```
5
6  # LIBRARIES ----
7  library(tidyverse)
8  library(tidyquant)
9
10 library(DataExplorer)
11 library(correlationfunnel)
12
13 library(recipes)
14
15 library(tidygraph)
16 library(ggraph)
```

Network Analysis

For Viral Marketing

```
28
29 # 2.1 Minimum Payments has NA (missing d
```

Matt Dancho & Kristen Kehrer

Business Science Webinar

Webinar Structure

- **Presentation**
  (20 min)
- **Demo's**
  (30 min)
- **Pro-Tips**
  (15 mins)

Dream Team

20 Years+ of Data Science Experience

LinkedIn Top Voice
Instructor
Consultant
Founder

Founder
Consultant
Instructor
Business Guru

Agenda

- **Business Case Study**
  - Customer Credit Card History
- **Network Analysis**
  - 2 Types
  - Key Concepts
- **R Packages**
  - tidygraph
  - ggraph
- **30-Min Demo**
  - Bank Customers
  - Account History
  - **EDA**
  - **Network Analysis**
  - **Machine Learning**
- **Pro-Tips:**
  - Tactics to **Explain** Why Customers belong to Communities

Customer Communities

Business Case

Customers Naturally Form Communities

Can Be Profitable to Detect Communities

Customer Communities are **Natural Phenomenon**

Some Customers are **Influencers**.

Focus on the Most Influential Customers:

1. **Avoid Trap** of Focusing on EVERYONE
2. Customize Products & Services for Key Groups - **Viral Marketing**

Customer History

Descriptive Features

Customers

```
> credit_card_tbl
# A tibble: 8,950 x 18
   CUST_ID BALANCE BALANCE_FREQUEN… PURCHASES ONEOFF_PURCHASES INSTALLMENTS_PU… CASH_ADVANCE PURCHASES_FREQU… ONEOFF_PURCHASE…
   <chr>     <dbl>            <dbl>     <dbl>            <dbl>            <dbl>        <dbl>           <dbl>           <dbl>
 1 C10001     40.9            0.818      95.4                0             95.4            0           0.167               0
 2 C10002   3202.             0.909       0                  0              0           6443.          0                   0
 3 C10003   2495.             1         773.               773.             0              0           1                   1
 4 C10004   1667.             0.636    1499               1499              0            206.          0.0833              0.0833
 5 C10005    818.             1          16                 16              0              0           0.0833              0.0833
 6 C10006   1810.             1        1333.                0           1333.             0           0.667               0
 7 C10007    627.             1        7091.             6403.            688.             0           1                   1
 8 C10008   1824.             1         436.                0            436.             0           1                   0
 9 C10009   1015.             1         861.              661.            200              0           0.333               0.0833
10 C10010    152.             0.545    1282.             1282.              0              0           0.167               0.167
# … with 8,940 more rows, and 9 more variables: PURCHASES_INSTALLMENTS_FREQUENCY <dbl>, CASH_ADVANCE_FREQUENCY <dbl>,
#   CASH_ADVANCE_TRX <dbl>, PURCHASES_TRX <dbl>, CREDIT_LIMIT <dbl>, PAYMENTS <dbl>, MINIMUM_PAYMENTS <dbl>, PRC_FULL_PAYMENT <dbl>,
#   TENURE <dbl>
```

