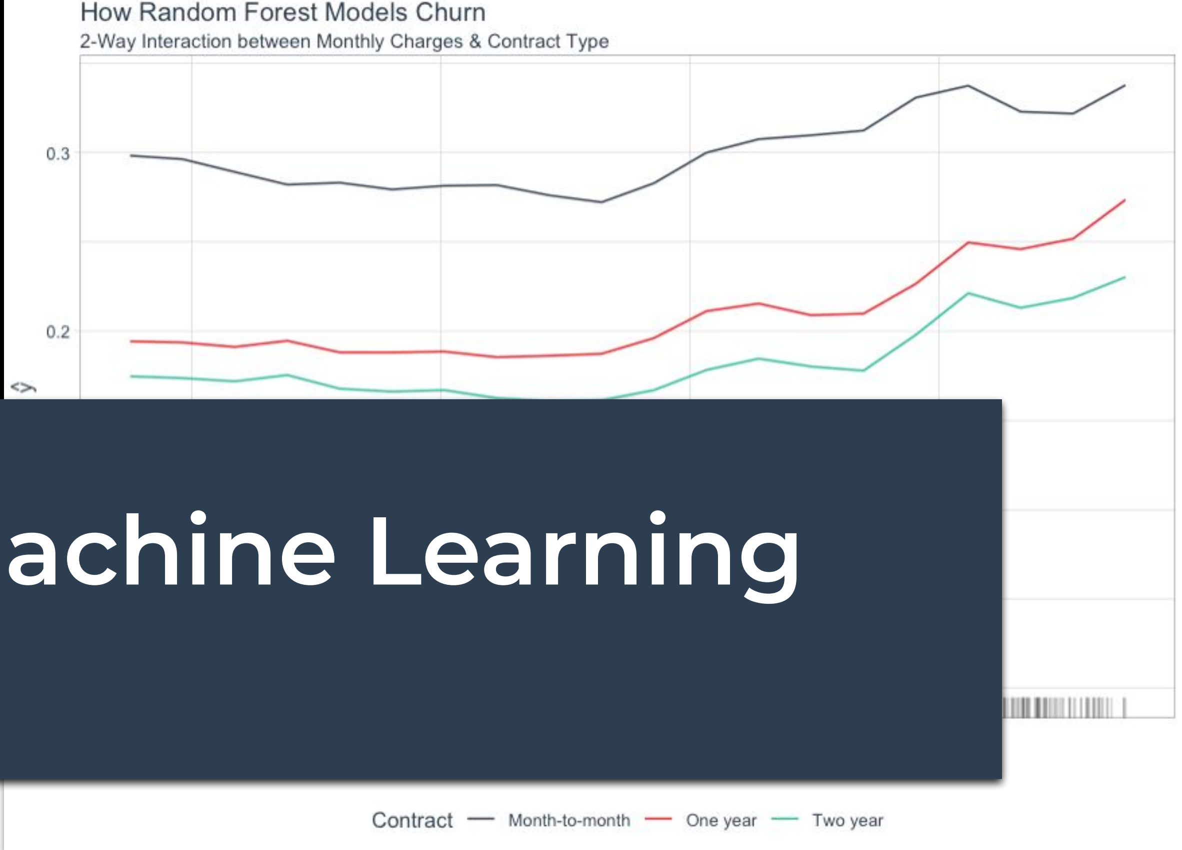
```
library(rsample)
library(recipes)
library(h2o)

library(iml)
library(DALEX)

library(correlationfunnel)
library(DataExplorer)
```



Explaining Machine Learning

For Customer Churn

Difficulty: **Intermediate**

Matt Dancho & David Curry
Business Science Learning Lab

Learning Lab Structure

- **Presentation**
  (20 min)

- **Demo's**
  (30 min)

- **Pro-Tips**
  (15 mins)

Matt Dancho

Founder of Business Science, Matt designs and executes educational courses and workshops that deliver immediate value to organizations. His passion is **up-leveling future data scientists** coming from **untraditional backgrounds**.

David Curry

Founder of Sure Optimize, David works with businesses to help improve website performance and SEO using data science. His passion is **ethical Machine Learning initiatives**.

Success Story

Casper Craus

- Data Engineer - Keyphase
- Started course 5 Weeks Ago
- Got the job!

"Before starting DS4B 101, I was in the middle of a job transition. I got the job, and I'm hired as a Data Engineer."

Handling missing values and Outliers

CCrause

27/09/2019

Loading the weather-data that is semi wrangled

Previously I wrangled a dataset that contained weather data. With this presentation I plan to check for outliers, look for missing value and explore the different ways of dealing with NA values and experiment with some basic functional programming and filtering time-series data.

```
library(tidyverse)
weather_data_pivot_tbl =
readr::read_rds("../7daysofdatascience/Data_wrangling/weather_data_pivoted.rd
s")
glimpse(weather_data_pivot_tbl)
```

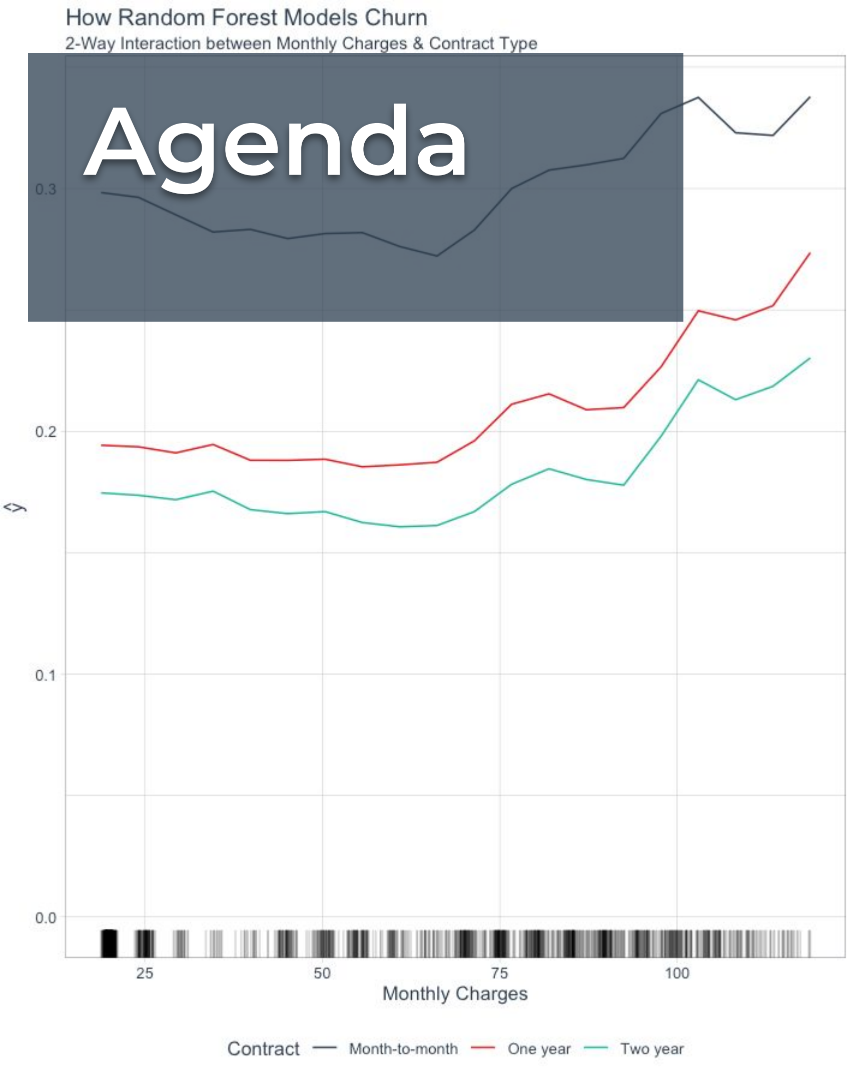
```
## Observations: 366
## Variables: 23
## $ date                    <chr> "2014/12/1", "2014/12/2", "2014/12/3...
## $ Events                  <chr> "Rain", "Rain-Snow", "Rain", "", "Ra...
## $ Max.TemperatureF        <dbl> 64, 42, 51, 43, 42, 45, 38, 29, 49, ...
## $ Mean.TemperatureF       <dbl> 52, 38, 44, 37, 34, 42, 30, 24, 39, ...
## $ Min.TemperatureF        <dbl> 39, 33, 37, 30, 26, 38, 21, 18, 29, ...
## $ Max.Dew.PointF          <dbl> 46, 40, 49, 24, 37, 45, 36, 28, 49, ...
## $ MeanDew.PointF          <dbl> 40, 27, 42, 21, 25, 40, 20, 16, 41, ...
## $ Min.DewpointF           <dbl> 26, 17, 24, 13, 12, 36, -3, 3, 28, 3...
## $ Max.Humidity            <dbl> 74, 92, 100, 69, 85, 100, 92, 92, 10...
## $ Mean.Humidity           <dbl> 63, 72, 79, 54, 66, 93, 61, 70, 93, ...
## $ Min.Humidity            <dbl> 52, 51, 57, 39, 47, 85, 29, 47, 86, ...
## $ Max.Sea.Level.PressureIn <dbl> 30.45, 30.71, 30.40, 30.56, 30.68, 3...
## $ Mean.Sea.Level.PressureIn <dbl> 30.13, 30.59, 30.07, 30.33, 30.59, 3...
## $ Min.Sea.Level.PressureIn <dbl> 30.01, 30.40, 29.87, 30.09, 30.45, 3...
s <dbl> 10, 10, 10, 10, 10, 10, 10, 10, 10, ...
es <dbl> 10, 8, 5, 10, 10, 4, 10, 8, 2, 3, 7,...
s <dbl> 10, 2, 1, 10, 5, 0, 5, 2, 1, 1, 1, 7...
<dbl> 22, 24, 29, 25, 22, 22, 25, 21, 38, ...
<dbl> 13, 15, 12, 12, 10, 8, 15, 13, 20, 1...
<dbl> 29, 29, 38, 33, 26, 25, 32, 28, 52, ...
<dbl> 0.01, 0.10, 0.44, 0.00, 0.11, 1.09, ...
<dbl> 6, 7, 8, 3, 5, 8, 6, 8, 8, 8, 7, ...
<dbl> 268, 62, 254, 292, 61, 313, 350, 354...
```

#Business Science Success

Casper Crause 2:38 AM

Hi Matt, This is a word of thanks. Over the course of 5 weeks my data science skill set has shown tremendous growth. Before starting DS4B 101 I was in the middle of a job transition. I got the job and now I'm hired as a Data Engineer! Thank you so much for your hard work in creating course content that is second to none! I truly believe you have touched the lives of thousands of people like me! We will be working closely with a company that applies machine learning to estimate the potential yield of the harvests of their clients. One of the super cool perks is I get to work remotely. I have been assigned the role of project manager for this particular project! So I'm really keen to learn H2O .AI in your 201 course!

