Classification of Magic The Gathering Cards

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Introduction

- **Motivation:** To assist the organizations that determine the ranks of cards by providing them with a rough idea of each card's usefulness.
- **Objective:** Determine whether a card is considered above/below average.
- **Result:** Achieved a classification model with 92% accuracy.

Info


NAME
Serra Angel
MANA COST
TYPE LINE
Creature — Angel
EXPANSION SYMBOL
Flying, vigilance
The angel remembers her past lives like dreams. Her song held up meadows. Her blade drove back darkness. Her wings carried her across the ages.
TEXT BOX
4/4
POWER/ TOUGHNESS
033/269 U
DOM • EN
Donato Giancola
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Methodology

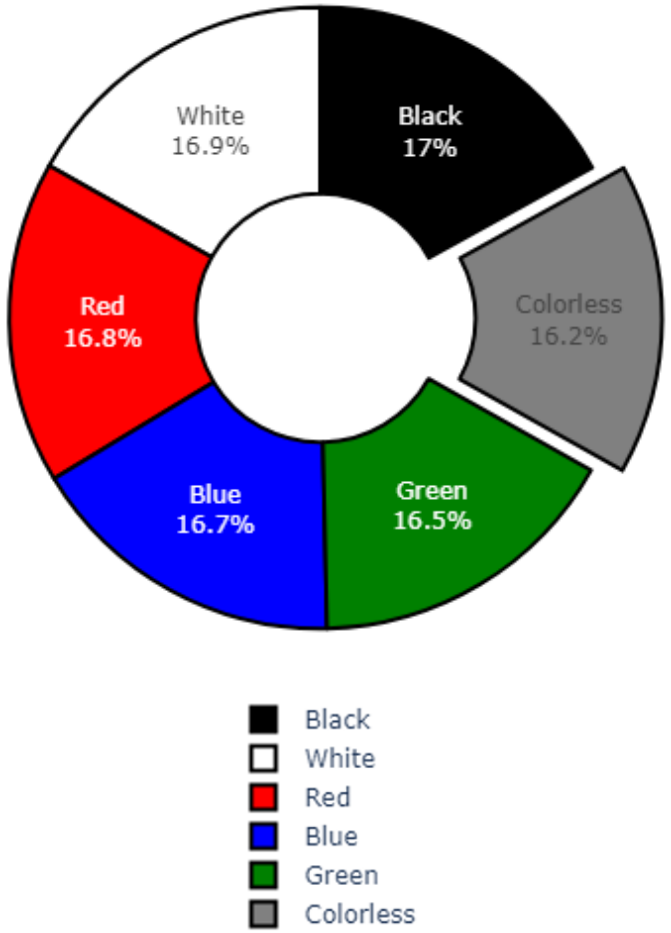
- **Data:**
  - 69,000+ cards (25,000+ unique cards)
  - 80+ features (engineered 750+ features)
  - https://scryfall.com/docs/api/bulk-data
- **Metrics:**
  - Intrinsic Card Info
  - Third Party Card Ranking
- **Tools:**
  - Pandas, Numpy, Sklearn, Plotly, Excel

Methodology Cont.

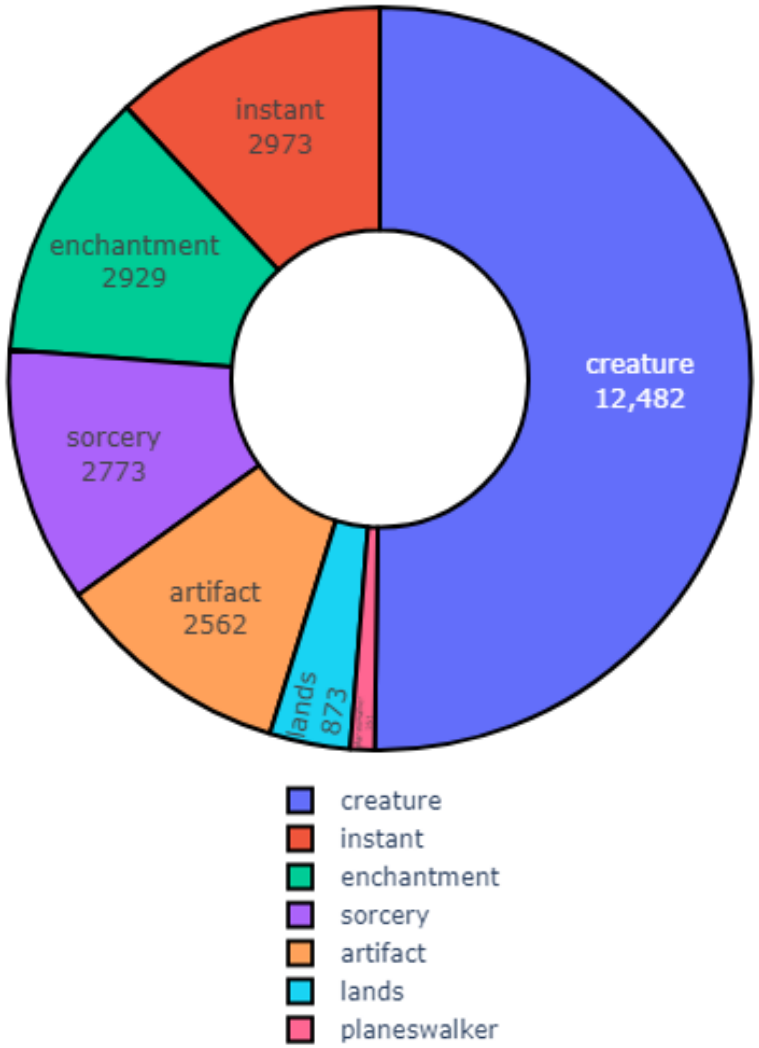
- **Models Used:**
  - Logistic Regression
  - Decision Tree
  - Random Forest
  - Adaptive Boost
  - Gradient Boost
  - Ensemble
- **Trade Study Procedure:**
  - Each model tested on 100% of features and top 50% correlated features
  - Each Configuration tested on different hyperparameter configurations

