# Unlocking the Secrets of Heart Transplant Success with Machine Learning

COLLEGE of CHARLESTON
M.S. IN DATA SCIENCE AND ANALYTICS
1770

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## Introduction

- Machine learning (ML) models can be used to predict medical outcomes
- United Network for Organ Sharing (UNOS) collects transplant data from across the US
- The dataset used has data on over 40,000 heart transplants
- Current ML models are more accurate than scoring systems in predicting heart transplant failure and mortality[1]
- This study uses an XGBoost model to identify patients at risk of heart transplant failure before 365 days post-transplant
- Studies with other UNOS datasets have found success with Random Forest and XGBoost algorithms[2]

## The Process

Collect Data from the Medical University of South Carolina

Feature Engineering
- Converted 365DaySurival to bool
- Converted PROTEIN_URINE to bool
- Mapped features to new values:

| Gender | |
|---|---|
| M | 0 |
| F | 1 |

| ABOMAT | |
|---|---|
| ABO incompatible | 0 |
| ABO compatible | 1 |
| ABO identical | 2 |

Data Cleaning
- Removed object columns
- Selected columns based on physician feedback
- Removed objects with null values

Create, Train, and Test XGBoost Model

Evaluate Metrics and Features

## Results

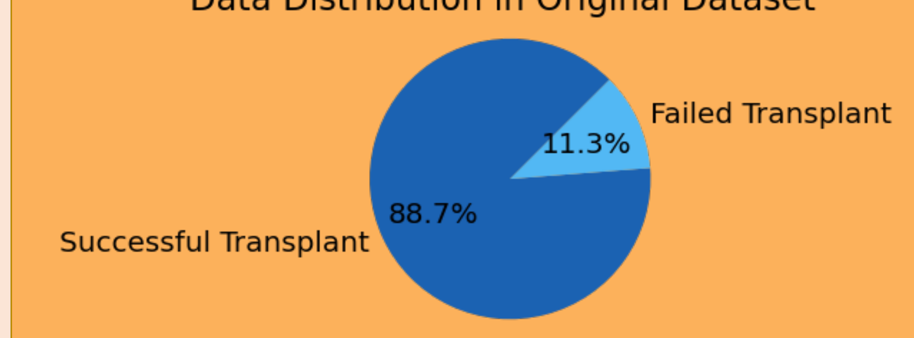


**Figure 1:** Data distribution showing uneven class distributions in dataset

- The dataset is highly skewed, as shown in Figure 1
- Unbalanced classes will likely result in an overfit model favoring the dominant class

- Confusion matrix in Figure 2 built with Scikit-Learn library after model testing
- Test results show high accuracy, but low specificity