Network Analysis Basics

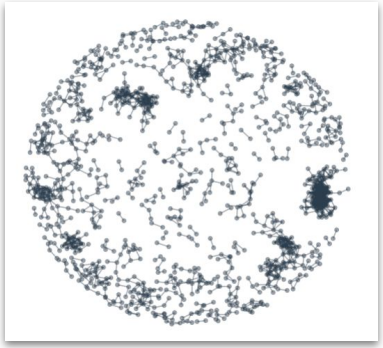
80/20 Concepts

Types of Network Analysis

1

Undirected

Strength of Relationship

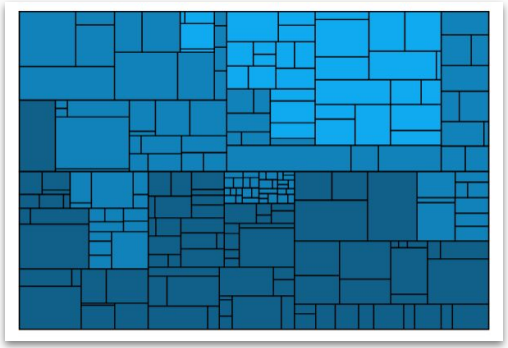


Clustering

2

Directed

Hierarchical Structure



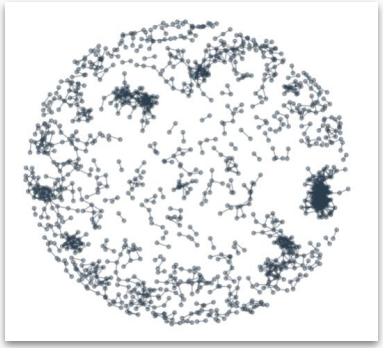
Composition of Groups

Types of Network Analysis

1

Undirected

Strength of Relationship

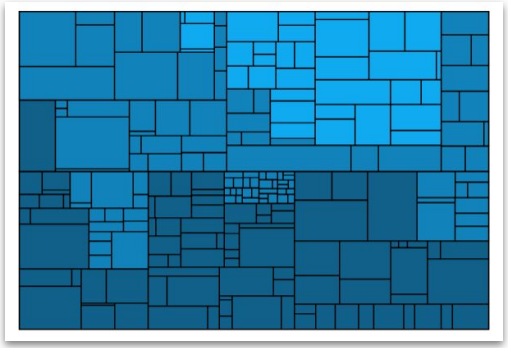


Clustering

2

Directed

Hierarchical Structure



Composition of Groups

Core Concepts

80/20

Adjacency Matrix

Customer Data

```
> credit_card_tbl
# A tibble: 8,950 x 18
   CUST_ID BALANCE BALANCE_FREQUEN~ PURCHASES ONEOFF_PURCHASES INSTALLMENTS_PU~ CASH_ADVANCE PURCHASES_FREQU~ ONEOFF_PURCHASE~
   <chr>     <dbl>            <dbl>     <dbl>           <dbl>            <dbl>        <dbl>           <dbl>           <dbl>
 1 C10001     40.9            0.818      95.4               0             95.4            0           0.167               0
 2 C10002   3202.             0.909       0                 0              0           6443.          0                   0
 3 C10003   2495.             1         773.              773.             0            0             1                 1
 4 C10004   1667.             0.636    1499              1499              0          206.            0.0833            0.0833
 5 C10005    817.             1          16                16              0            0             0.0833            0.0833
 6 C10006   1810.             1        1333.               0           1333.           0             0.667             0
 7 C10007    627.             1        7091.            6403.           688.           0             1                 1
 8 C10008   1824.             1         436.               0            436.           0             1                 0
 9 C10009   1015.             1         861.             661.           200            0             0.333             0.0833
10 C10010    152.             0.545    1282.            1282.             0            0             0.167             0.167
# ... with 8,940 more rows, and 9 more variables: PURCHASES_INSTALLMENTS_FREQUENCY <dbl>, CASH_ADVANCE_FREQUENCY <dbl>,
#   CASH_ADVANCE_TRX <dbl>, PURCHASES_TRX <dbl>, CREDIT_LIMIT <dbl>, PAYMENTS <dbl>, MINIMUM_PAYMENTS <dbl>, PRC_FULL_PAYMENT <dbl>,
#   TENURE <dbl>
```