Results - EDA

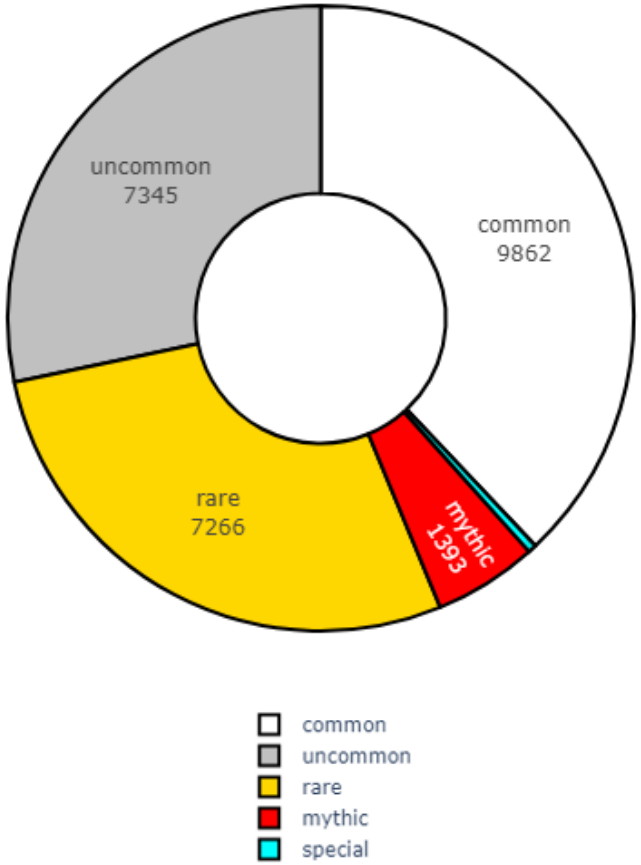
Color Distribution



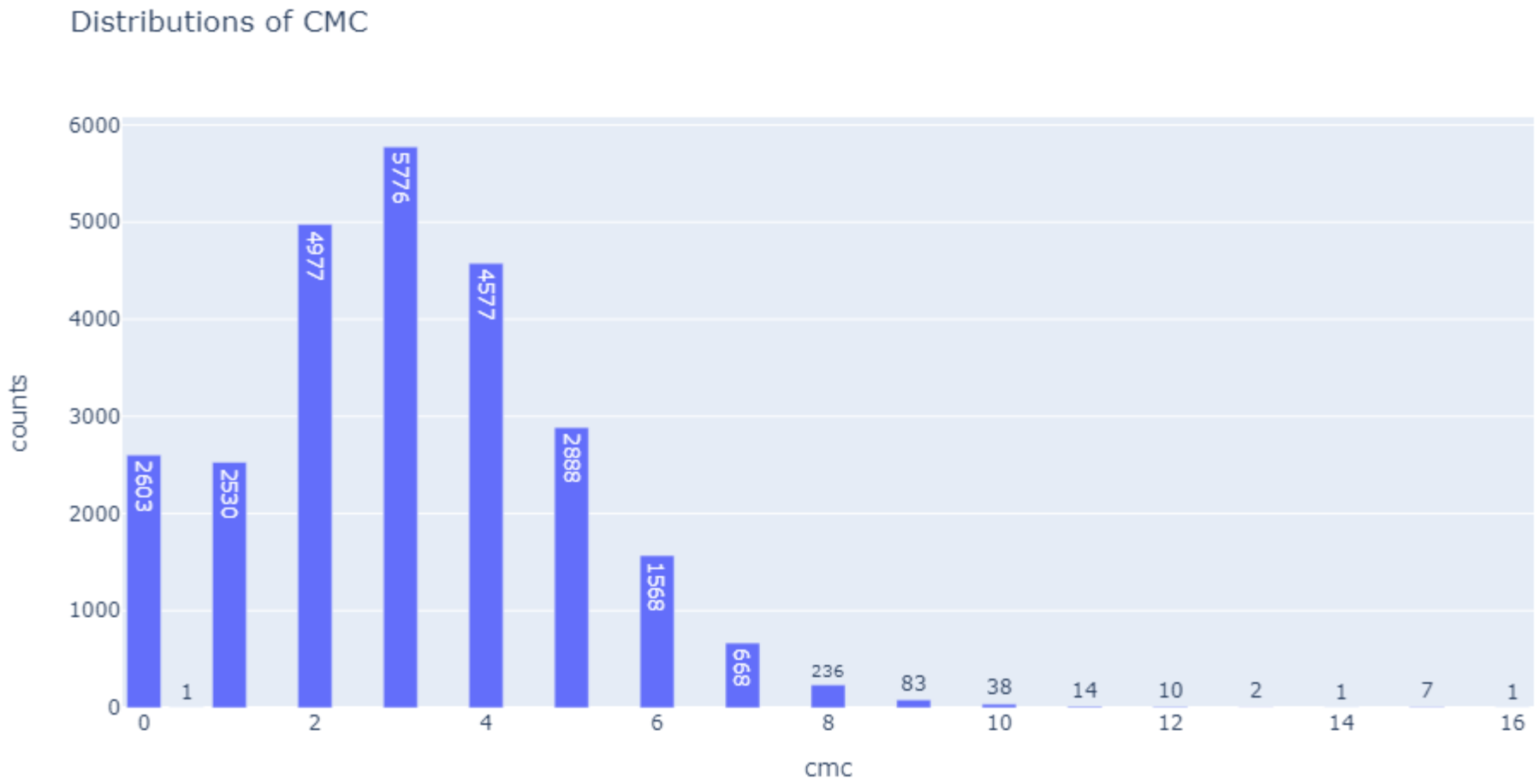
