40.016: Analytics Edge

Week 3 Lecture 1

Risk analysis: Challenger disaster

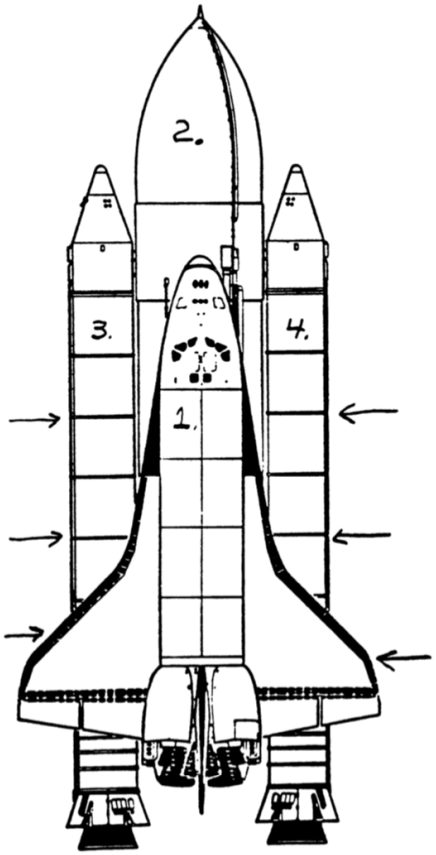
Term 6, 2020

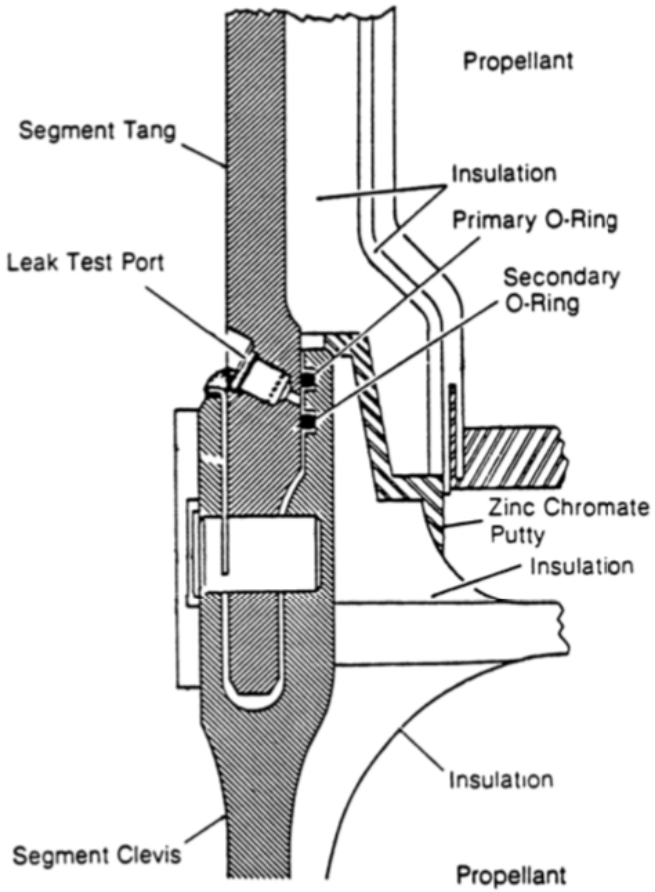
The Challenger space shuttle

- January 28, 1986.
- 7 crew members.
- Included a teacher (Teacher in space program).
- one of the objectives: observe Halley's comet.

If you are interested in this topic, check out: *Challenger: The Final Flight – Netflix*

Challenger schematic and the O-Ring





Left: Schematic of Challenger shuttle. Subsystem 1 houses crew and system control, subsystem 2 is the external liquid-fuel tank, and subsystems 3 and 4 are the solid rocket motors (Morton Thiokol).

