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Predicting Cancer Survivability through Patient Features

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Introduction

Problem

- **Breast Cancer**:
  - Most frequently diagnosed and leading cause of cancer death among females.
  - About 2.3 million new cases and 670,000 death globally in 2022 (WHO).

Goal

- Develop a data-driven robust model for classifying breast cancer patient outcomes as "survive" or "deceased."
- Possible adoption and integration of the developed model to benefit stakeholders.

Stakeholders

- Healthcare providers
- Patients
- Insurance companies
- Government institutions

Data Gathering and Cleaning

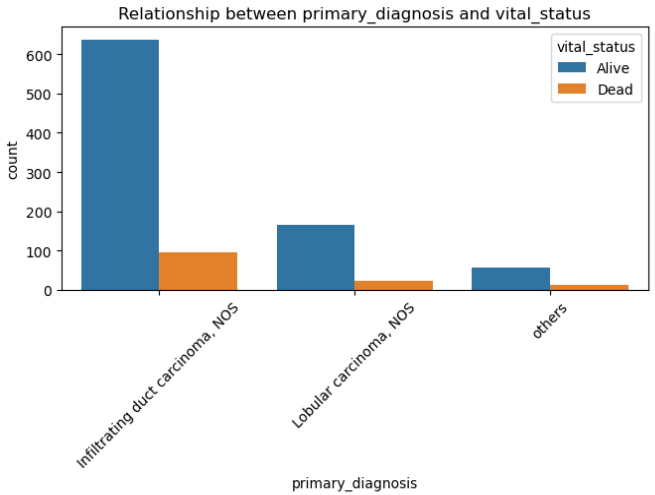
Data

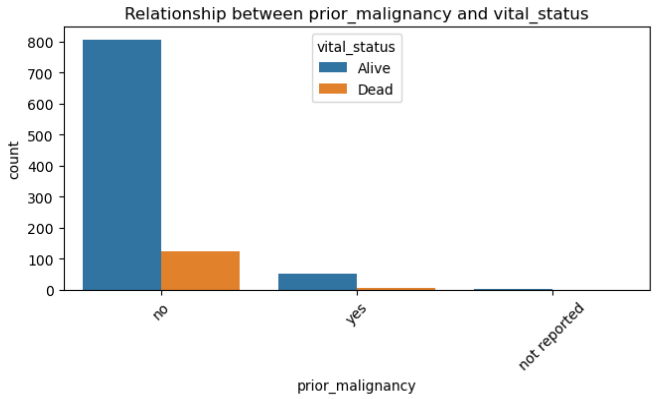
- Clinical and biospecimen datasets on breast cancer from the GDC data portal
- Size: 1006 observations X 42 variables
- Patient demographics, diagnoses, and treatment types from diagnoses
- Drop redundant and noninformative columns, and missing values

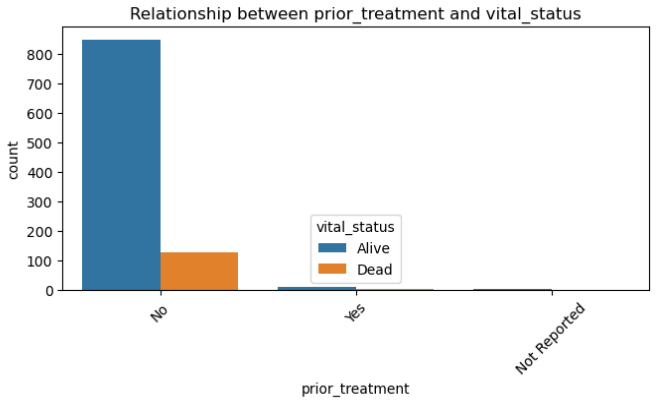
Final dataset

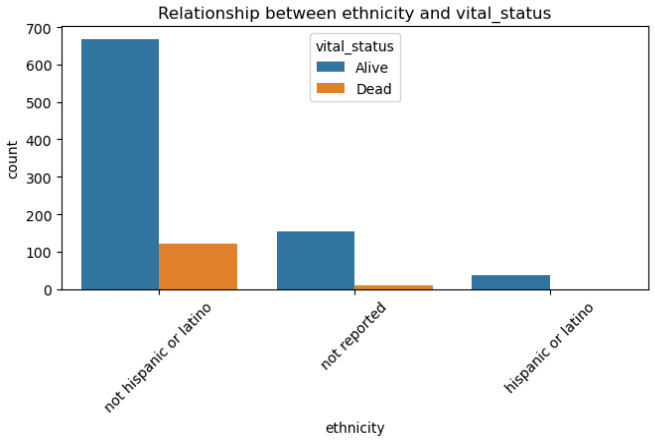
- ***Response variable***: vital status - "Alive" or "Dead"
- ***Independent variables***: Pathologic stages, prior treatment, treatment type - radiation or pharmaceutical treatment, ethnicity, race
- Size: 991 observations X 12 variables