Agenda



- **Business Case Study**
  - Customer Churn
  - Why Explanations are CRITICAL
- **Explainable ML**
  - Key Concepts
- **R Packages**
  - IML
  - DALEX
- **30-Min Demo**
  - Telecom Customers
  - ML - Churn Prediction
  - ML - Churn Explanation
- **Pro-Tips:**
  - Tactics to **Deliver Stories** to Executives

Learning Labs PRO

Every 2-Weeks

1-Hour Course

Recordings + Code + Slack

$19/month

university.business-science.io

Lab 19
Using Customer Credit Card History for Networks Analysis

Lab 18
Time Series Anomaly Detection with anomalize

Lab 17
Anomaly Detection with H2O Machine Learning

Lab 16
R's Optimization Toolchain, Part 2 - Nonlinear Programming

Lab 15
R's Optimization Toolchain, Part 1 - Linear Programming

Lab 14
Customer Churn Survival Analysis

Continuous Learning
Jet Fuel for your Brain

Learning Labs Pro

Community-Driven Data Science Courses

Matt Dancho $19/m

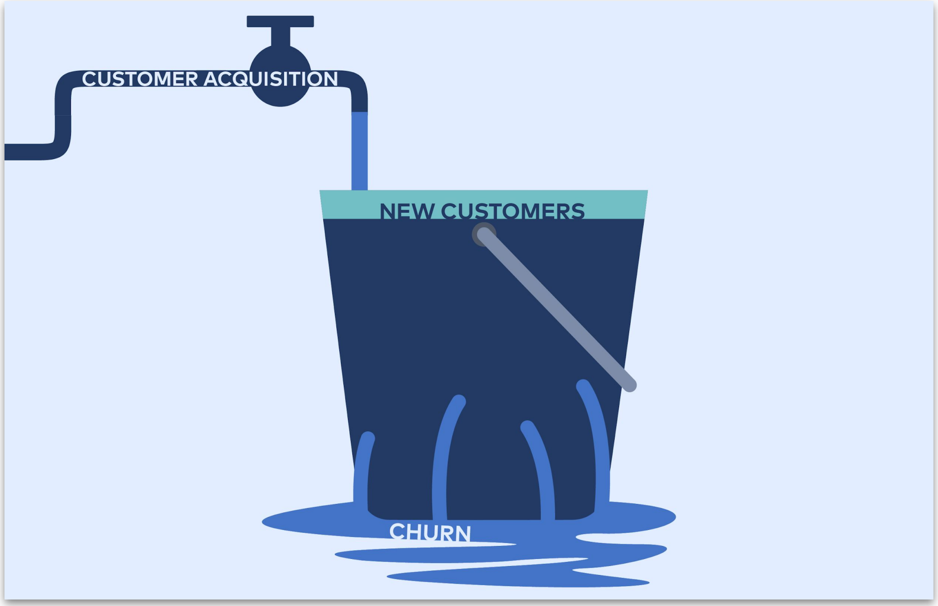
Customer Churn

Business Case

Why Explanations Matter

Customer Churn

1. Subscriptions are a function of **inflow** and **outflow**
2. Outflow is called **churn**
3. If we can **explain** churn, we can **reduce** churn
4. Increases revenue, **improves customer experience**



Telecommunications Subscriptions

Understand Subscriber Behavior

1. Use **Random Forest** to model behavior

2. Use **Explainable ML** to understand what is causing RF to predict churn

Customer Subscription History

Descriptive Features

Customers

```
> customer_churn_raw_tbl
# A tibble: 7,043 x 21
   customerID gender SeniorCitizen Partner Dependents tenure PhoneService MultipleLines InternetService OnlineSecurity
   <chr>      <chr>          <dbl> <chr>   <chr>       <dbl> <chr>        <chr>         <chr>           <chr>
 1 7590-VHVEG Female             0 Yes     No              1 No           No phone ser… DSL             No
 2 5575-GNVDE Male               0 No      No             34 Yes          No            DSL             Yes
 3 3668-QPYBK Male               0 No      No              2 Yes          No            DSL             Yes
 4 7795-CFOCW Male               0 No      No             45 No           No phone ser… DSL             Yes
 5 9237-HQITU Female             0 No      No              2 Yes          No            Fiber optic     No
 6 9305-CDSKC Female             0 No      No              8 Yes          Yes           Fiber optic     No
 7 1452-KIOVK Male               0 No      Yes            22 Yes          Yes           Fiber optic     No
 8 6713-OKOMC Female             0 No      No             10 No           No phone ser… DSL             Yes
 9 7892-POOKP Female             0 Yes     No             28 Yes          Yes           Fiber optic     No
10 6388-TABGU Male               0 No      Yes            62 Yes          No            DSL             Yes
# … with 7,033 more rows, and 11 more variables: OnlineBackup <chr>, DeviceProtection <chr>, TechSupport <chr>,
#   StreamingTV <chr>, StreamingMovies <chr>, Contract <chr>, PaperlessBilling <chr>, PaymentMethod <chr>,
#   MonthlyCharges <dbl>, TotalCharges <dbl>, Churn <chr>
```

Explainable ML Basics

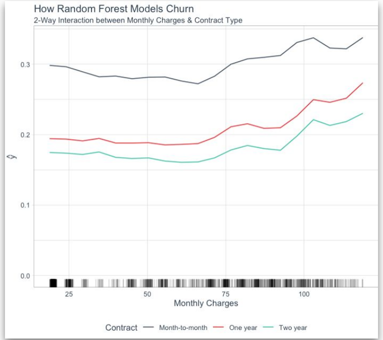
80/20 Concepts

Types of Explanations

1

Global

1 or 2 Features, All Observations

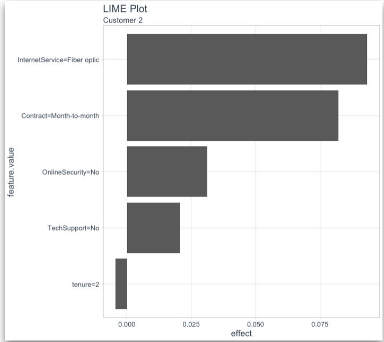


What is the Churn Effect for Contract Type?

2

Local

1 Observation, Many Features

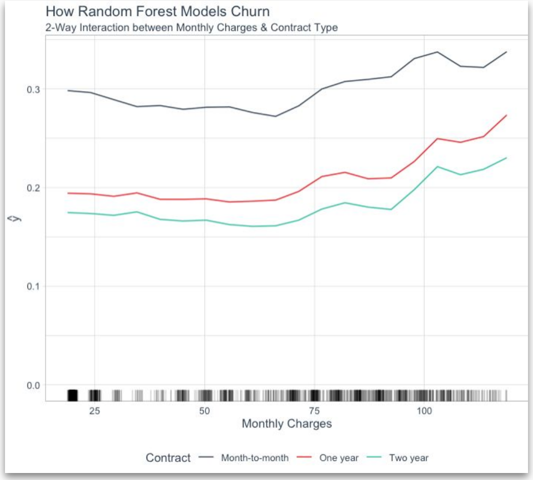


What is causing Customer ID 5575-GNVDE to Churn?

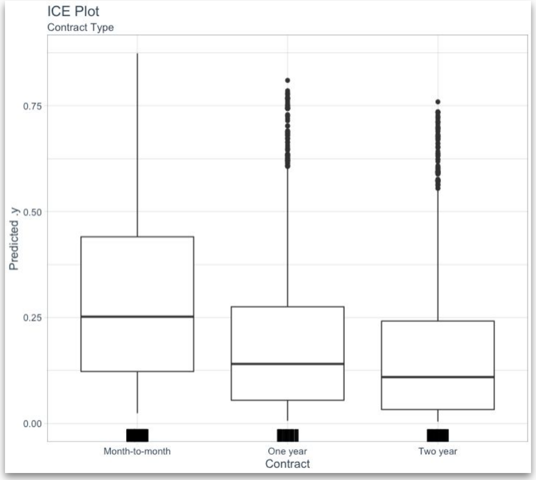
Explainable ML Methods

Critical explanations that matter to the business

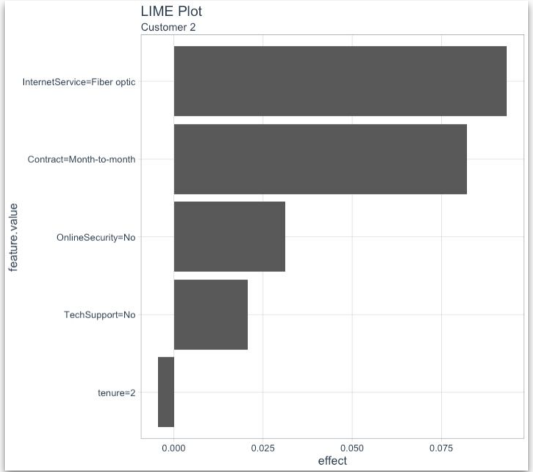
- GLOBAL - PDP & ICE
- LOCAL - LIME & Shapley