Basic Card Types



Rarity

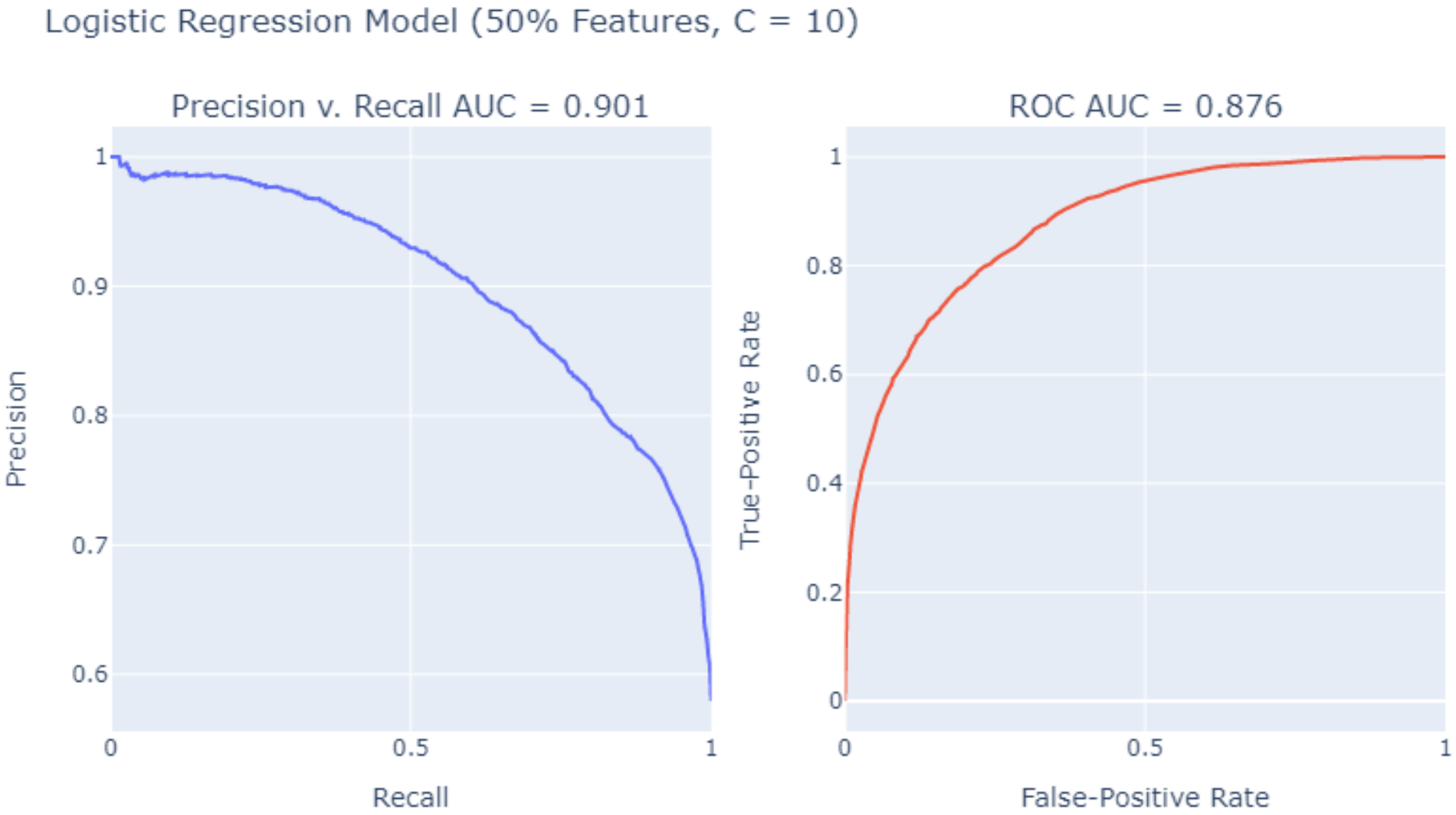


Results Cont. - EDA