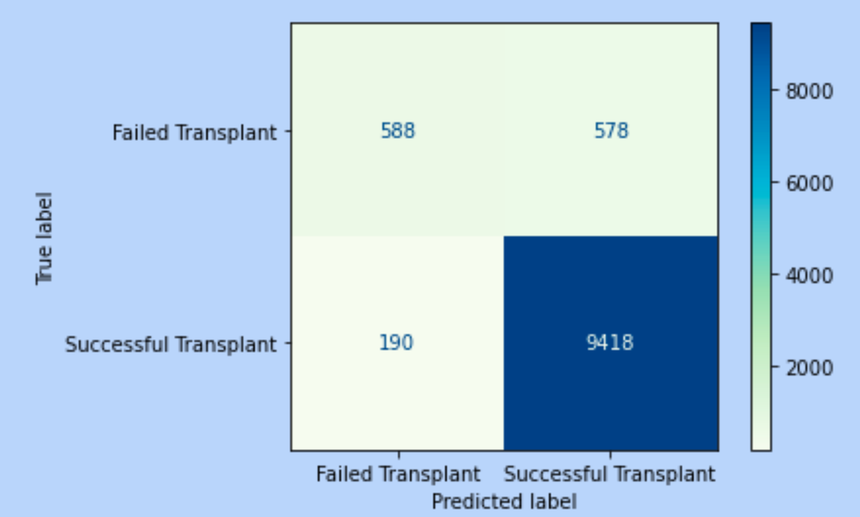


**Figure 2:** Confusion matrix generated from the test data predictions

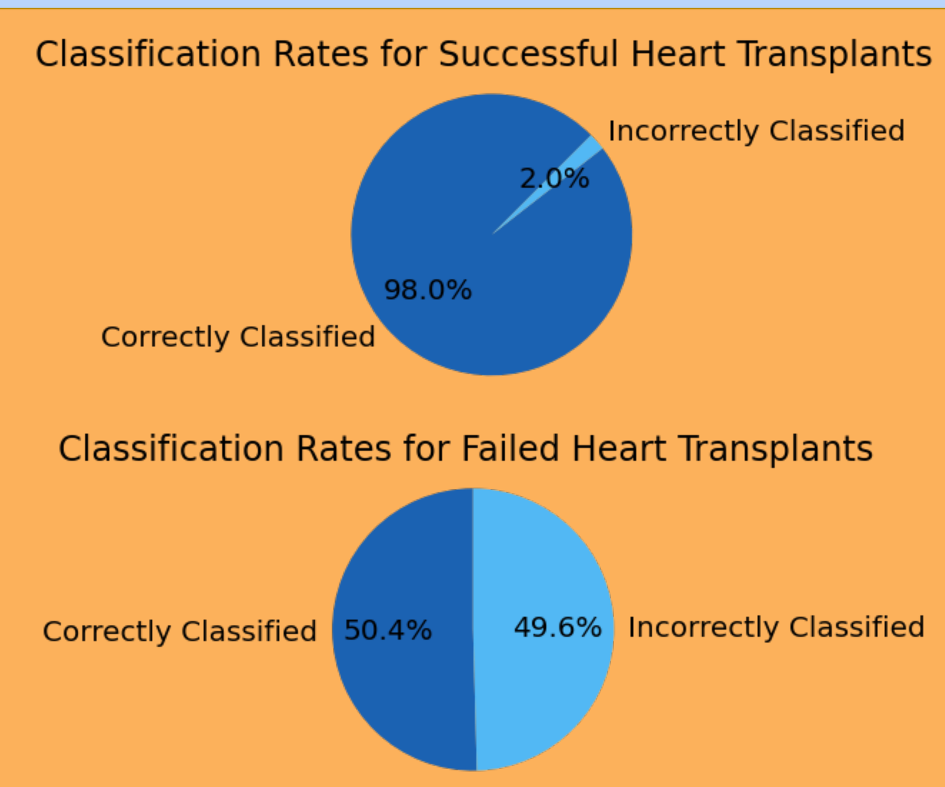


**Figure 3:** Classification rates for both classes

- Almost all successful transplants were classified correctly while only half of failed transplants were, as shown in Figure 3
- Table 1 shows good model performance for all metrics except specificity

| Metric | Score |
|---|---|
| Accuracy | 0.929 |
| Precision | 0.942 |
| Recall | 0.98 |
| Specificity | 0.504 |
| F1 Score | 0.961 |
| AUC ROC | 0.742 |

**Table 1:** Evaluation metrics calculated from model predictions

- Transplant year and donor age are the top features used in classification, per Figure 4
- Features with a larger SHAP value range play a larger role in classification

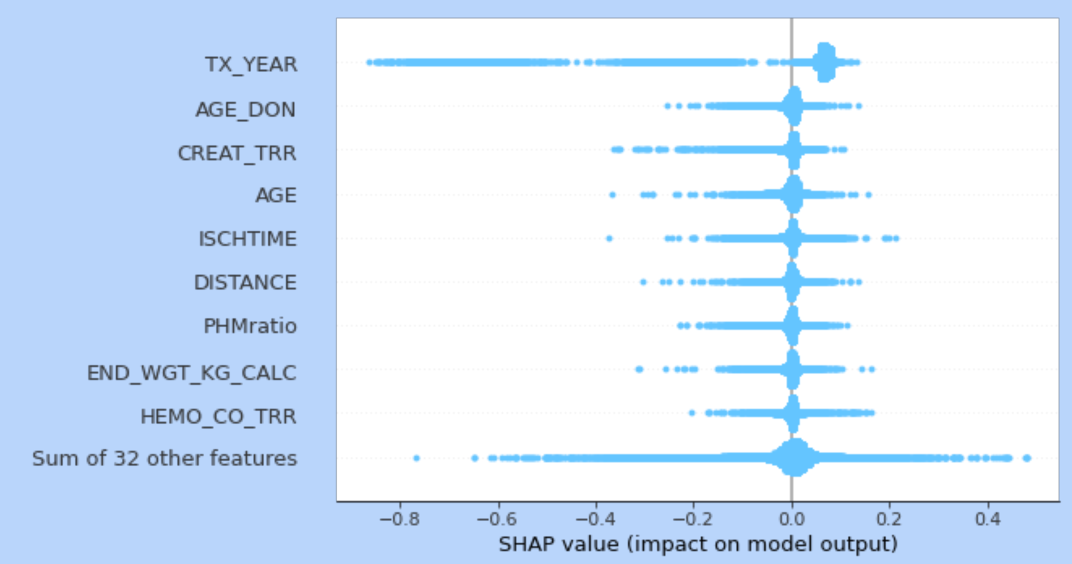


**Figure 4:** Top features impacting transplant success prediction

## Conclusions

- The model accurately classifies 93% of successful heart transplants
- The model's specificity is low, only accurately classifying 50% of failed transplants
- Discrepancy in accuracy and specificity likely due to unbalanced classes
- The model is likely overfit and favors successful transplant classification
- The model is still successful and suggests that ML models can be used to predict heart transplant outcomes

## Future Work

- Reduce the model complexity to address overfitting concerns
- Focus on a smaller subset of features
- Return to object-type features for feature engineering
- Try other algorithms, such as Random Forest

## Acknowledgements

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## Works Cited

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2. Miller, R. J. H., Sabovčik, F., Cauwenberghs, N., Vens, C., Khush, K. K., Heidenreich, P. A., Haddad, F., & Kuznetsova, T. (2022). Temporal shift and predictive performance of machine learning for Heart Transplant Outcomes. *The Journal of Heart and Lung Transplantation*, *41*(7), 928–936. https://doi.org/10.1016/j.healun.2022.03.019

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