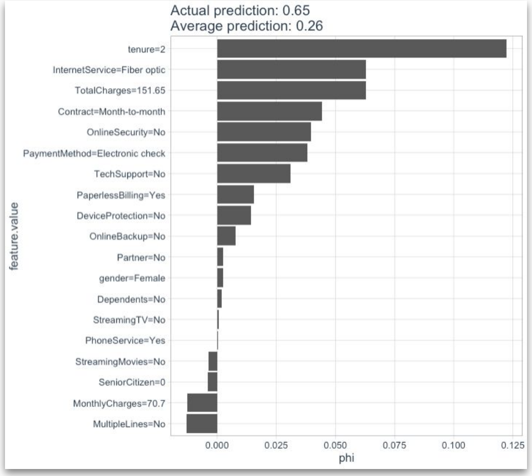
PDP



ICE



LIME

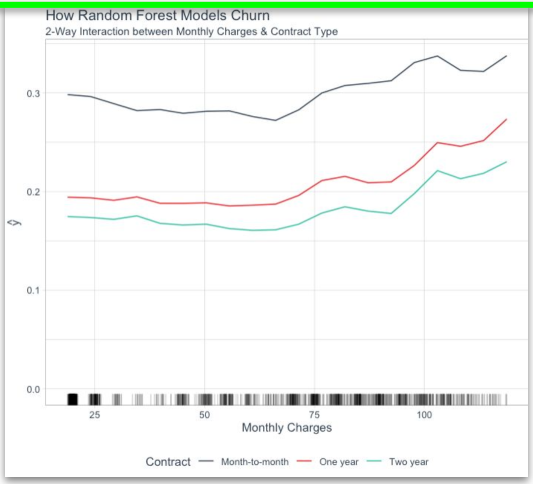


Shapley

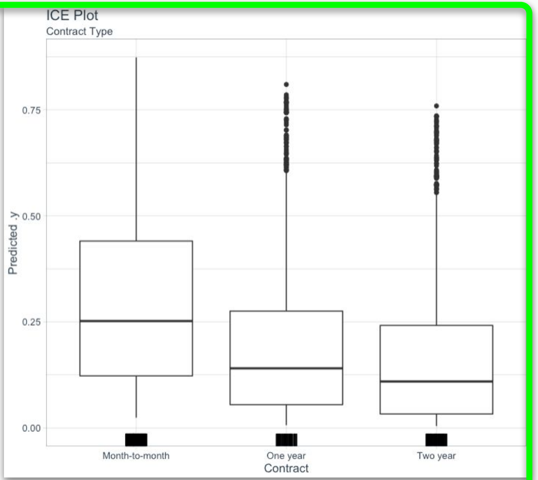
Explainable ML Methods

Critical explanations that matter to the business

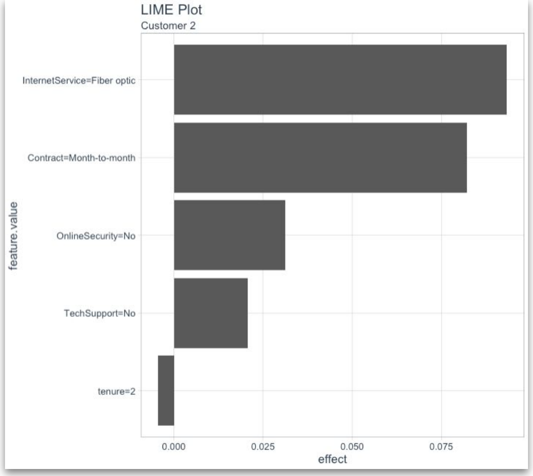
- **GLOBAL - PDP & ICE**
- LOCAL - LIME & Shapley



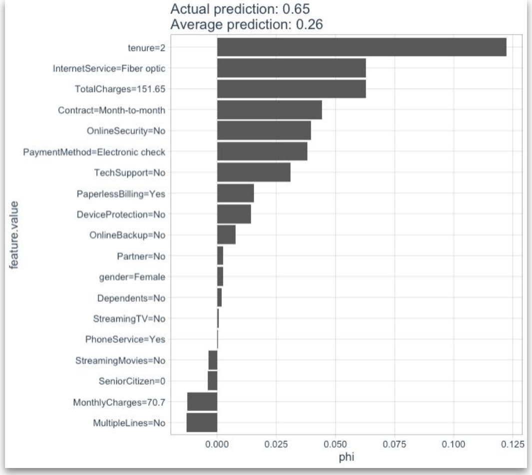
PDP



ICE



LIME

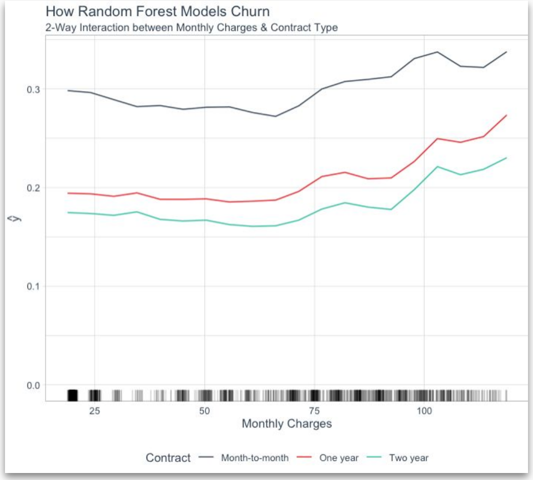


Shapley

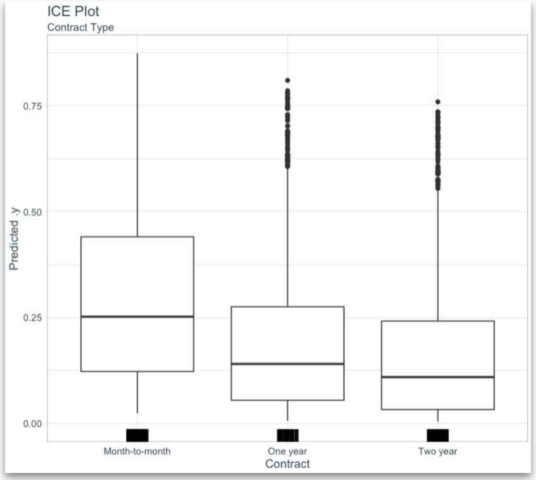
Explainable ML Methods

Critical explanations that matter to the business

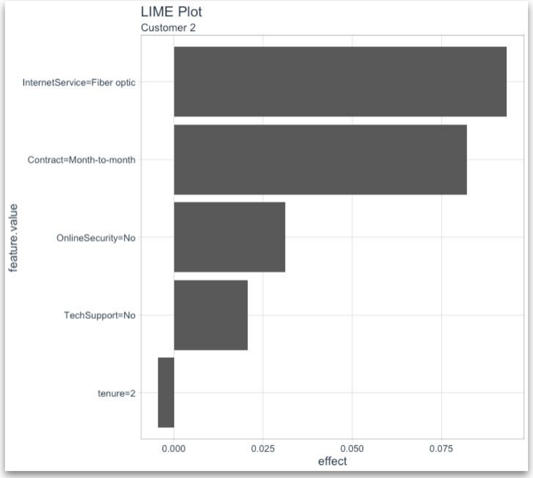
- GLOBAL - PDP & ICE
- **LOCAL - LIME & Shapley**