Results Cont. – Logistic Regression

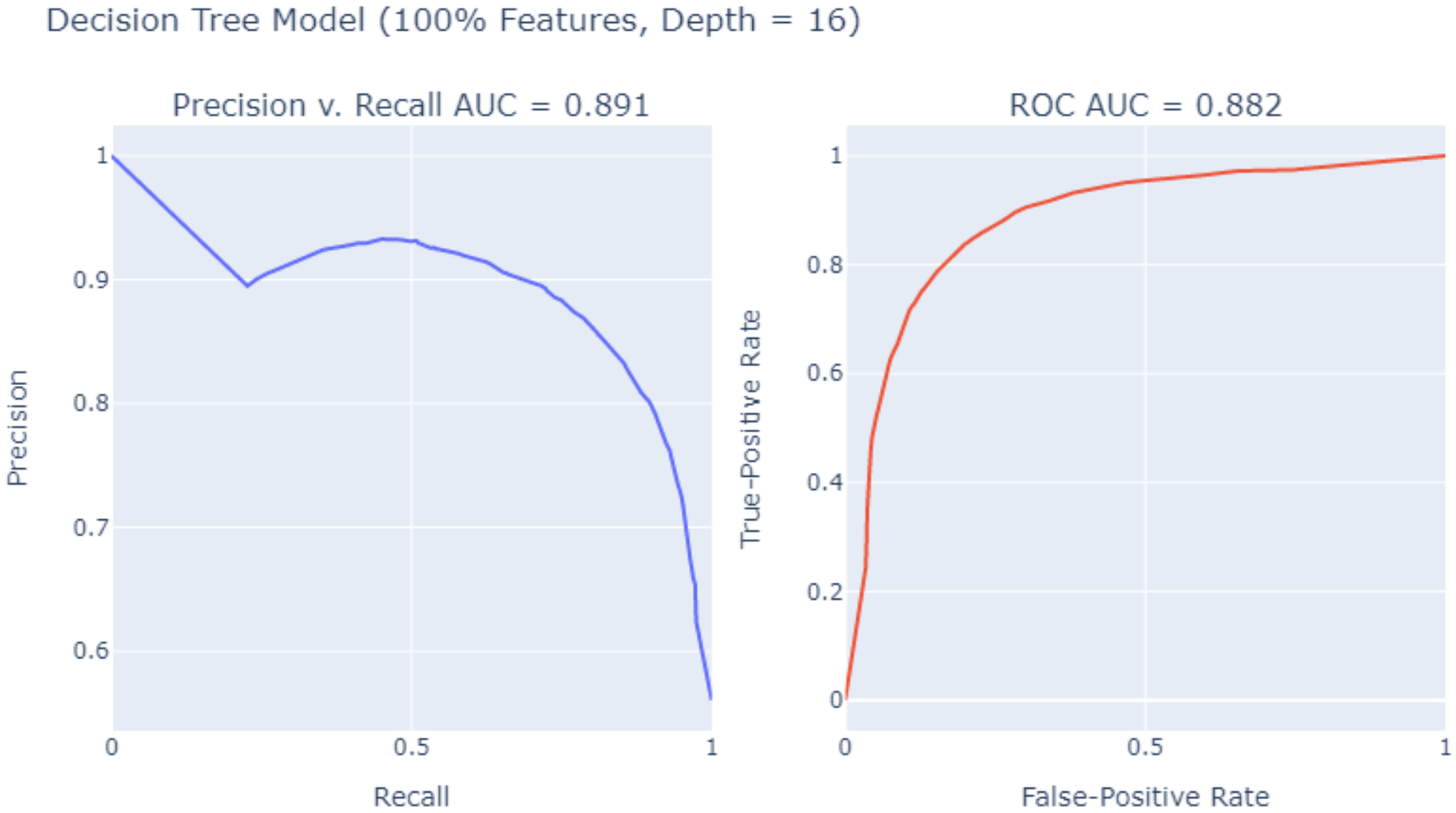
Tuned C parameter between:
C = 0.1
C = 1
C = 10