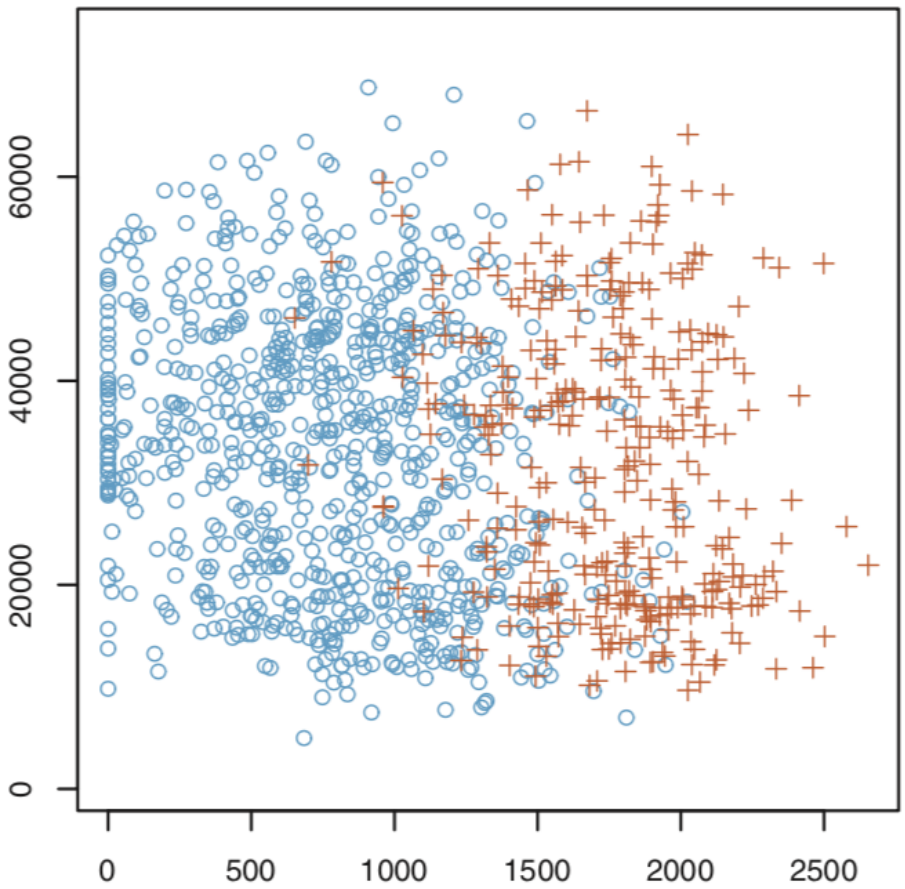
Right: Solid Rocket Motor Subsection (Morton Thiokol).

Challenger disaster:

Rogers commission report *excerpt*

The report of the fateful series of NASA and Morton Thiokol meetings, telephone conferences, notes and facsimile transmissions on January 27, the night before the launch of 51-L, shows that only limited consideration was given to the past history of O-ring damage in terms of temperature. The managers compared as a function of temperature, the flights for which thermal distress of O-rings had been observed - not the frequency of occurrences based on all flights. In such a comparison, there is nothing irregular in the distribution of O-ring distress over the spectrum of joint temperatures at launch between 53° and 75° Fahrenheit.