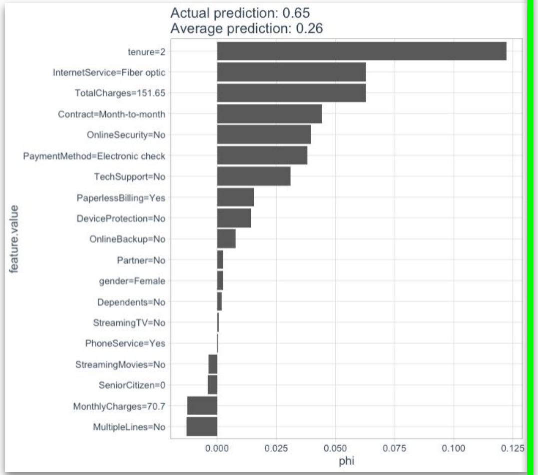
PDP



ICE



LIME



Shapley

Core Concepts

80/20 Theory

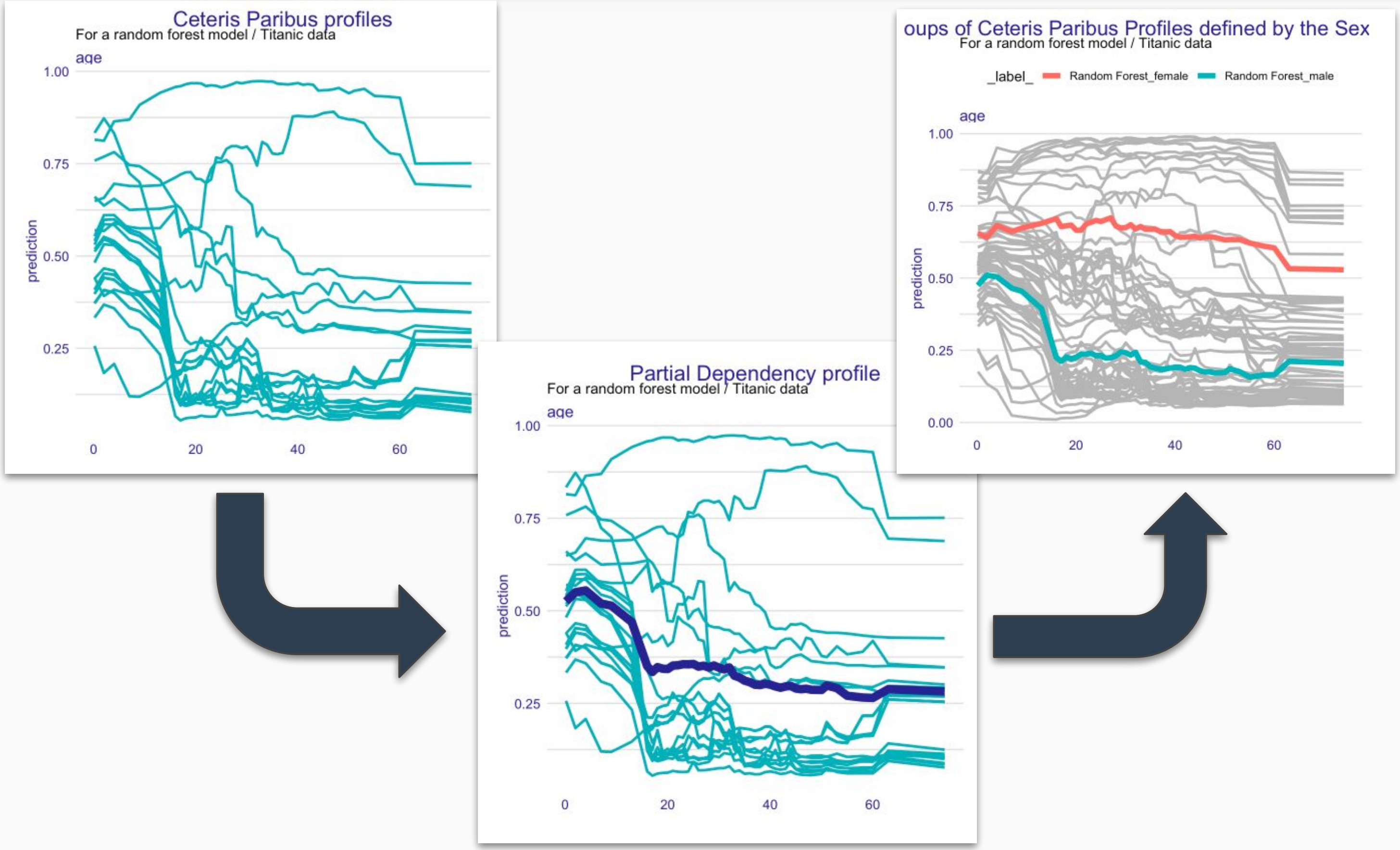
Partial Dependence Plots (PDP) - Global

Key Concept

Show how the expected model response for random observations.

Hold all other features constant & **vary feature** of interest.

Then **Average Results**.



https://pbiecek.github.io/PM_VEE/partialDependenceProfiles.html

Individual Conditional Expectation (ICE) Plot - Global

Key Concept

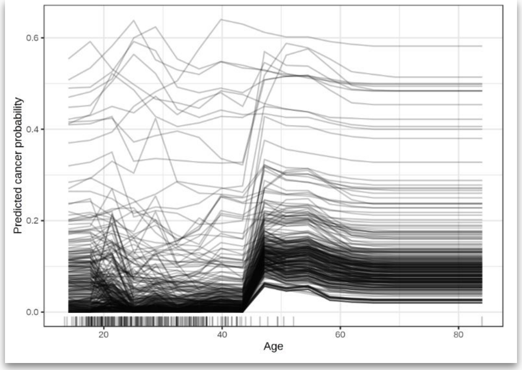
Same as PDP, except:

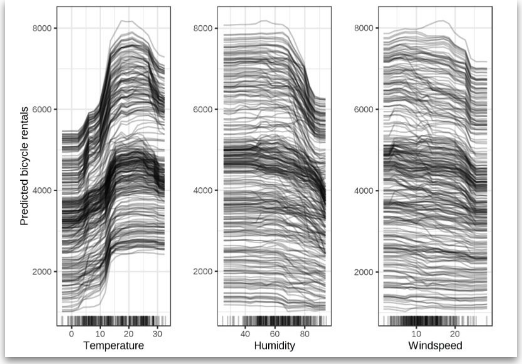
Don't Average (unlike PDP).

Center (if desired).

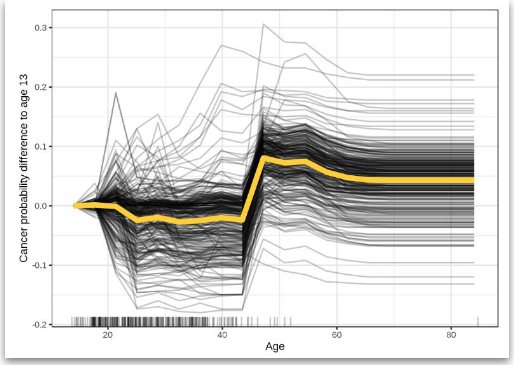
Show Trend Line (if desired).

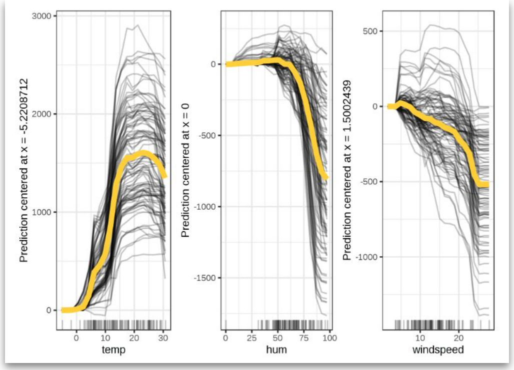
ICE





ICE (Centered)





https://christophm.github.io/interpretable-ml-book/ice.html

Local Interpretable Model-Agnostic Explanation (LIME) Plot - Local

Key Concept

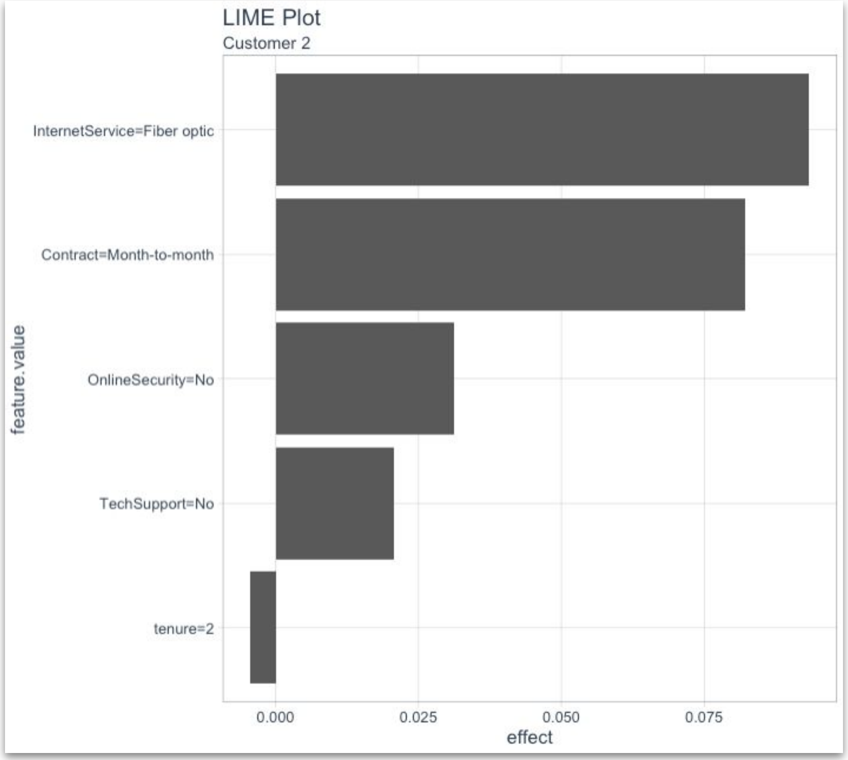
Select observation of interest

Probe the Black Box with **permuted** samples of training data.

Weight sample by proximity to sample of interest.

Train an interpretable model on weighted:

- Lasso
- Decision Tree



https://christophm.github.io/interpretable-ml-book/ice.html

Shapley Value Plot - Local

Key Concept

Each Feature is Player in **Game**

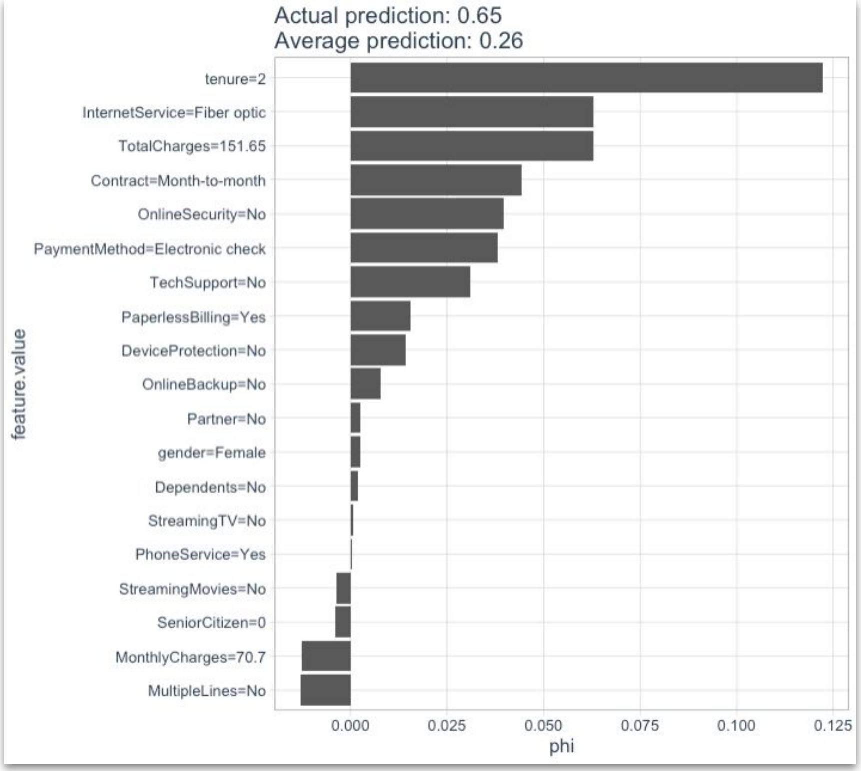
Prediction is **Payout**

How much has each feature contributed to the prediction?