Results Cont. – Decision Tree

Tuned Max depth between None, 16, & 4

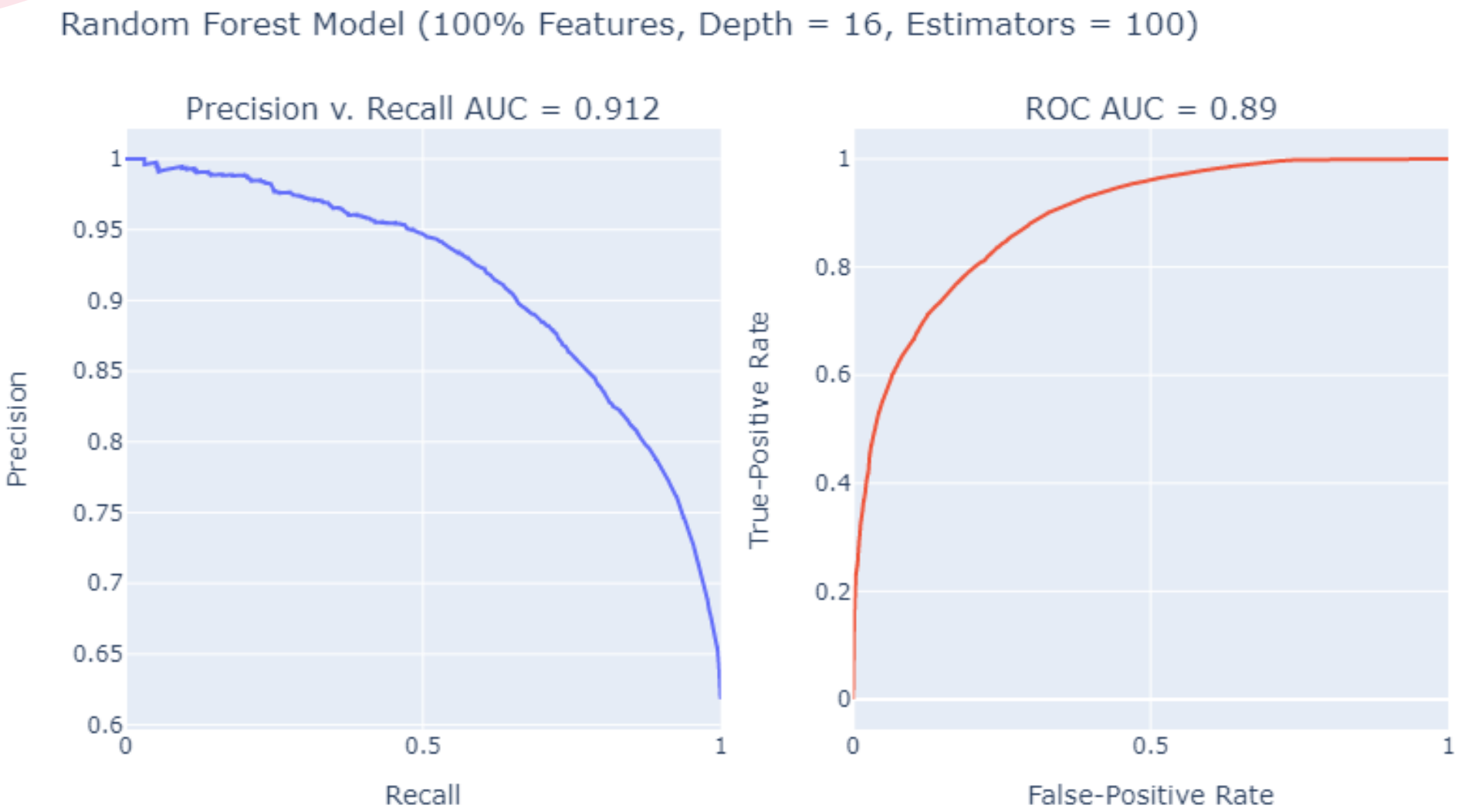
Optimal Max Depth found to be 16



Results Cont. – Random Forest

Tuned n_estimators between 10, 100, & 1,000

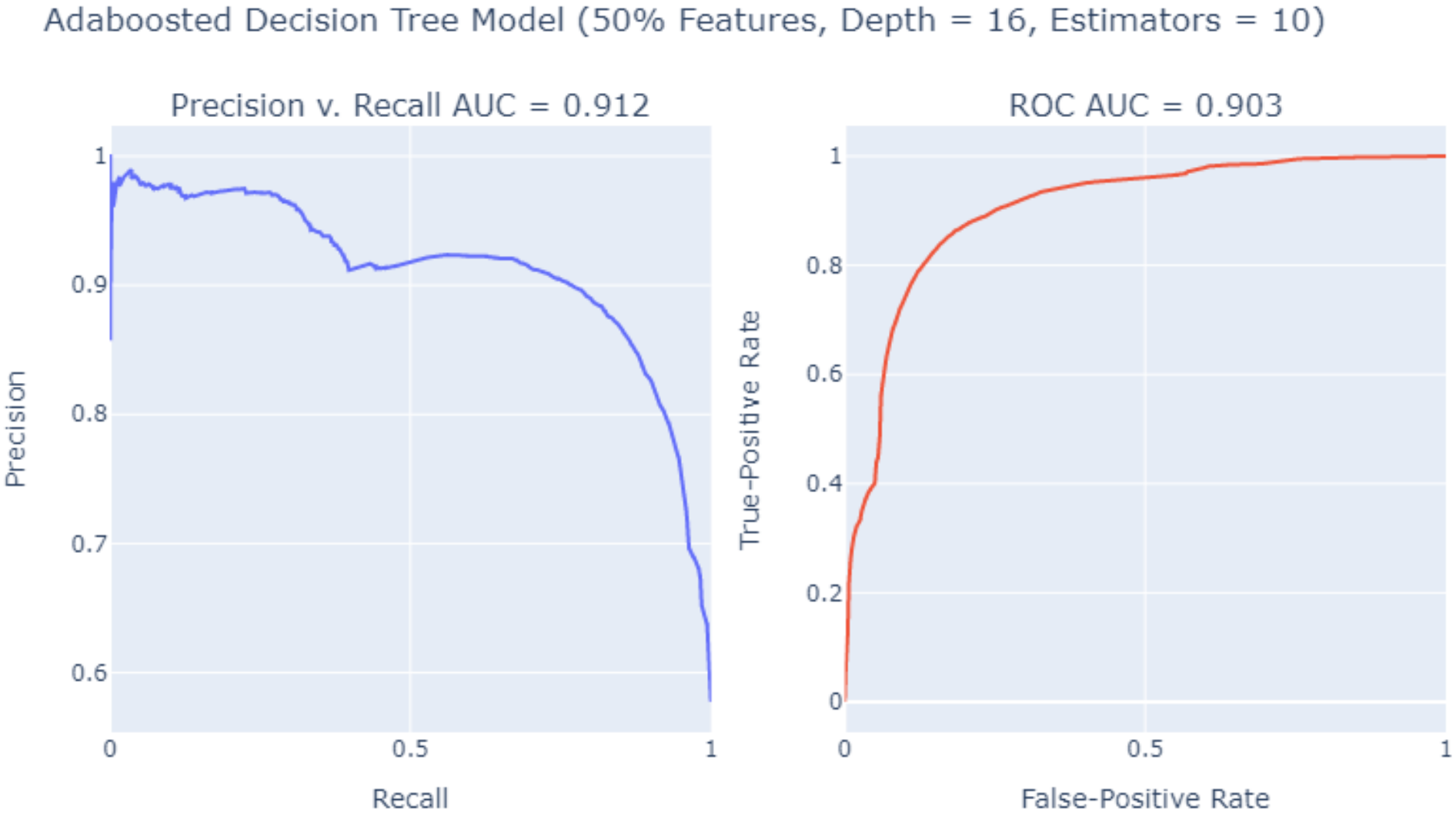
Max Depth set to 16 based on decision tree results