Adjacency Matrix

```
# A tibble: 8,950 x 8,951
   CUST_ID C10001 C10002 C10003 C10004 C10005 C10006 C10007 C10008 C10009 C10010  C10011 C10012 C10013 C10014 C10015
   <chr>     <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>   <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
 1 C10001  1      0.0842 -0.171  0.125  0.807  0.386 -0.193  0.0384 0.279 -0.0580  0.166   0.608  0.0828 0.00733 0.511
 2 C10002  0.0842 1      -0.276  0.249  0.207 -0.368 -0.448 -0.469  0.0102 0.135  -0.500  -0.127 -0.720 -0.509   0.484
 3 C10003 -0.171 -0.276  1       0.0913 0.0823 -0.156  0.292 -0.0332 0.266  0.226  -0.120   0.353  0.109  0.0579 -0.0655
 4 C10004  0.125  0.249  0.0913  1      0.0419 -0.386  0.222 -0.496  0.464  0.860  -0.536   0.463  -0.196 -0.103   0.288
 5 C10005  0.807  0.207  0.0823  0.0419 1       0.269 -0.223 -0.0651 0.434 -0.168  -0.00797 0.565  -0.0794 -0.115   0.792
 6 C10006  0.386 -0.368 -0.156  -0.386  0.269  1      -0.273  0.696  0.185 -0.390   0.857  -0.0811 0.466  0.591   0.149
 7 C10007 -0.193 -0.448  0.292   0.222 -0.223 -0.273  1       -0.0878 0.214  0.433  -0.146   0.372  0.529  0.285  -0.473
 8 C10008  0.0384 -0.469 -0.0332 -0.496 -0.0651  0.696 -0.0878  1      0.125 -0.440   0.938  -0.259  0.685  0.548  -0.184
 9 C10009  0.279  0.0102 0.266   0.464  0.434   0.185  0.214  0.125  1       0.508  0.0476  0.302  0.151  0.465   0.413
10 C10010 -0.0580  0.135  0.226   0.860 -0.168  -0.390  0.433 -0.440  0.508  1      -0.481   0.303 -0.175  0.126  -0.0478
# ... with 8,940 more rows, and 8,935 more variables: C10016 <dbl>, C10017 <dbl>, C10018 <dbl>, C10019 <dbl>, C10020 <dbl>,
#   C10021 <dbl>, C10022 <dbl>, C10023 <dbl>, C10024 <dbl>, C10025 <dbl>, C10026 <dbl>, C10027 <dbl>, C10028 <dbl>, C10029 <dbl>,
#   C10030 <dbl>, C10031 <dbl>, C10032 <dbl>, C10033 <dbl>, C10034 <dbl>, C10035 <dbl>, C10036 <dbl>, C10037 <dbl>, C10038 <dbl>,
#   C10039 <dbl>, C10040 <dbl>, C10041 <dbl>, C10043 <dbl>, C10044 <dbl>, C10045 <dbl>, C10046 <dbl>, C10047 <dbl>, C10048 <dbl>,
#   C10049 <dbl>, C10050 <dbl>, C10051 <dbl>, C10052 <dbl>, C10053 <dbl>, C10054 <dbl>, C10055 <dbl>, C10056 <dbl>, C10057 <dbl>,
#   C10058 <dbl>, C10059 <dbl>, C10060 <dbl>, C10061 <dbl>, C10062 <dbl>, C10063 <dbl>, C10064 <dbl>, C10065 <dbl>, C10067 <dbl>,
#   C10068 <dbl>, C10069 <dbl>, C10070 <dbl>, C10071 <dbl>, C10072 <dbl>, C10073 <dbl>, C10074 <dbl>, C10075 <dbl>, C10077 <dbl>,
#   C10078 <dbl>, C10079 <dbl>, C10080 <dbl>, C10081 <dbl>, C10082 <dbl>, C10083 <dbl>, C10084 <dbl>, C10085 <dbl>, C10086 <dbl>,
#   C10087 <dbl>, C10088 <dbl>, C10089 <dbl>, C10090 <dbl>, C10092 <dbl>, C10093 <dbl>, C10094 <dbl>, C10095 <dbl>, C10096 <dbl>,
#   C10097 <dbl>, C10098 <dbl>, C10099 <dbl>, C10100 <dbl>, C10101 <dbl>, C10102 <dbl>, C10103 <dbl>, C10104 <dbl>, C10105 <dbl>,
#   C10106 <dbl>, C10107 <dbl>, C10108 <dbl>, C10109 <dbl>, C10110 <dbl>, C10111 <dbl>, C10112 <dbl>, C10113 <dbl>, C10114 <dbl>,
#   C10115 <dbl>, C10116 <dbl>, C10117 <dbl>, C10118 <dbl>, C10119 <dbl>, ...
```