Coalition - Features that work together to make prediction

Gain - The actual prediction minus the average for all features

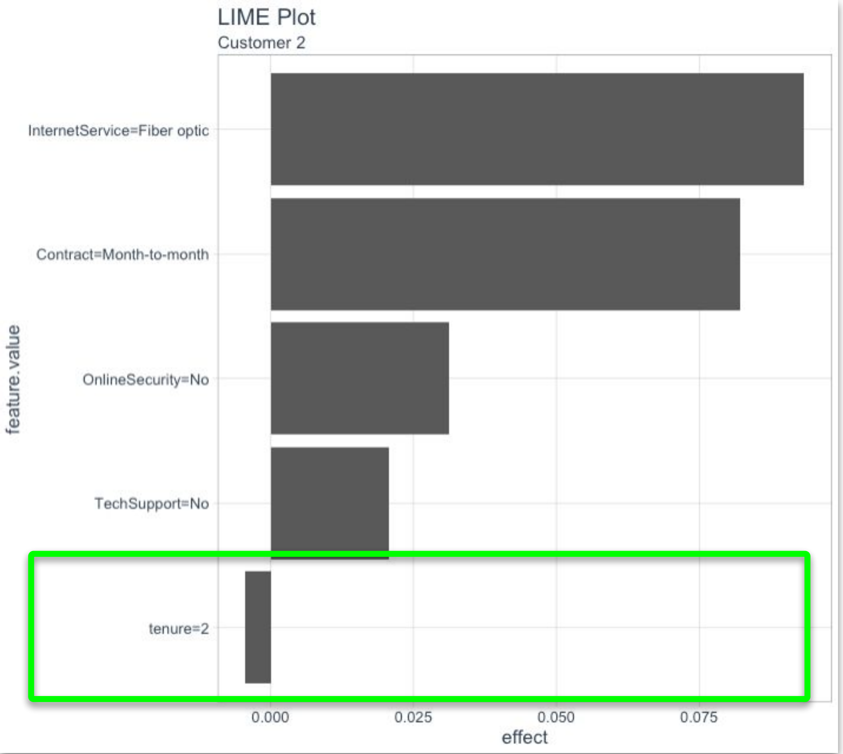
Shapley Value - Average Contribution to the prediction in different coalitions



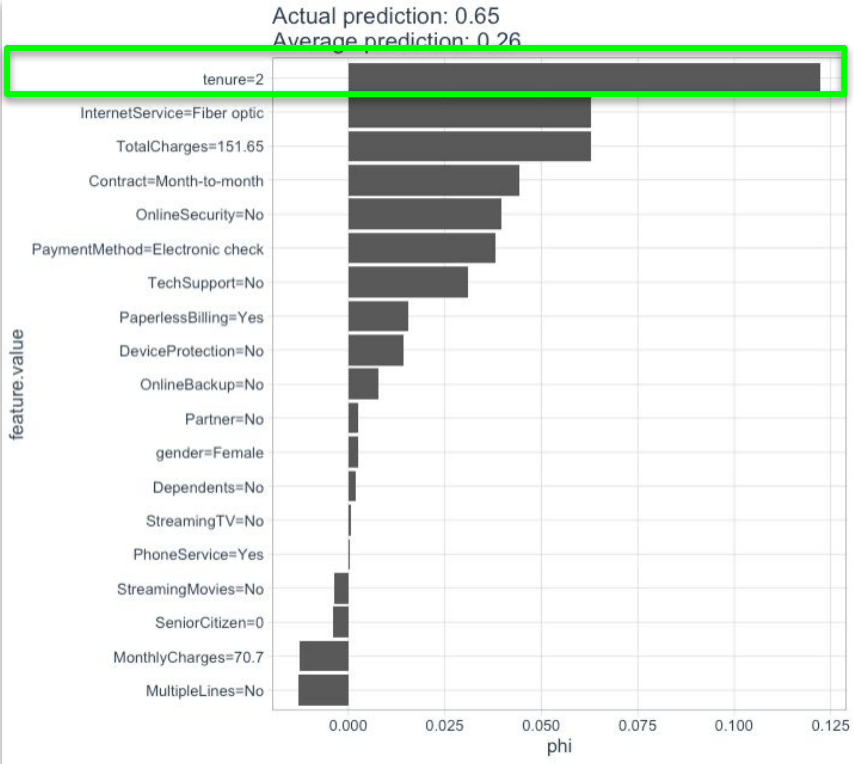
https://christophm.github.io/interpretable-ml-book/ice.html

LIME vs Shapley

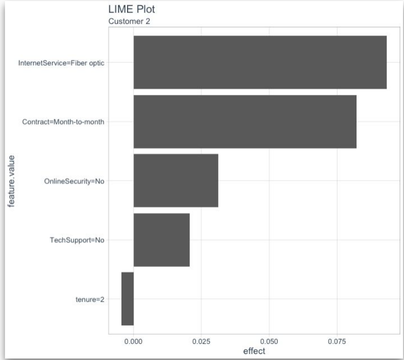
LIME

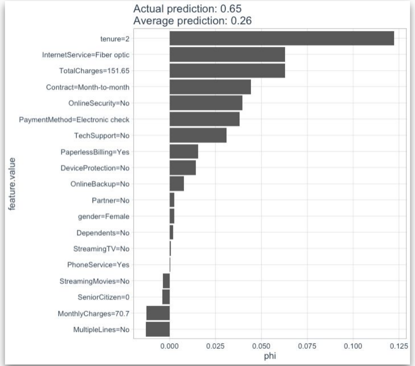


Shapley



LIME vs Shapley





LIME

- Con - Does not guarantee a fair distribution
- Con - Assumes Linear Behavior
- **Pro - Very Fast**
- **Pro - Effect is Weight x Feature Value = Impact to Linear Model**

Shapley

- **Pro - Guarantees a fair distribution of feature values**
- **Pro - Models explanations as a game**
- Con - Can be very slow as coalitions of features increase
- Con - Phi not easily interpreted

SHAP (SHapley Additive exPlanations)

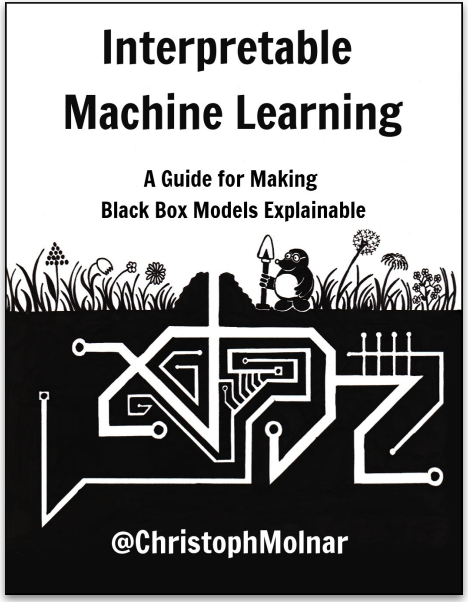
The goal of SHAP is to explain the prediction of an instance x by computing the contribution of each feature to the prediction.

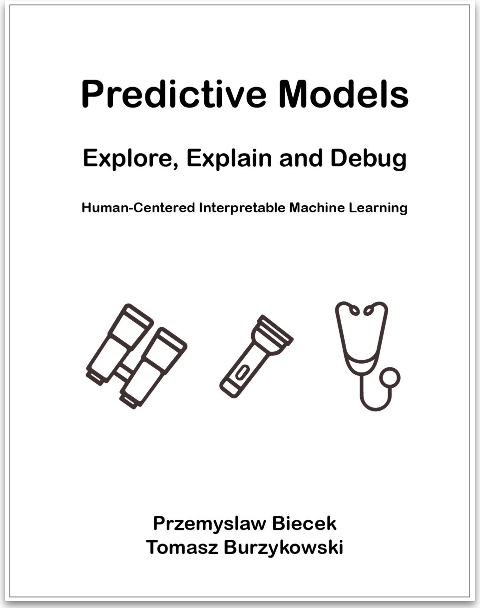
More interpretable than Shapley - SHAP is additive & closer to LIME's "Effect"

Still slow - KernelSHAP is extremely slow, TreeSHAP is faster

Implemented in DALEX

Books





CREATOR OF IML

https://christophm.github.io/interpretable-ml-book/

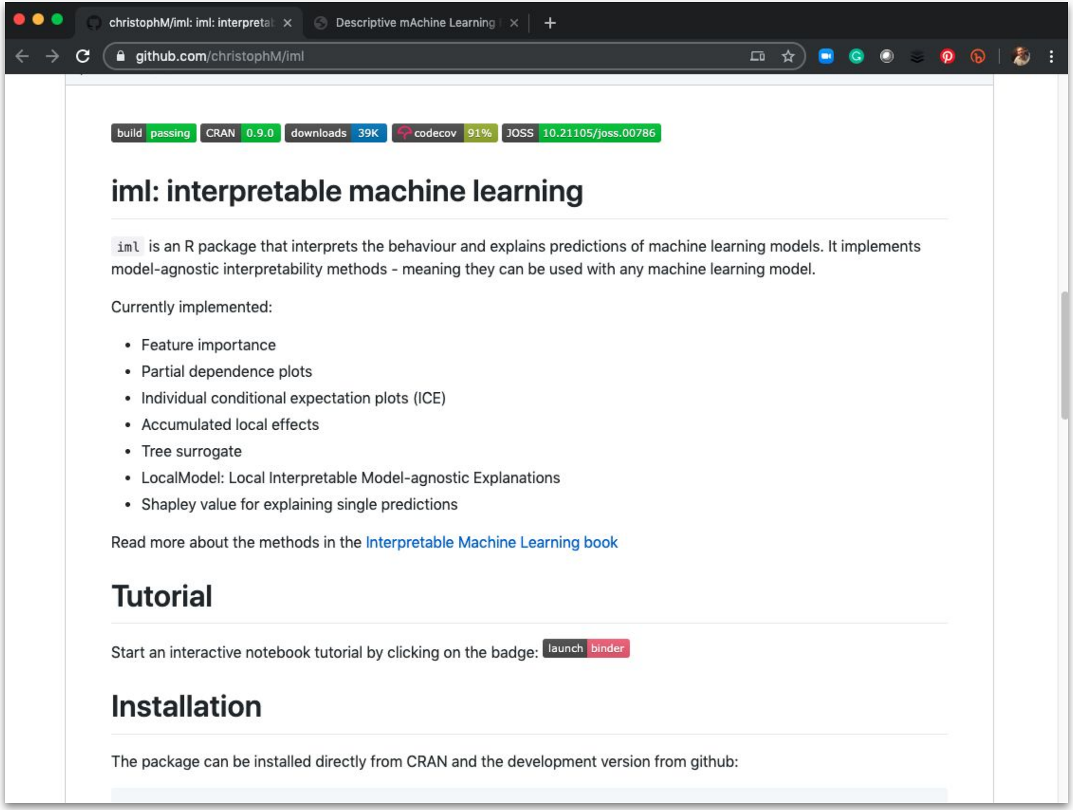
CREATORS OF DALEX

https://pbiecek.github.io/PM_VEE/

Explainable ML

Software

iml


christophM/iml: iml: interpretab
Descriptive mAchine Learning
github.com/christophM/iml

build passing | CRAN 0.9.0 | downloads 39K | codecov 91% | JOSS 10.21105/joss.00786

iml: interpretable machine learning

`iml` is an R package that interprets the behaviour and explains predictions of machine learning models. It implements model-agnostic interpretability methods - meaning they can be used with any machine learning model.