Results Cont. – Adaptive boost

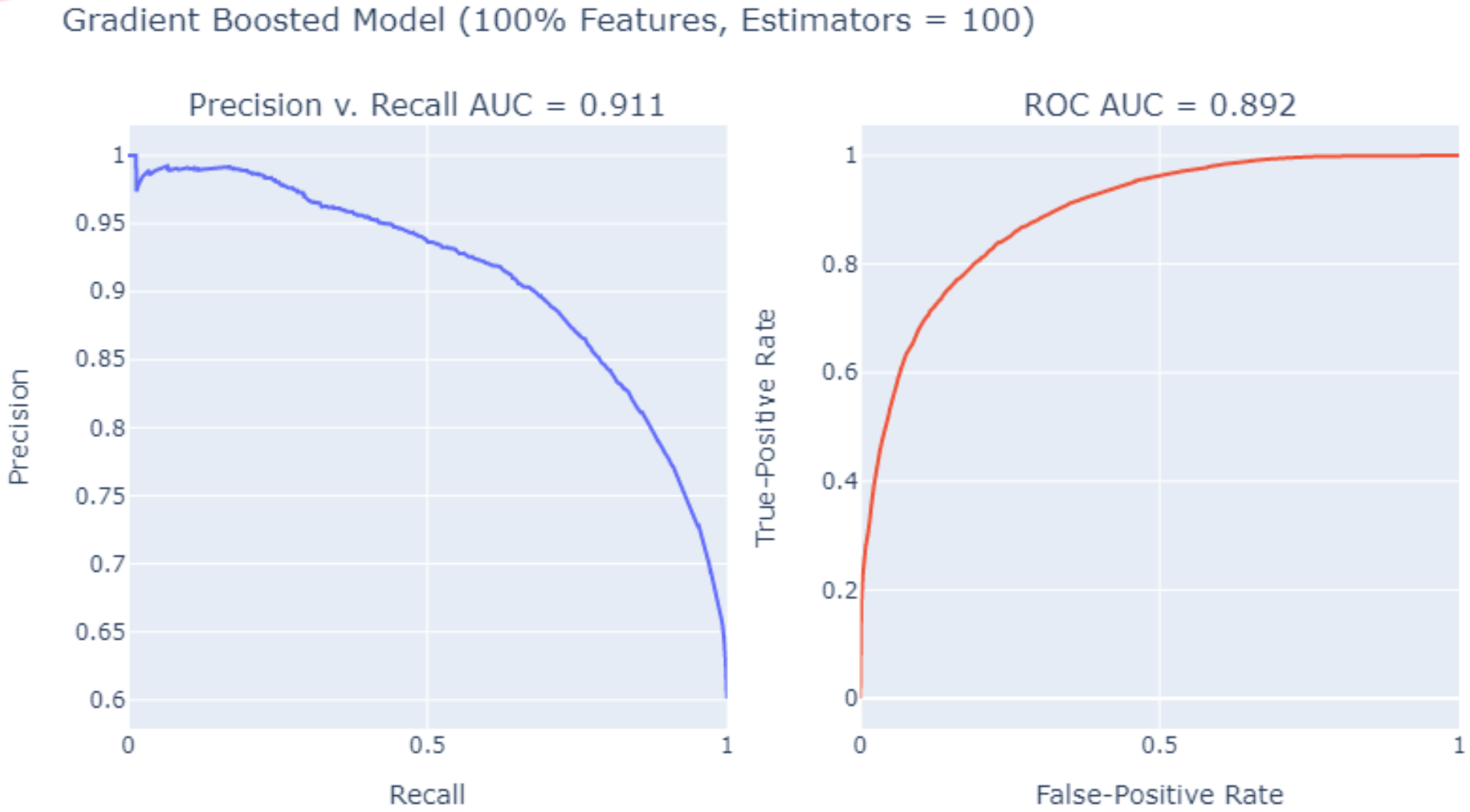
Tuned n_estimators between 10, 100, & 1,000