Key Concept

N x N matrix of **Relationship Strength** (Measure)

Nodes & Edges

Nodes

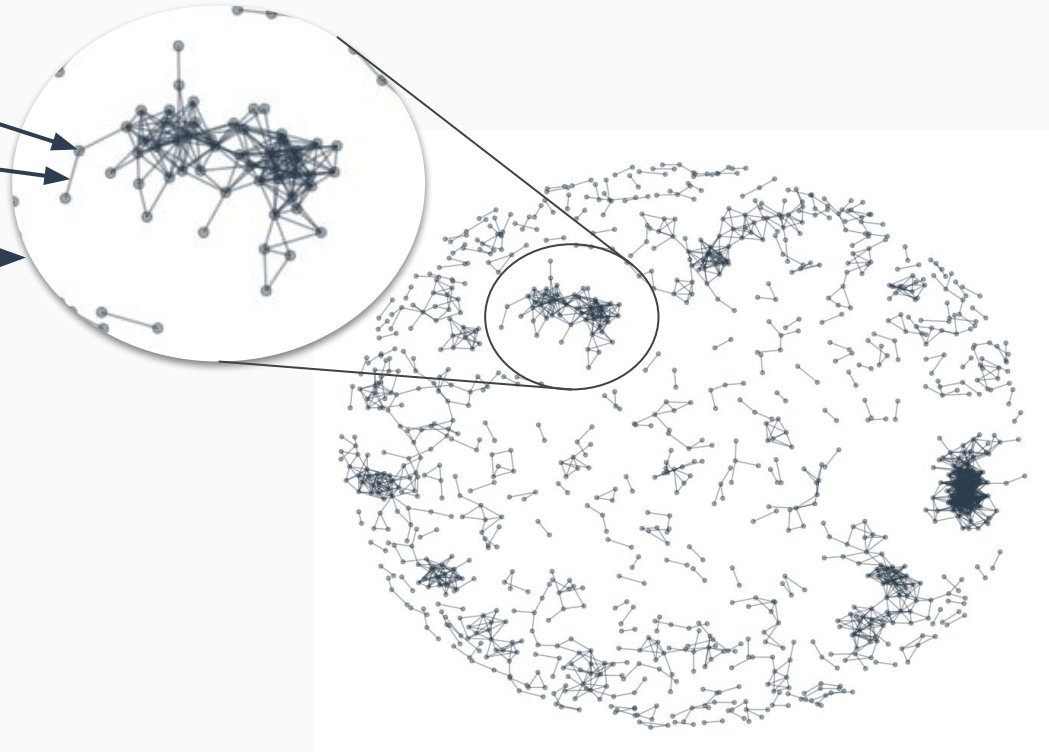
- Customers

Edges

- Relationship Strength

Clusters (Groups)

- Densely Connected Web



Key Concept

Groups (Clusters) have more edges connecting more nodes at a given relationship **threshold**.

Pruning & Threshold

Pruning

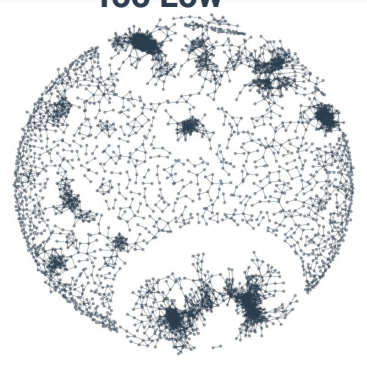
- Filtering to reduce to the **most “influential” nodes**
- We use a **threshold** to find an optimal visualization that explains the groups

Threshold = 0.9999

Too High

Threshold = 0.99

Too Low



Threshold = 0.996

Just Right!

Key Concept

Data mining is subjective. Where do we cut off?