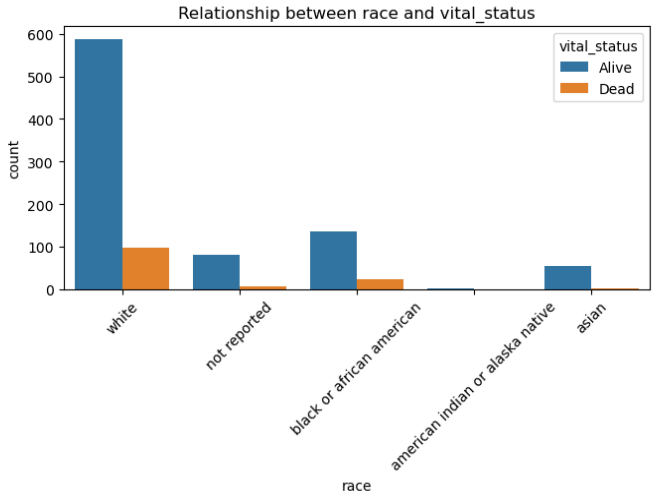
Categorical Features and Vital Status



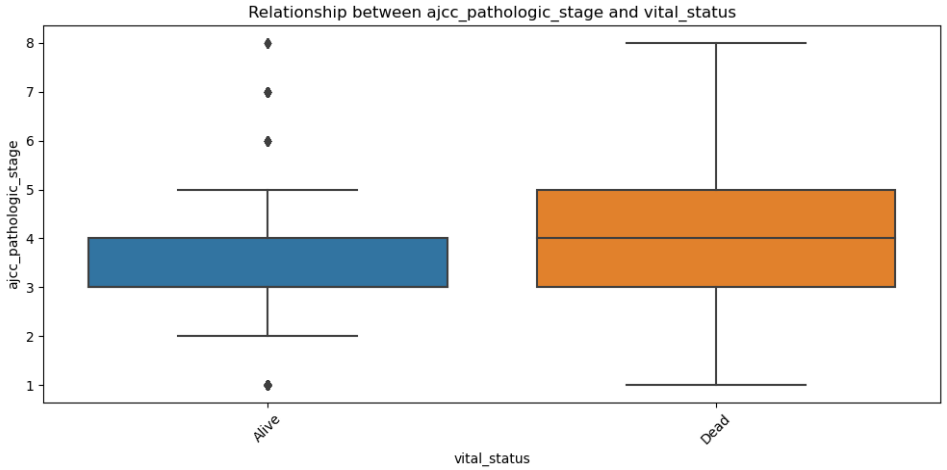


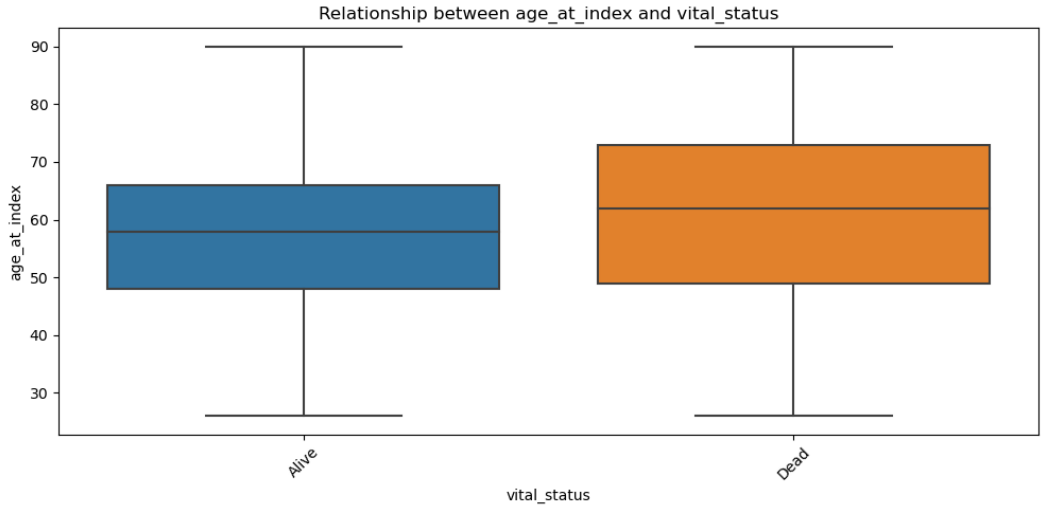






Continuous Features and Vital Status





There exist some relationships between vital status and pathologic stages and age.

Data Split and Models

Data Splitting: 80% training set and 20% test set (while stratifying the outcome). We further split the training data into a training set and validation set using StratifiedKFold (K=3).

Base Model: Decision Tree Classifier with an average validation accuracy of 84.85%.