Boosted best decision tree



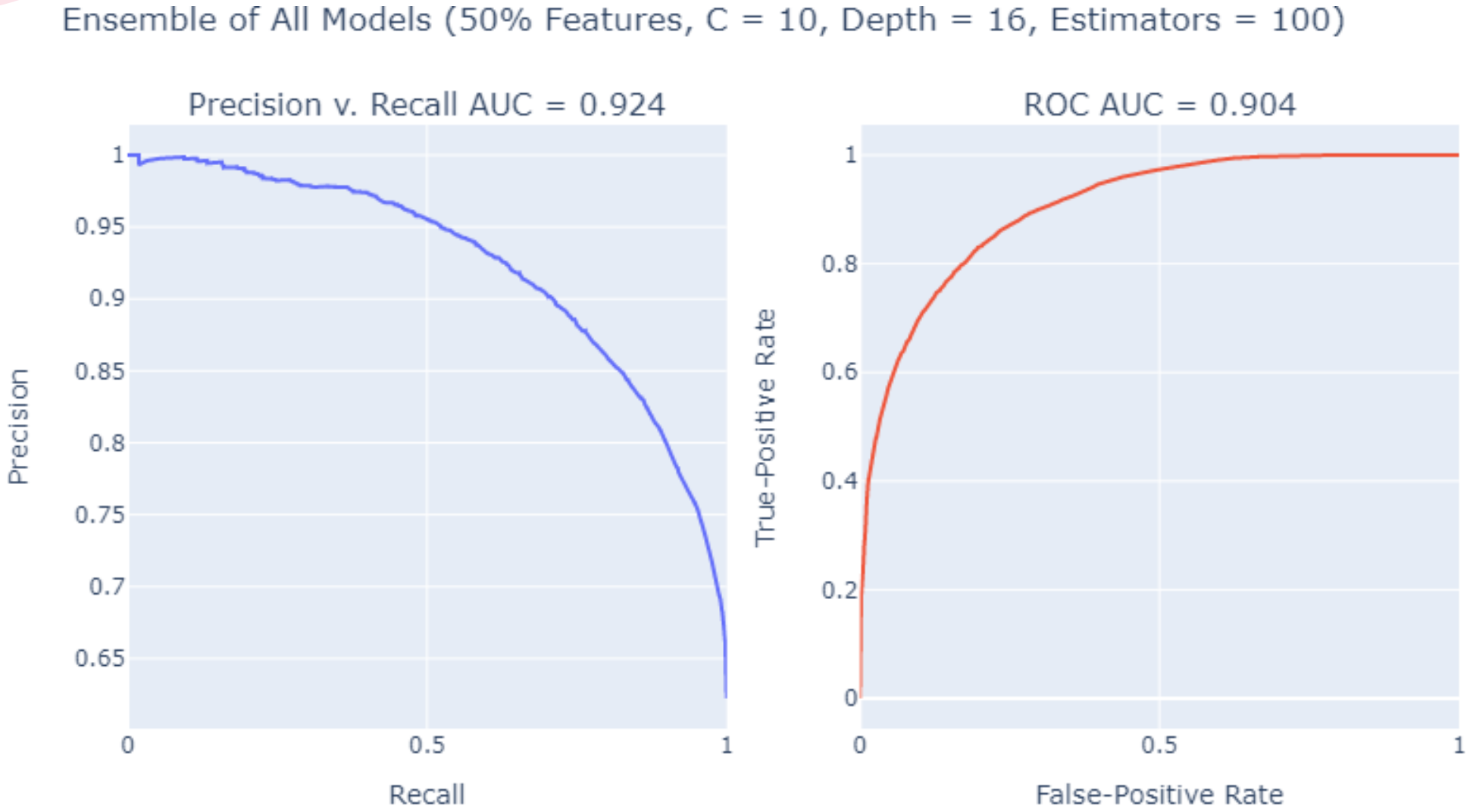
Results Cont. – Gradient Boosting

Tuned n_estimators between 10, 100, & 1,000



Results Cont. – Ensemble of Prior Best Models

Best Precision-Recall AUC and best ROC AUC



Results Cont. - Best Results

Ensemble 50% Features:

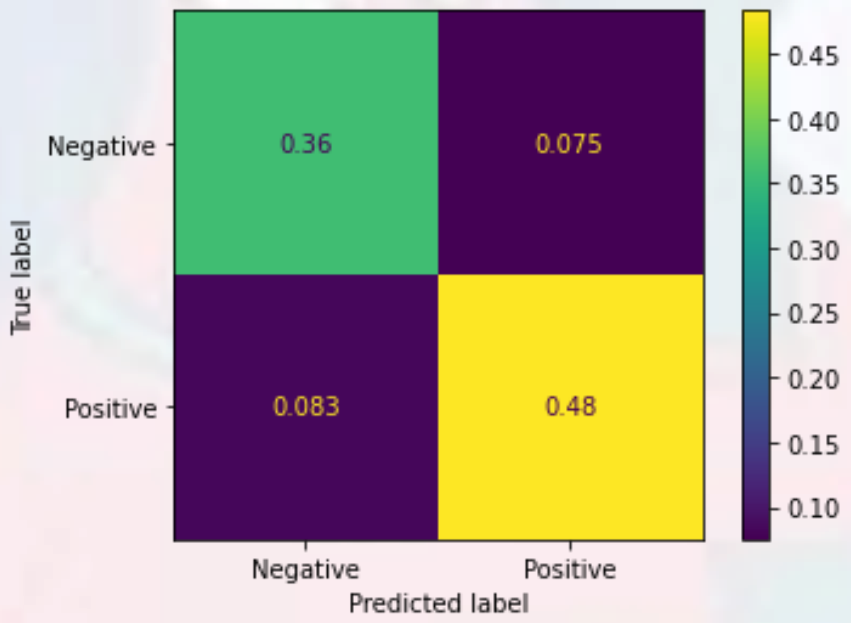
- Accuracy Score: 0.819
- F1 Score: 0.844
- Precision v Recall Score: 0.924
- ROC AUC Score: 0.905
- Overfit Score: 0.034

Best Performances Outside of Ensemble:

- Best Accuracy: 0.849 Adaboost
- Best F1: 0.867 Adaboost
- Best PvR: 0.912 Adaboost, Random Forest (TIE)
- Best ROC: 0.921 Adaboost
- Best Overfit: 0.000 Decision Tree, Gradient Boost (TIE)