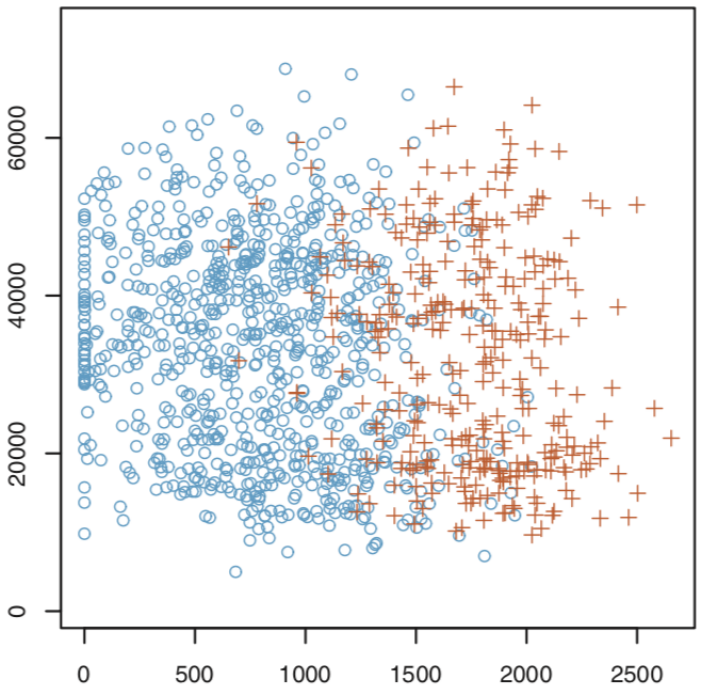
Classification



Classification

- Objective: Predict binary/ categorical variables with some respondent, explanatory variables.
- `O-Ring failure` $\sim$ `Temperature, Pressure`
- Many methods: Linear discriminant analysis, perceptrons, even linear regression.
- We concentrate on **Logistic Regression**.