Other Models:

- Random Forest Classifier (RF)
- AdaBoost Classifier
- Support Vector Classifier (SVC)
- Logistic Regression
- K-Nearest Neighbor
- Multi-Layer Perceptron (MLP)

Results: Classifying patient outcome

We evaluated our models based on their **accuracy**, **precision**, **sensitivity**, **selectivity**, **false positive rate**, and **false negative rate**, with respect to the validation sets.

We were particularly interested in:

- **Accuracy:** The model correctly classifies patient outcome.
  - Models were similarly accurate (~89-90%), and more accurate than the base model
- **Sensitivity (true positive rate):** the model correctly identifies 'deceased' outcomes as 'deceased'
  - Best model: Decision tree (53.33%), Multilayer perceptron (45.72%), Random Forest (41.9%)

Low sensitivity and high false negative rates in general imply limitations in our approach.

Random Forest: Hyperparameter Tuning

Fine-tune with grid search for max depth and number of estimators.

Choice of Hyperparameters

- Maximum depth: 10
- Number of estimators: 100

Model performance: Applying the model to the test set, we obtain:

- **Accuracy:** 92.46%
- **Precision:** 82.35%
- **Sensitivity:** 53.85%
- **False Negativity:** 46.15%

Results: Classifying patient outcome over a time interval

Goal: Consider a time frame for survival prediction.

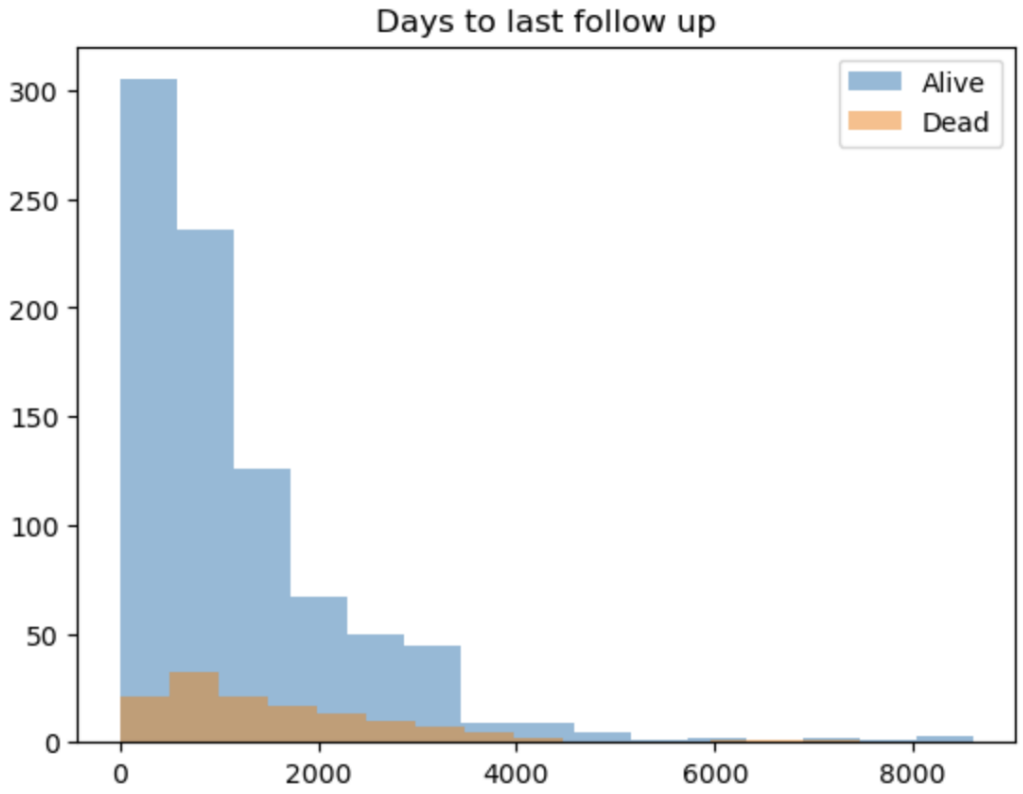
- Models: Random Forest, SVM.

- Mean of days of follow up:
  - Alive: ~ 1,200
  - Dead: ~ 1,600

- Number of days: 365, 720, ..
- Results:
  - Best model SVM

Prediction of survival within:

- 1 year - accuracy: 0.97, precision = 0.00
- 2 years - accuracy: 0.94, precision = 0.00
- 3 years - accuracy: 0.81, precision = 0.00
- 4 years - accuracy: 0.57, precision = 0.60
- 5 years - accuracy: 0.86, precision = 0.86



Discussion

Significance of results

- **Healthcare providers & patients**: Helps support physician decision-making and effective care delivery
- **Insurance companies**: Support pricing and reimbursement decisions
- **Government institutions**: Helps support resource allocation planning

Future directions

- The features in our model are limited. Other data that may be useful are gene expression data, information about immune cell abundance, and biopsy slide images.
- Explore more advanced algorithms
- Develop a web-based interface model to predict cancer survivability

Thank you!

To all the mentors, and instructors at The Erdos Institute!