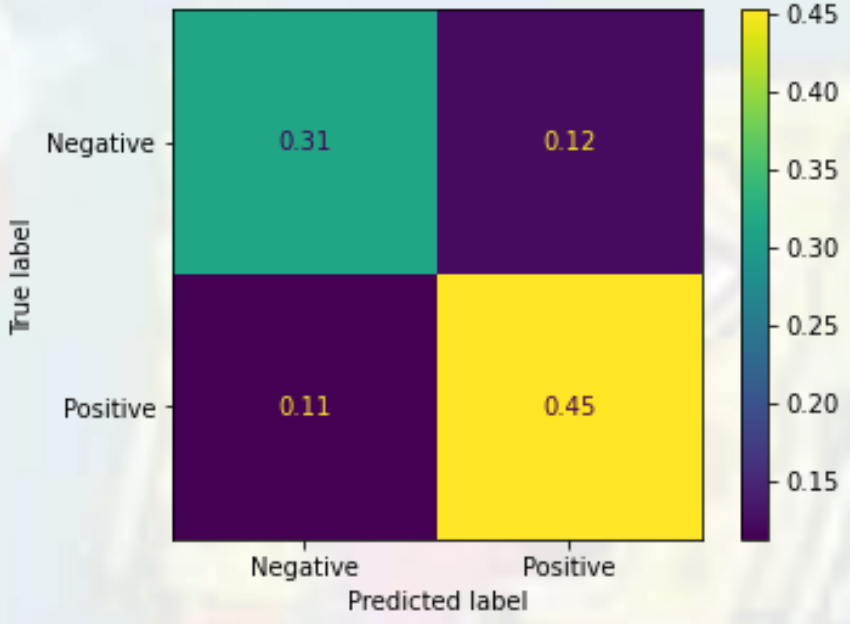
Results Cont. – Best Vs. Worst Confusion Matrix

Adaboost 50%



15.8% Misclassified

Logistic Regression 100%



23% Misclassified

Conclusion

- Given the intrinsic information regarding any given card, it's in game usefulness can be classified with reasonable accuracy.
- The ensemble method of combining logistic regression, decision trees, random forests, ada-boost, and gradient boost yielded the best results.

Future Work

- Make use of the rules text per card.
- Utilizing power/toughness values.
- Classify playstyles from card information.
- Deeper feature engineering.
- Tuning more hyperparameters.

Appendix

Model	Feature Correlation Cutoff	HyperParameters	Val Scores	Train Scores	Test Score	F1 Score	ROC AUC Score	Overfit Score	Eval Metric	
Logistic Regression	100% of Features	C = 0.1	0.767	0.77	0.77	0.795	0.85	0.0035	0.8015	
		C = 1	0.774	0.781	0.762	0.806	0.859	0.007	0.8020	Best 100 LR
		C = 10	0.757	0.76	0.77	0.789	0.846	0.0031	0.7986	
	Top 50%	C = 0.1	0.778	0.783	0.783	0.809	0.869	0.0051	0.8152	
		C = 1	0.783	0.792	0.786	0.811	0.874	0.0081	0.8156	
		C = 10	0.788	0.788	0.785	0.814	0.874	0.0011	0.8232	Best 50 LR
Decision Tree	100% of Features	Max Depth = None	0.814	0.992	0.823	0.843	0.825	0.1776	0.6527	
		Max Depth = 16	0.826	0.877	0.826	0.847	0.882	0.051	0.8007	Best 100 DT
		Max Depth = 4	0.751	0.747	0.755	0.772	0.799	0.0044	0.7709	
	Top 50%	Max Depth = None	0.795	0.898	0.805	0.823	0.858	0.103	0.7257	
		Max Depth = 16	0.803	0.82	0.796	0.82	0.871	0.017	0.8120	Best 50 DT
		Max Depth = 4	0.725	0.725	0.73	0.789	0.777	0	0.7653	
Random Forest	100% of Features	n_estimators = 10	0.79	0.81	0.793	0.831	0.886	0.02	0.8167	
		n_estimators = 100	0.803	0.821	0.802	0.837	0.891	0.018	0.8253	Best 100 RF
		n_estimators = 1000	0.801	0.822	0.803	0.836	0.894	0.021	0.8233	
	Top 50%	n_estimators = 10	0.775	0.793	0.778	0.814	0.866	0.018	0.8013	
		n_estimators = 100	0.792	0.799	0.794	0.819	0.875	0.007	0.8223	Best 50 RF
		n_estimators = 1000	0.792	0.799	0.786	0.823	0.876	0.007	0.8213	
AdaBoost	100% of Features	n_estimators = 10	0.839	0.92	0.849	0.867	0.905	0.081	0.7927	Best 100 Ada
		n_estimators = 50	0.837	0.993	0.848	0.867	0.921	0.156	0.7227	
		n_estimators = 100	0.843	0.991	0.845	0.864	0.915	0.148	0.7267	
	Top 50%	n_estimators = 10	0.81	0.861	0.815	0.839	0.895	0.051	0.7987	Best 50 Ada
		n_estimators = 50	0.807	0.899	0.821	0.843	0.894	0.092	0.7607	
		n_estimators = 100	0.81	0.898	0.816	0.839	0.884	0.088	0.7583	
Gradient Boosting	100% of Features	n_estimators = 10	0.74	0.738	0.737	0.791	0.835	0.002	0.7857	
		n_estimators = 50	0.793	0.795	0.8	0.827	0.882	0.002	0.8343	
		n_estimators = 100	0.805	0.81	0.813	0.837	0.894	0.005	0.8430	Best 100 Grad
	Top 50%	n_estimators = 10	0.721	0.725	0.779	0.779	0.808	0.004	0.7847	
		n_estimators = 50	0.76	0.76	0.771	0.804	0.856	0	0.8103	
		n_estimators = 100	0.781	0.782	0.786	0.818	0.87	0.001	0.8237	Best 50 Grad
Ensemble	100% of Features Stack	ab_50, ab_10, gb	0.854	0.973	0.863	0.88	0.939	0.119	0.7750	
		lr_c1, rf_n1000, ab, gb	0.835	0.892	0.842	0.861	0.922	0.057	0.8180	
		Best Models of LR, DT, RF, AB, GB	0.84	0.897	0.839	0.859	0.92	0.057	0.8157	
	Top 50%		0.814	0.848	0.819	0.844	0.905	0.034	0.8220	Best Ens