Network Analysis

Software

tidygraph

Tidy Network Data

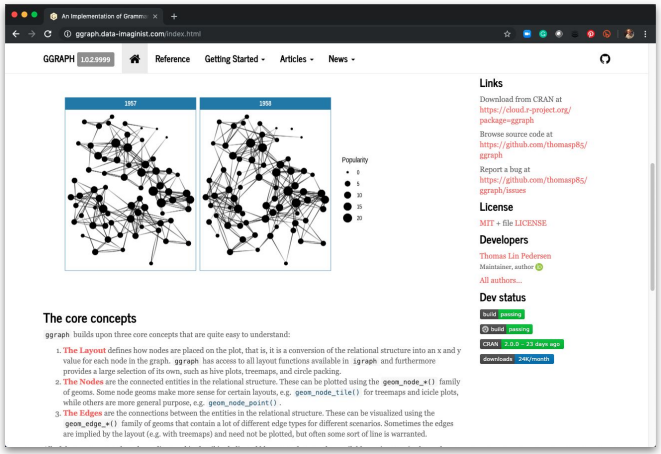
- Combines Node and Edge Data inside 1 tidygraph object
- Makes it super easy to work with network data
- Can activate() inner node and edge tbls to manipulate them
- Can apply special network analysis functions like group_components() & centrality_degree()

```
# A tbl_graph: 1125 nodes and 2156 edges
#
# An undirected simple graph with 247 components
#
# Node Data: 1,125 x 1 (active)
  name
  <chr>
1 C10278
2 C16180
3 C17657
4 C14958
5 C11181
6 C12206
# … with 1,119 more rows
#
# Edge Data: 2,156 x 3
   from    to weight
  <int> <int>  <dbl>
1     1   711  0.996
2     2   712  0.997
3     3   712  0.998
# … with 2,153 more rows
```

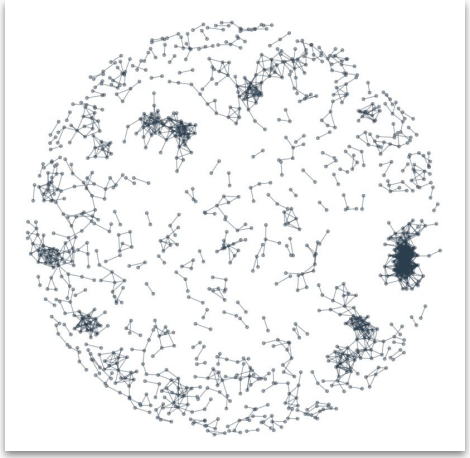
https://github.com/thomasp85/tidygraph

ggraph

Visualization Package for tidygraph data




```
152 # 7.0 NETWORK VISUALIZATION -----
153
154 customer_correlation_matrix %>%
155
156     prep_corr_matrix_for_tbl_graph(edge_limit = 0.996) %>%
157
158     as_tbl_graph(directed = FALSE) %>%
159
160     ggraph(layout = "kk") +
161     geom_edge_link(alpha = 0.5, color = palette_light()["blue"]) +
162     geom_node_point(alpha = 0.5, color = palette_light()["blue"]) +
163     theme_graph(background = "white")
164
```

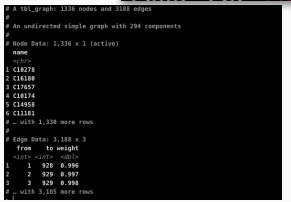


https://ggraph.data-imaginist.com/

Customer Segmentation Workflow

Step-By-Step

CUST_ID	C10001	C10002	C10003	C10004	C10005
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1 C10001	1	0.0842	-0.171	0.125	0.807
2 C10002	0.0842	1	-0.276	0.249	0.207
3 C10003	-0.171	-0.276	1	0.0913	0.0823
4 C10004	0.125	0.249	0.0913	1	0.0419
5 C10005	0.807	0.207	0.0823	0.0419	1