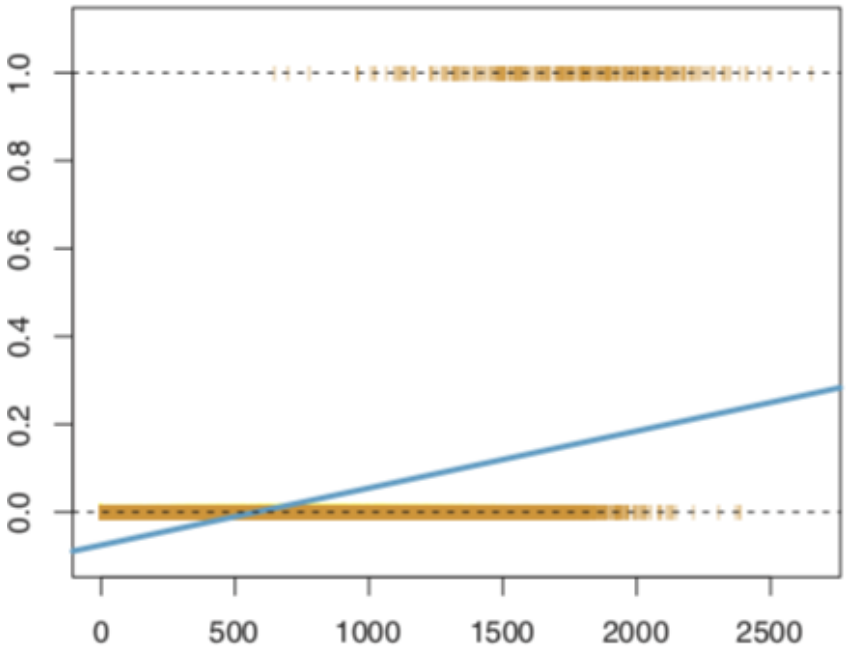
Logistic Regression

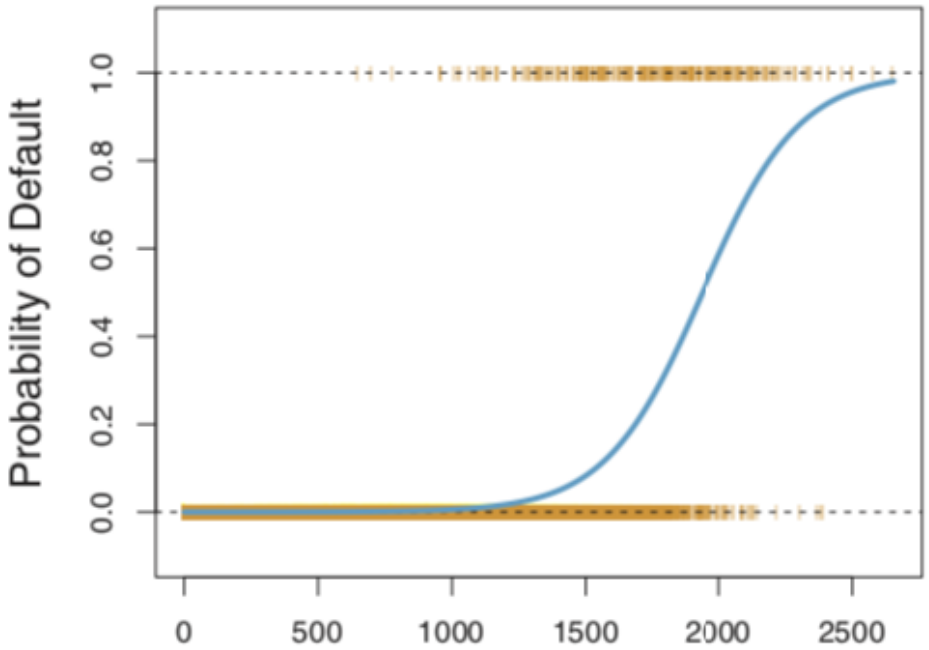


1. n = number of observations
2. p = number of predictor variables
3. $y \in \{0, 1\}$: dependent variable (binary outcome)
4. $x_1, \ldots, x_p$ = independent variables (predictors)

We want to model $y \sim x_1, \ldots, x_p$.

Linear regression vs. Logistic regression





Logistic regression

Define

- $\boldsymbol{\beta}^{\mathsf{T}} = (\beta_0, \ldots, \beta_p)$.
- $\boldsymbol{x}^{\mathsf{T}} = (1, x_1, \ldots, x_p)$.

Logistic regression

Data: $(y_i, \boldsymbol{x}_i)$ for $i = 1, \ldots, n$ where $\boldsymbol{x}_i^{\mathsf{T}} = (x_{i1}, \ldots, x_{ip})$.

Quality of fit: deviance and AIC

- **Null deviance:**
- **Residual deviance:**
- **AIC:**

Quality of fit: confusion matrix

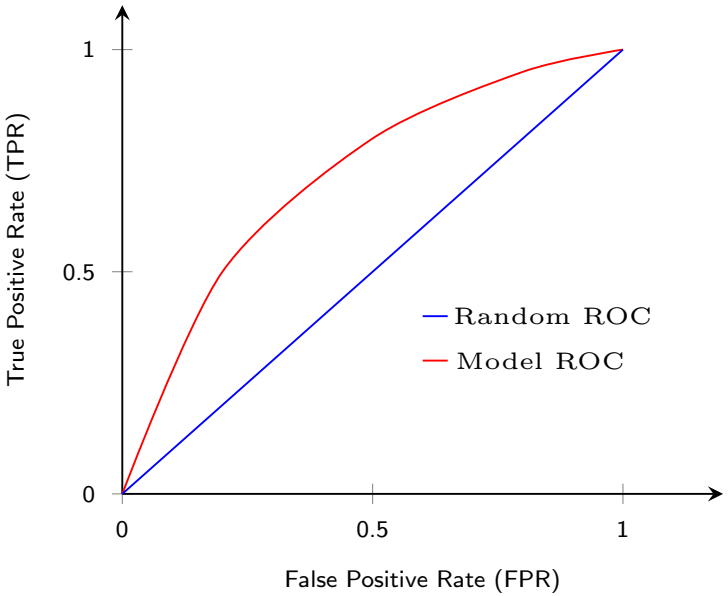
Predict based on a threshold t and the estimated $\hat{\boldsymbol{\beta}}$.

	Actual = 0	Actual = 1
Predict = 0	True Negative (TN)	False Negative (FN)
Predict = 1	False Positive (FP)	True Positive (TP)

- True negative rate: TNR =
- False positive rate: FPR =
- True positive rate: TPR =
- False negative rate: FNR =
- Overall Accuracy: Accuracy =

Quality of fit:

Receiver operating characteristic (ROC) curve



Quality of fit: Area under the curve (AUC)