, and CH_4 of the exoplanets.

Layer
Bidirectional LSTM(200)
Dropout(0.2)
Bidirectional LSTM(300)
Dropout(0.2)
Bidirectional LSTM(300)
Dropout(0.2)
Flatten()
Dense(100, "relu")
Dense(3, "linear")

Figure 1: Diagram of LSTM model

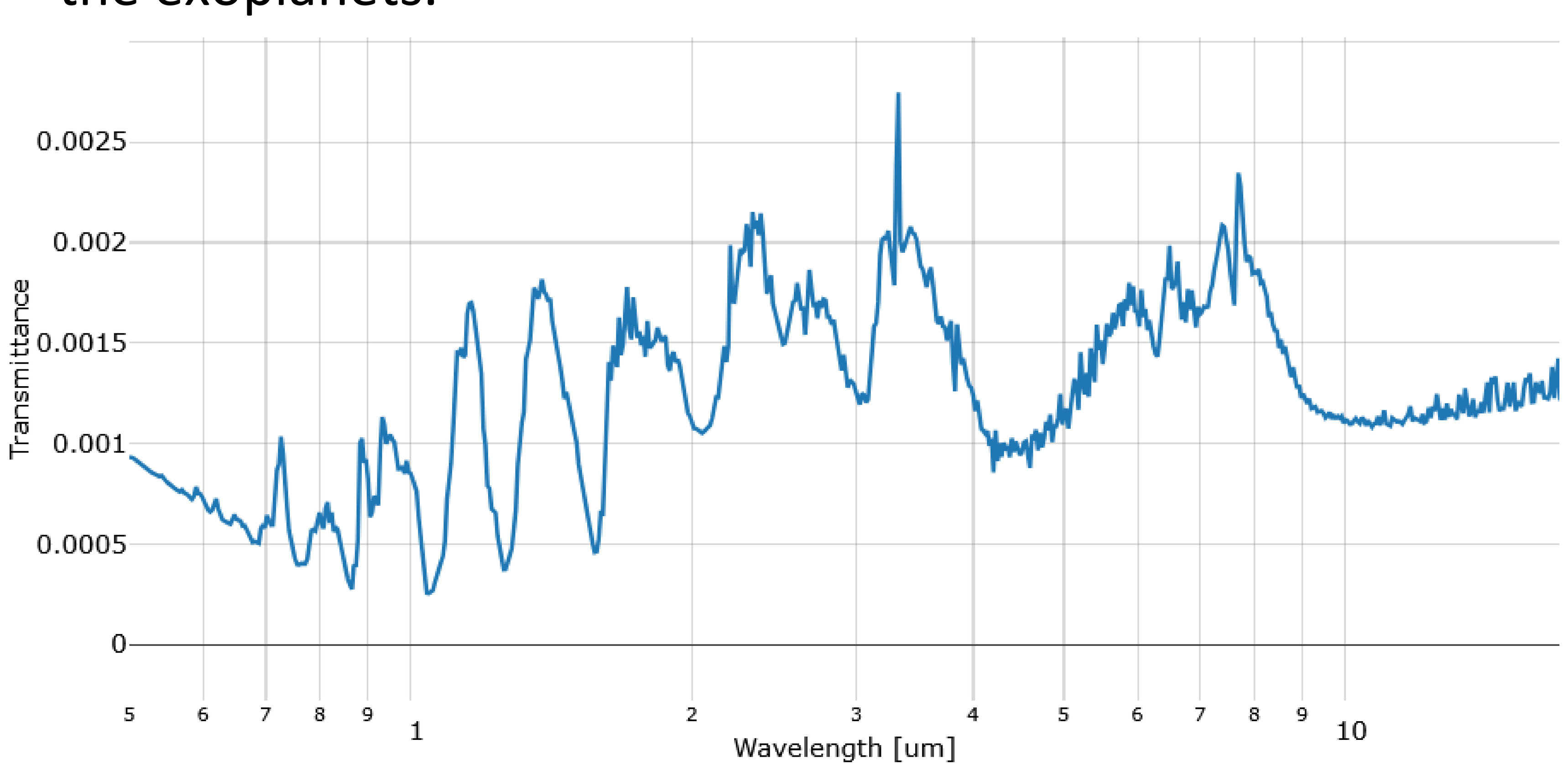

Figure 2: Example transmission spectra from NASA PSG

Results

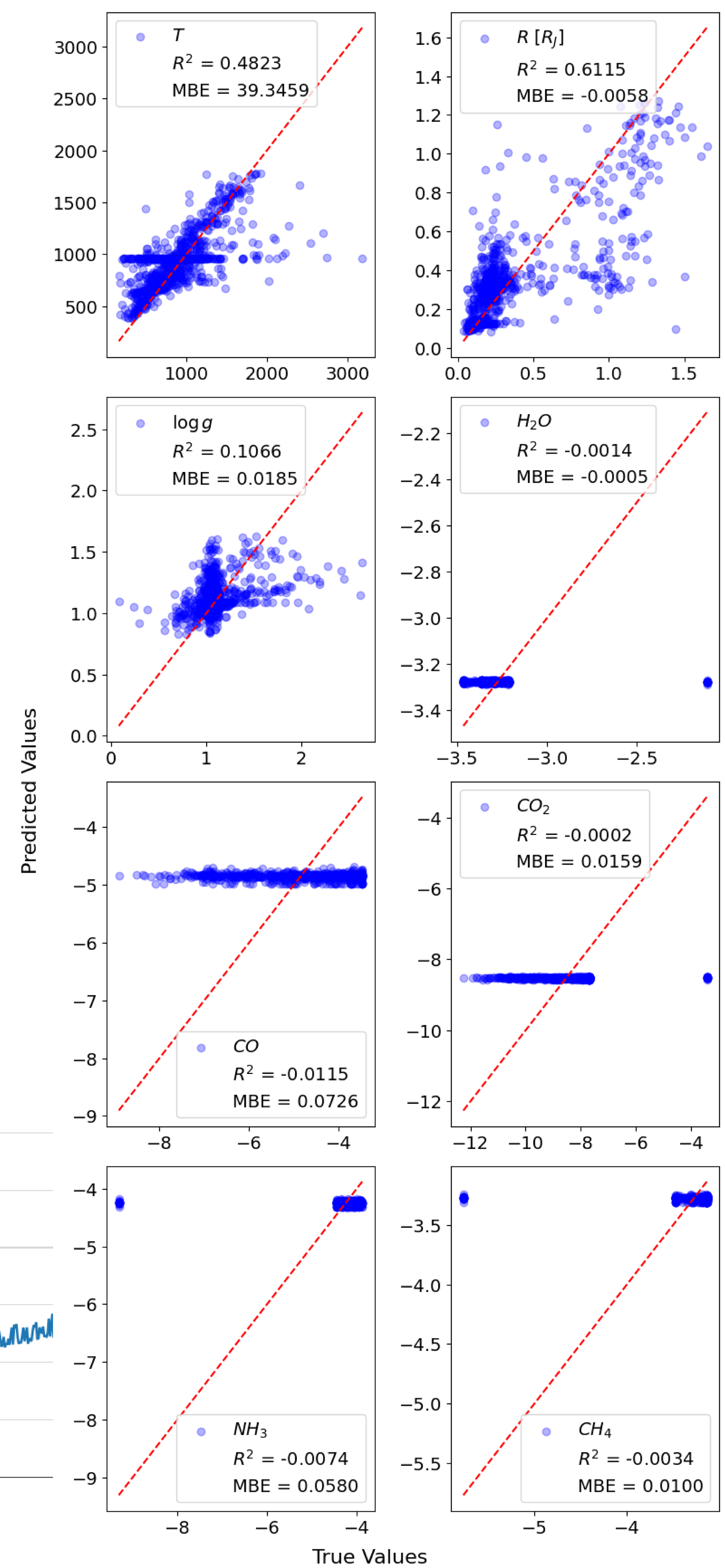

Figure 3: Resulting LSTM predictions

	R^2				MBE			
	LSTM	GNN	CNN	Baye	LSTM	GNN	CNN	Baye
Temp	0.482	0.4185	0.34	0.3	39.346	42.354	-127.49	-184.75
Radius	0.612	0.466	1.0	1.0	-0.006	0.053	0.01	-0.01
log g	0.106	0.062	0.42	0.32	0.019	0.071	-0.17	0.26
H_2O	-0.001	-0.006	0.31	0.37	0.001	0.018	-0.06	-0.29
CO	-0.011	-0.009	0.01	0.03	0.073	0.117	0.12	-0.41
CO_2	0.000	-0.016	0.07	0.08	0.016	0.179	-0.06	-0.54
NH_3	-0.007	-0.001	0.26	0.31	0.058	0.031	-0.39	-0.56
CH_4	-0.003	-0.001	0.26	0.23	0.010	0.013	-0.5	0.1

Table 1: Comparing R^2 and MBE values for LSTM, GNN, CNN, and Bayesian models

- When comparing the LSTM and GNN model to preexisting CNN and Bayesian models (from Martínez et al. **[2]**), the LSTM and GNN models have better MBE values for almost all parameters, but in almost all cases, the LSTM and GNN models have far worse R^2 scores. The LSTM and GNN models are clearly best when predicting physical parameters rather than chemical parameters.

Conclusions

- There is some promise in using LSTM and GNN models in comparison to CNN and Bayesian models, but further work should be pursued to increase the accuracy of the models.
- Future work would include finalizing the specific construction of the model, getting more data for the model, and potentially predicting more parameters.

References

[1] Villanueva, G.L., et al. 2018. J. Quant. Spectrosc. Radiat. Transf. 217, 86–104

[2] Martínez. F. A., et al. 2022. A&A. 662, A108