Start

1

2

3

Finish

Data Clean & Transform

Exploratory Data Analysis

Adjacency Matrix, tidygraph, & ggraph Visualizations

Develop Segments

H2O & LIME

Predict & Explain Customer Segments

30-Min Demo

Analyze Customer Networks

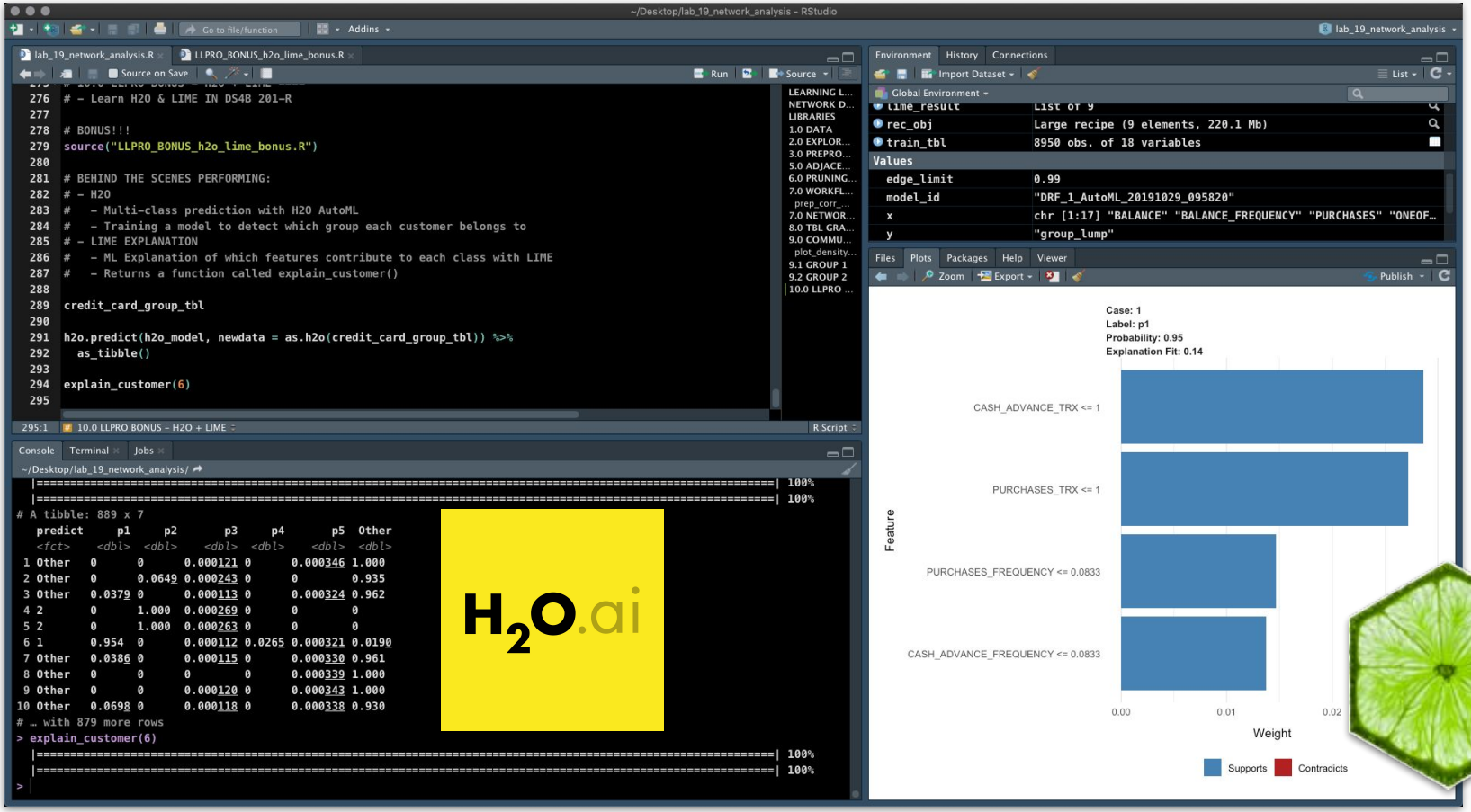
Secret Tactics for

Network Analysis

Use these tips to
increase your customer segmentation explainability

Pro Tip

Use H2O & LIME to EXPLAIN WHY

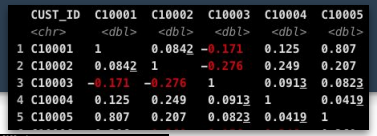


Data Science Transformation

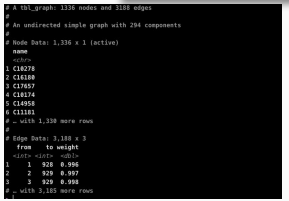
Skills that are needed to do what we just did