Currently implemented:

- Feature importance
- Partial dependence plots
- Individual conditional expectation plots (ICE)
- Accumulated local effects
- Tree surrogate
- LocalModel: Local Interpretable Model-agnostic Explanations
- Shapley value for explaining single predictions

Read more about the methods in the Interpretable Machine Learning book

Tutorial

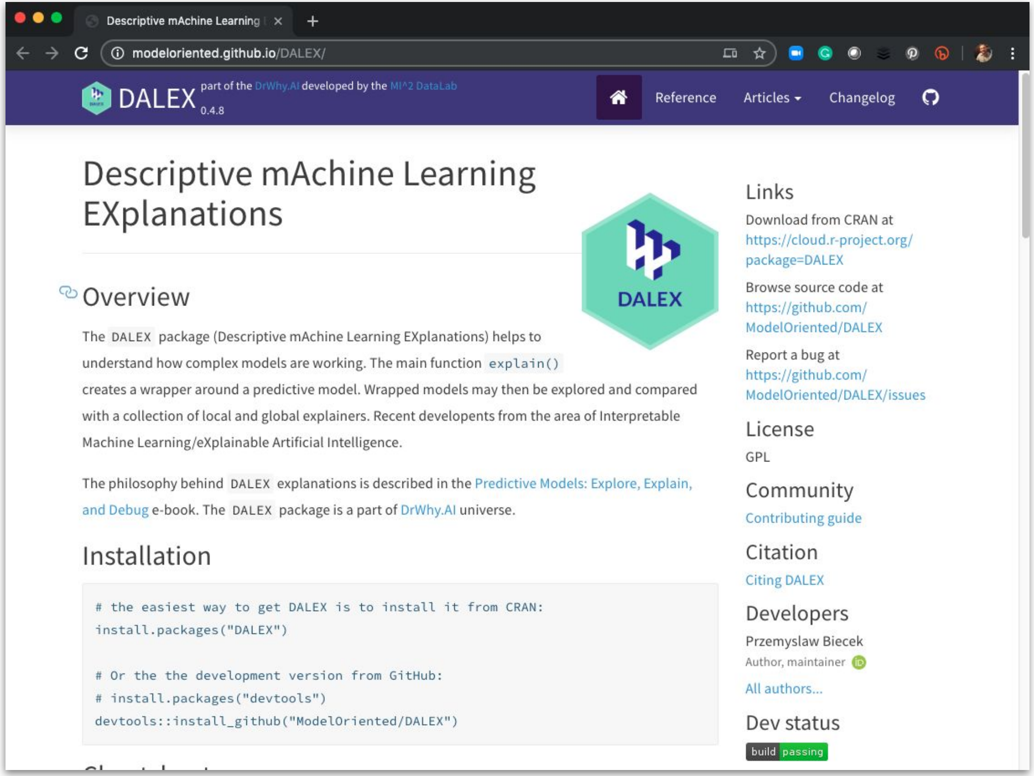
Start an interactive notebook tutorial by clicking on the badge: launch binder

Installation

The package can be installed directly from CRAN and the development version from github:

https://github.com/christophM/iml

DALEX



Descriptive mAchine Learning E ×

modeloriented.github.io/DALEX/

DALEX part of the DrWhy.AI developed by the MI^2 DataLab
0.4.8

Reference Articles Changelog

Descriptive mAchine Learning EXplanations

Overview

The DALEX package (Descriptive mAchine Learning EXplanations) helps to understand how complex models are working. The main function explain() creates a wrapper around a predictive model. Wrapped models may then be explored and compared with a collection of local and global explainers. Recent developents from the area of Interpretable Machine Learning/eXplainable Artificial Intelligence.

The philosophy behind DALEX explanations is described in the Predictive Models: Explore, Explain, and Debug e-book. The DALEX package is a part of DrWhy.AI universe.

Installation

```
# the easiest way to get DALEX is to install it from CRAN:
install.packages("DALEX")

# Or the the development version from GitHub:
# install.packages("devtools")
devtools::install_github("ModelOriented/DALEX")
```

Links

Download from CRAN at https://cloud.r-project.org/package=DALEX

Browse source code at https://github.com/ModelOriented/DALEX

Report a bug at https://github.com/ModelOriented/DALEX/issues

License

GPL

Community

Contributing guide

Citation

Citing DALEX

Developers

Przemyslaw Biecek
Author, maintainer

All authors...

Dev status

build passing

https://github.com/ModelOriented/DALEX

Customer Churn Workflow

Step-By-Step

Start

1

Data Clean & Transform

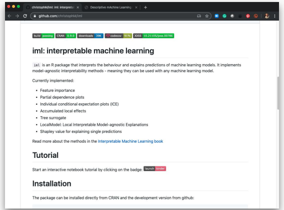
Exploratory Data Analysis

2

Machine Learning

Develop Segments

3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IML

Explain
Customer Segments

Finish

30-Min Demo

Analyze Customer Networks

Secret Tactics for

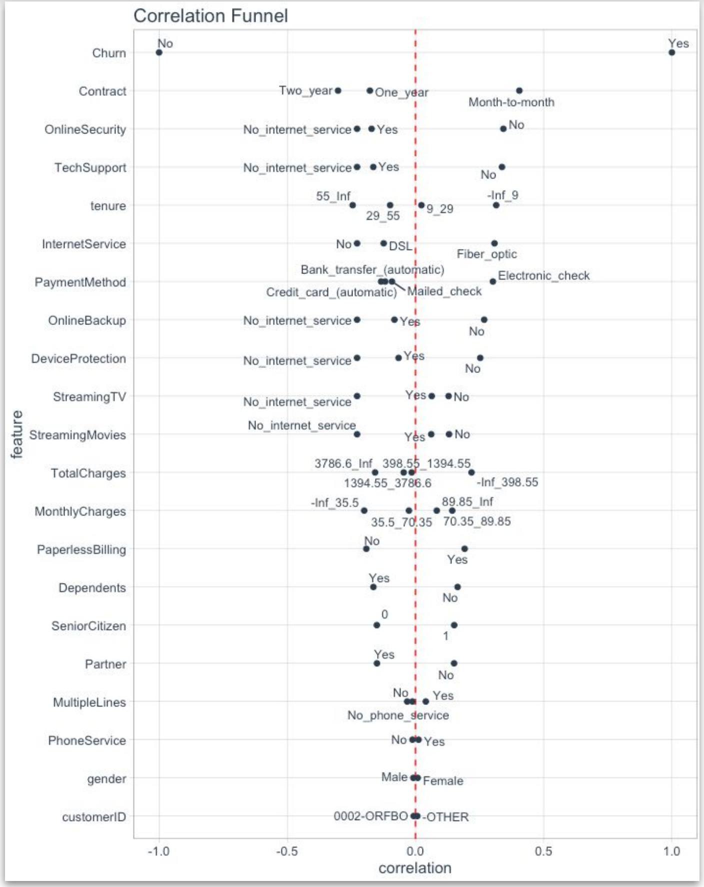
Explaining with Machine Learning

Use these tips to

increase help build a story

Pro Tip #1

Make a correlation funnel

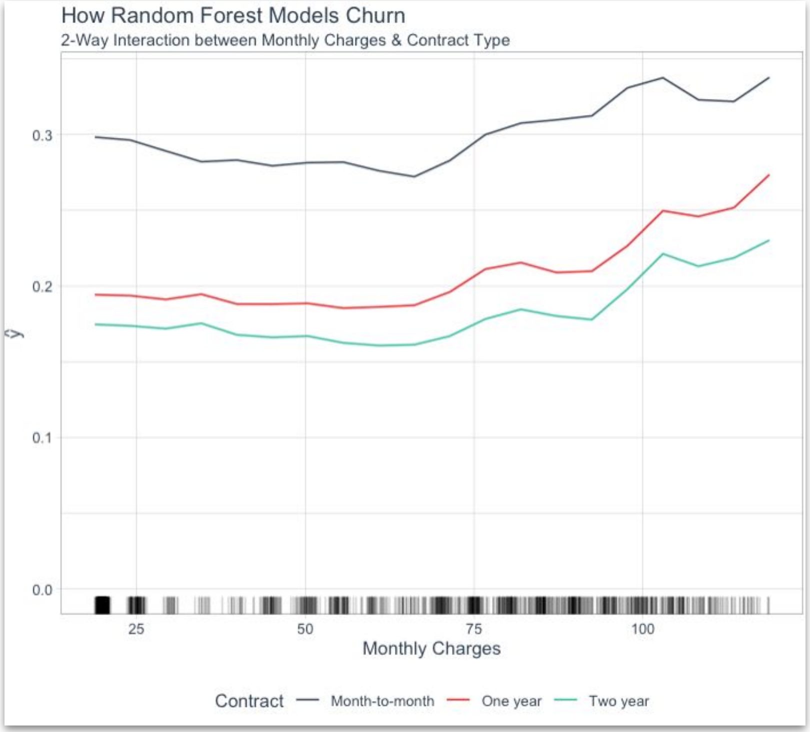


Get a general understanding of your model.

Focus on explaining the top features

Pro Tip #2

Build a feature story



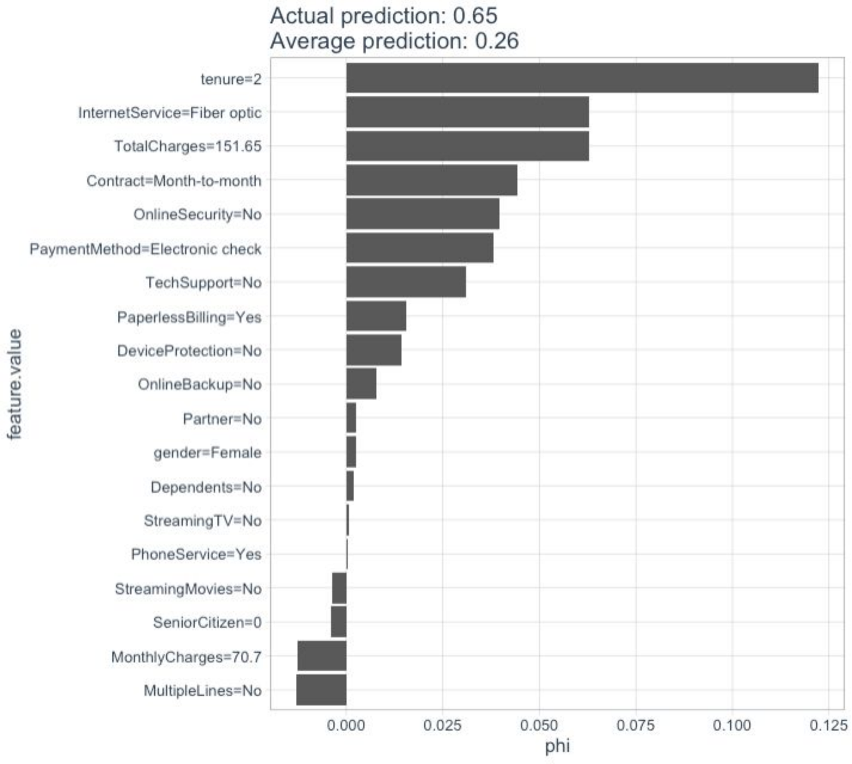
Use top features

Check interactions

Build a story

Pro Tip #3

Pick one customer, and explain her!



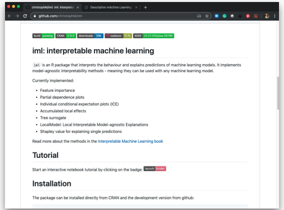
Talk about what **specifically** makes her susceptible to leaving

Data Science Transformation

Skills that are needed to do what we just did

Customer Churn Workflow

Step-By-Step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- Accumulated local effects
- Tree surrogate
- LocalModel: Local Interpretable Model-agnostic Explanations
- Shapley value for explaining single predictions

Read more about the methods in the Interpretable Machine Learning book

Tutorial

Start an interactive notebook tutorial by clicking on the badge: launch binder

Installation

The package can be installed directly from CRAN and the development version from github:

Data Clean & Transform

Exploratory Data Analysis

Machine Learning

Develop Segments

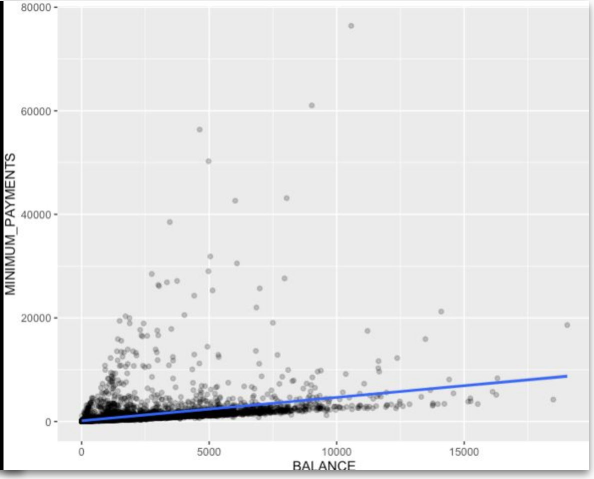
IML

Explain Customer Segments

dplyr, ggplot2

101 & 201

```
# 2.1 Minimum Payments has NA (missing data)

credit_card_tbl %>%
    pull(MINIMUM_PAYMENTS) %>%
    quantile(na.rm = TRUE)

credit_card_no_missing_tbl <- credit_card_tbl %>%
    select_if(is.numeric) %>%
    filter(!is.na(MINIMUM_PAYMENTS)) %>%
    filter(!is.na(CREDIT_LIMIT))

credit_card_no_missing_tbl %>%
    binarize() %>%
    correlate(target = MINIMUM_PAYMENTS__825.49646275_Inf) %>%
    plot_correlation_funnel()

credit_card_tbl %>%
    ggplot(aes(BALANCE, MINIMUM_PAYMENTS)) +
    geom_point(alpha = 0.25) +
    geom_smooth(method = "lm")
```



dplyr, ggplot2

101 & 201

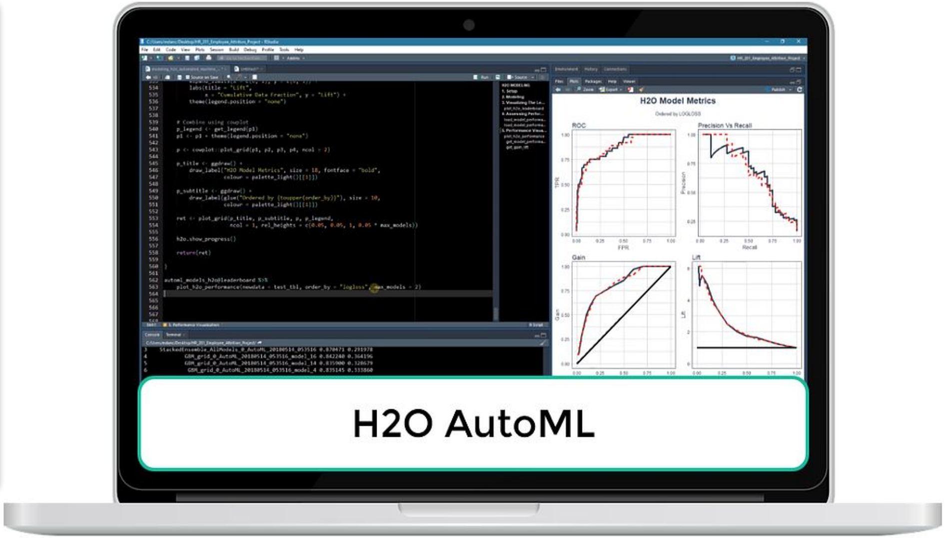
```
# 3.1 Preprocessing ----
set.seed(123)
rsample_splits <- initial_split(customer_churn_raw_tbl, prop = 0.8)

rec_obj <- recipe(Churn ~ ., data = training(rsample_splits)) %>%
    step_mutate(TotalCharges = ifelse(is.na(TotalCharges), 0, TotalCharges)) %>%
    step_rm(customerID) %>%
    step_string2factor(all_nominal()) %>%
    prep()

train_tbl <- bake(rec_obj, training(rsample_splits))
test_tbl  <- bake(rec_obj, testing(rsample_splits))

train_tbl
```

ggplot2 & purrr

H2O.ai

201

```
> h2o.predict(h2o_model, newdata = as.h2o(credit_card_group_tbl)) %>%
+   as_tibble()
  |===========================================================================
  |===========================================================================
# A tibble: 1,125 x 7
   predict    p1        p2        p3        p4       p5      Other
   <fct>     <dbl>     <dbl>     <dbl>     <dbl>    <dbl>    <dbl>
 1 Other   0       0.0000704 0.0228    0       0        0.977
 2 Other   0.0232  0.0000717 0.0000553 0       0.00376  0.973
 3 Other   0       0.0000737 0.0238    0       0.000107 0.976
 4 Other   0.00643 0.0000724 0.0000558 0.00343 0.000105 0.990
 5 Other   0       0.0000720 0.0000555 0       0.000104 1.000
 6 3       0       0.0000704 0.909     0       0.000102 0.0909
 7 3       0       0.0000761 0.995     0       0.000110 0.00491
 8 1       0.984   0.0000735 0.0000567 0.00349 0.000106 0.0127
 9 Other   0.195   0.0000602 0.0000464 0.00285 0.0000870 0.802
10 Other   0       0.0000737 0.0000568 0       0        1.000
# … with 1,115 more rows
```



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102

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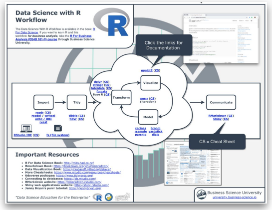
Business Analysis with R (DS4B 101-R)

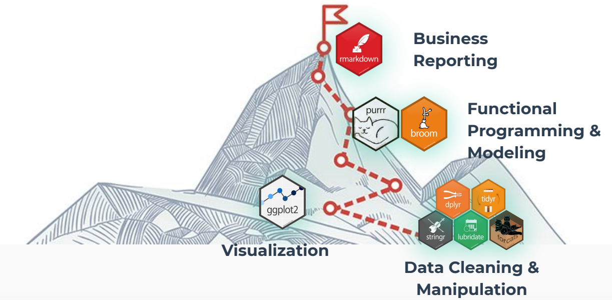
Data Science For Business with R (DS4B 201-R)

R Shiny Web Apps For Business (DS4B 102-R)

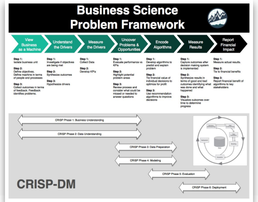
Project-Based Courses with Business Application

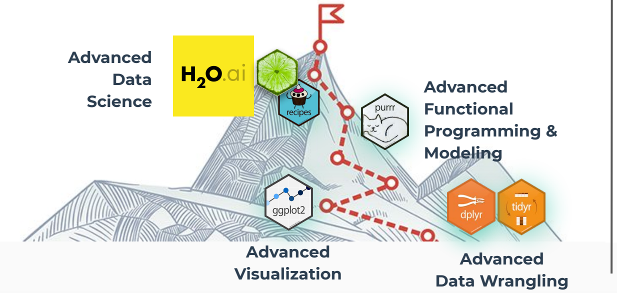
Data Science Foundations
7 Weeks



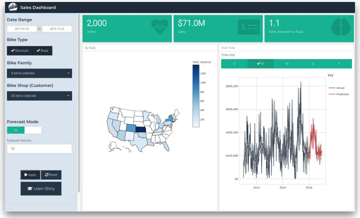


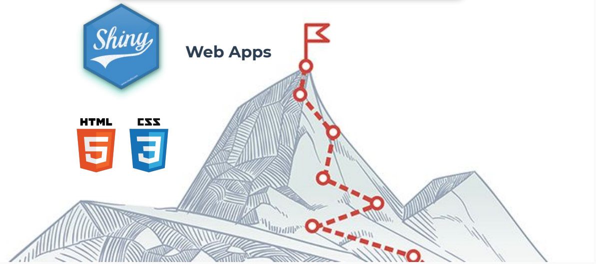
Machine Learning & Business Consulting
10 Weeks