Customer Segmentation Workflow

Step-By-Step



	CUST_ID	C10001	C10002	C10003	C10004	C10005
	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1	C10001	1	0.0842	-0.171	0.125	0.807
2	C10002	0.0842	1	-0.276	0.249	0.207
3	C10003	-0.171	-0.276	1	0.0913	0.0823
4	C10004	0.125	0.249	0.0913	1	0.0419
5	C10005	0.807	0.207	0.0823	0.0419	1



Start

1

2

3

Finish

Data Clean & Transform

Exploratory Data Analysis

101 & 201

Adjacency Matrix, tidygraph, & ggraph Visualizations

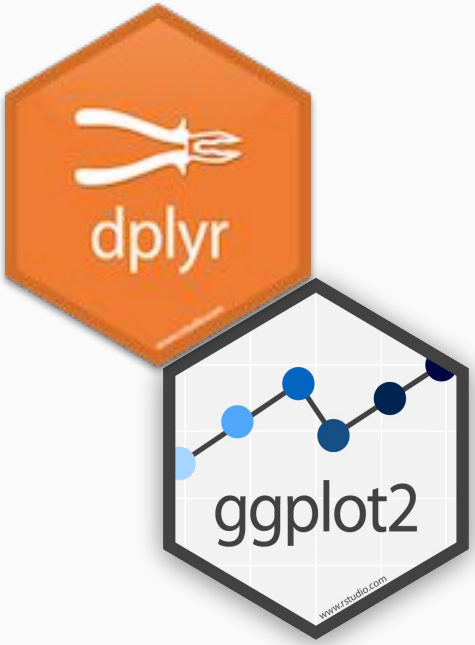
Lab 19

H2O & LIME

Predict & Explain Customer Segments

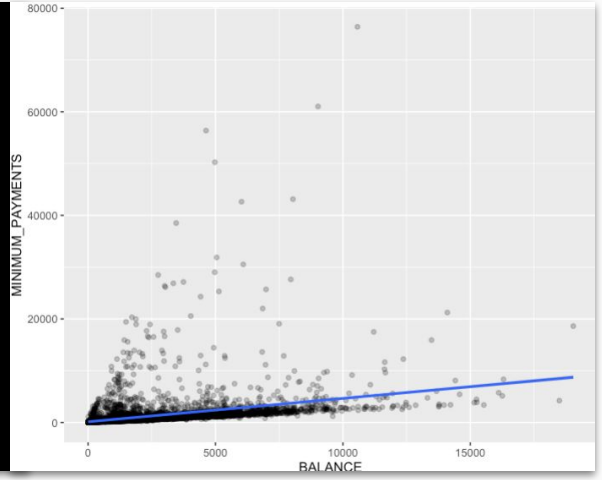
201

dplyr, ggplot2



101 & 201

```
30  # 2.1 Minimum Payments has NA (missing data)
31
32  credit_card_tbl %>%
33      pull(MINIMUM_PAYMENTS) %>%
34      quantile(na.rm = TRUE)
35
36  credit_card_no_missing_tbl <- credit_card_tbl %>%
37      select_if(is.numeric) %>%
38      filter(!is.na(MINIMUM_PAYMENTS)) %>%
39      filter(!is.na(CREDIT_LIMIT))
40
41  credit_card_no_missing_tbl %>%
42      binarize() %>%
43      correlate(target = MINIMUM_PAYMENTS__825.49646275_Inf) %>%
44      plot_correlation_funnel()
45
46  credit_card_tbl %>%
47      ggplot(aes(BALANCE, MINIMUM_PAYMENTS)) +
48      geom_point(alpha = 0.25) +
49      geom_smooth(method = "lm")
50
```