Web Application Development
4 Weeks





Business Science University
R-Track

Key Benefits

- Fundamentals - Weeks 1-5 (25 hours of Video Lessons)
  - Data Manipulation (dplyr)
  - Time series (lubridate)
  - Text (stringr)
  - Categorical (forcats)
  - Visualization (ggplot2)
  - Programming & Iteration (purrr)
  - 3 Challenges

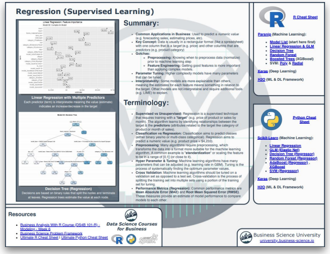
- **Machine Learning - Week 6 (8 hours of Video Lessons)**
  - **Clustering (3 hours)**
  - **Regression (5 hours)**
  - **2 Challenges**

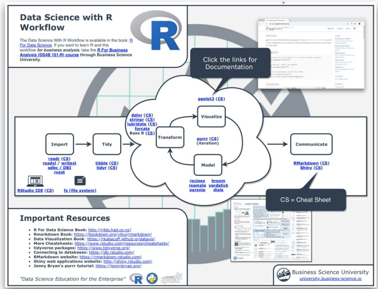
- Learn Business Reporting - Week 7
  - RMarkdown & plotly
  - 2 Project Reports:
    1. Product Pricing Algo
    2. Customer Segmentation

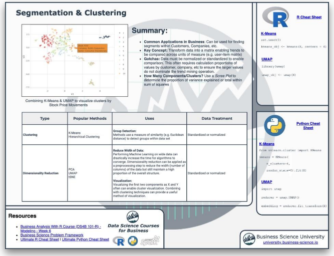
Business Analysis with R (DS4B 101-R)

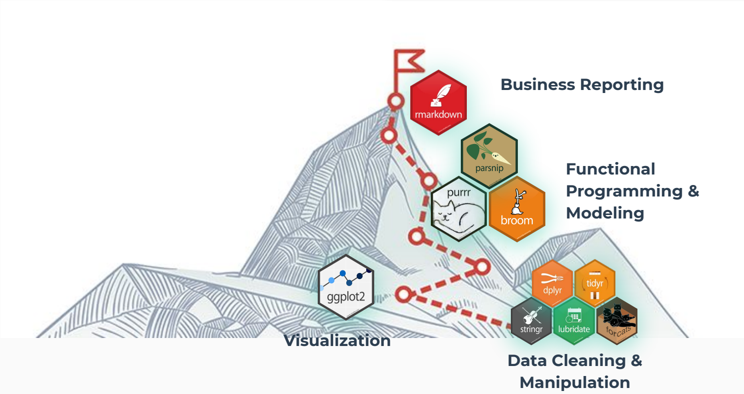
Data Science Foundations

7 Weeks









Key Benefits

End-to-End Churn Project

Understanding the Problem & Preparing Data - Weeks 1-4

- Project Setup & Framework
- Business Understanding / Sizing Problem
- Tidy Evaluation - rlang
- EDA - Exploring Data -GGally, skimr
- Data Preparation - recipes
- Correlation Analysis
- 3 Challenges

Machine Learning - Weeks 5, 6, 7

- **H2O AutoML - Modeling Churn**
- **ML Performance**
- **LIME Feature Explanation**

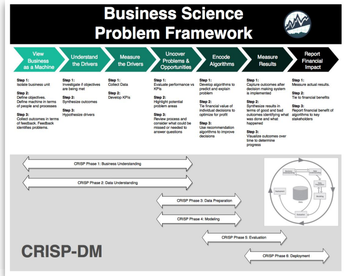
Return-On-Investment - Weeks 7, 8, 9

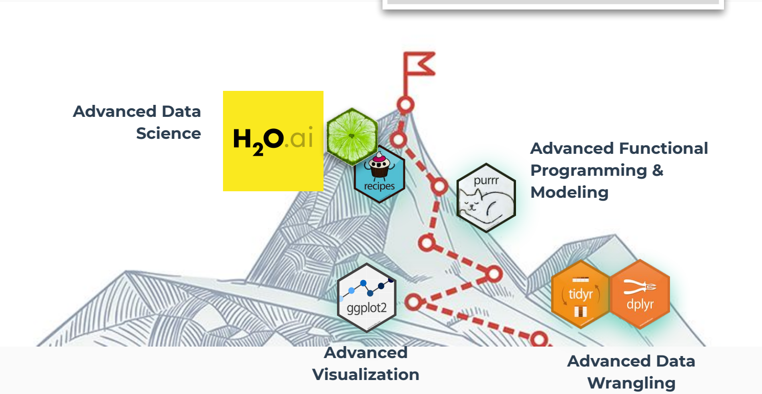
- **Expected Value Framework**
- **Threshold Optimization**
- **Sensitivity Analysis**
- **Recommendation Algorithm**

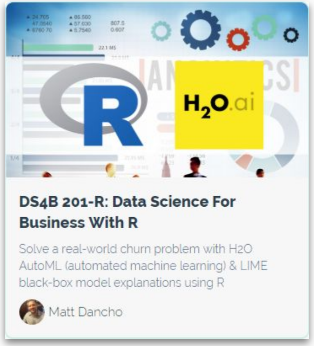
Data Science For Business (DS4B 201-R)

Machine Learning & Business Consulting

10 Weeks







Key Benefits

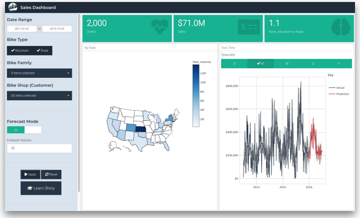
Learn Shiny & Flexdashboard
- Build Applications
- Learn Reactive Programming
- Integrate Machine Learning

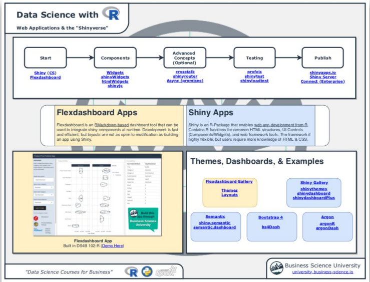
App #1: Predictive Pricing App
- Model Product Portfolio
- XGBoost Pricing Prediction
- Generate new products instantly

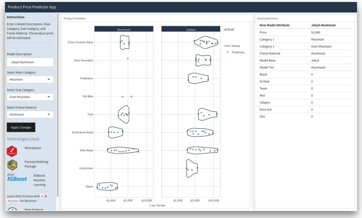
App #2: Sales Dashboard with Demand Forecasting
- Model Demand History
- Segment Forecasts by Product & Customer
- XGBoost Time Series Forecast
- Generate new forecasts instantly

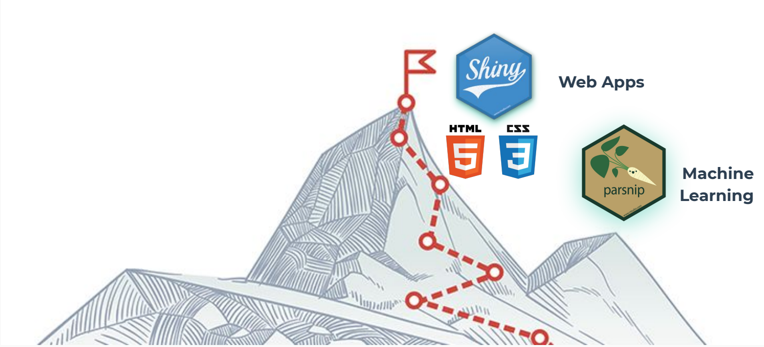
Shiny Apps for Business (DS4B 102-R)

Web Application Development
4 Weeks









Success Story

Masatake Hirono

- Took DS4B 201-R
- Completed the 10-Week Course
- **Landed a Job at one of the most Prestigious Management Consulting Firms**

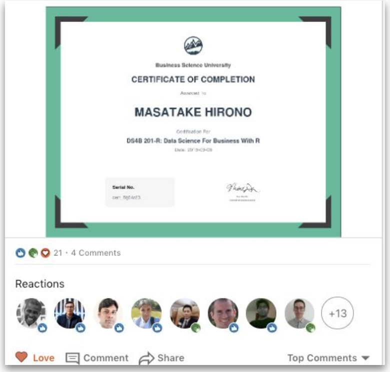
*“This course showed me how to place data analytics in **real business settings.**”*

Masatake Hirono • 1st
Data Scientist at 株式会社進研アド
4d

After struggling to balance with my work for many months, I've finally completed the Business Science University DS4B 201-R: Data Science For Business With R, taught by Matt Dancho. Unlike other MOOCs, this course showed me how to place data analytics in real business settings. Without this course, I would have never attempted to pay attention to business/financial impacts, generated through my analysis. His instruction turned me a more advanced data scientist and helped me find a new career opportunity. I will start to work at one of the most prestigious management consulting firms in October as a cognitive & analytics consultant. Highly recommended if you would like to use R as a professional business person!

#business_science_success #dataanalysis #machinelearningtraining

#Business Science Success



[redacted] 2d

How did it help you find another career opportunity? Did he place you in touch with hiring firms?

1 Reply

Masatake Hirono • 1st 1d
Data Scientist at 株式会社進研アド

Of course not. In a job interview, I was able to draw interviewer's attention because of my experiences to formulate some insight from analytics for driving business, which I had developed through his course.

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Matt Dancho

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Matt Dancho

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