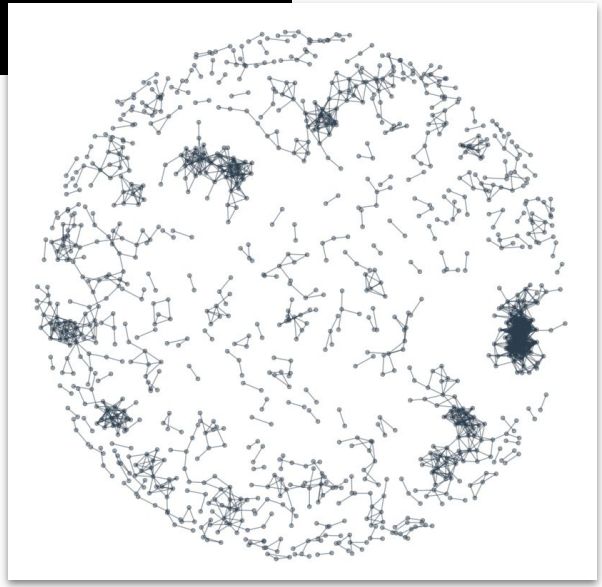
Adjacency Matrix, tidygraph, & ggraph

CUST_ID	C10001	C10002	C10003	C10004	C10005
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1 C10001	1	0.0842	-0.171	0.125	0.807
2 C10002	0.0842	1	-0.276	0.249	0.207
3 C10003	-0.171	-0.276	1	0.0913	0.0823
4 C10004	0.125	0.249	0.0913	1	0.0419
5 C10005	0.807	0.207	0.0823	0.0419	1

```
# A tbl_graph: 1336 nodes and 3188 edges
#
# An undirected simple graph with 294 components
#
# Node Data: 1,336 x 1 (active)
  name
  <chr>
1 C10278
2 C16180
3 C17657
4 C10174
5 C14958
6 C11181
# … with 1,330 more rows
#
# Edge Data: 3,188 x 3
   from    to weight
  <int> <int>  <dbl>
1     1   928  0.996
2     2   929  0.997
3     3   929  0.998
# … with 3,185 more rows
```

```
153 # 7.0 NETWORK VISUALIZATION ----
154
155 customer_correlation_matrix %>%
156
157     prep_corr_matrix_for_tbl_graph(edge_limit = 0.996) %>%
158
159     as_tbl_graph(directed = FALSE) %>%
160
161     ggraph(layout = "kk") +
162     geom_edge_link(alpha = 0.5, color = palette_light()["blue"]) +
163     geom_node_point(alpha = 0.5, color = palette_light()["blue"]) +
164     theme_graph(background = "white")
165
166
167
```

Learning Labs

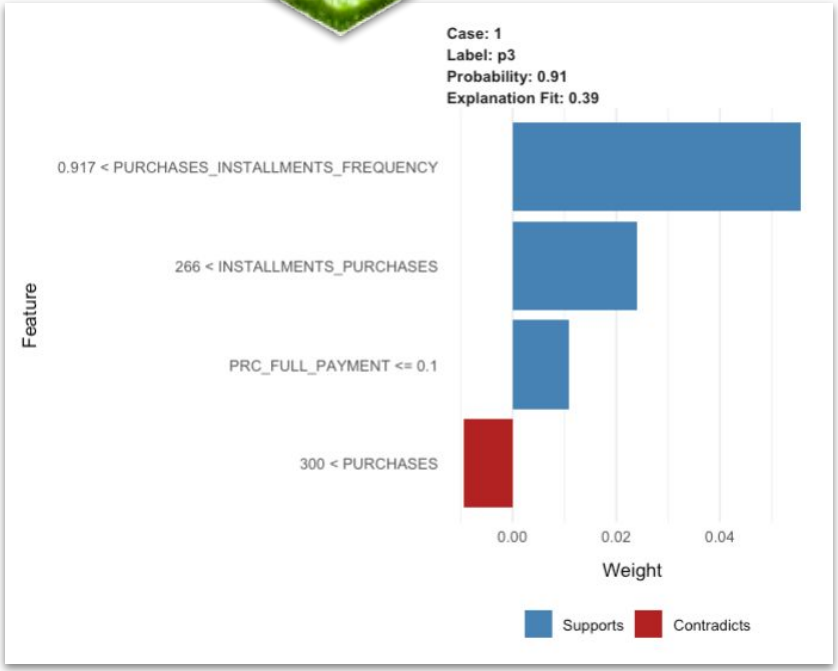


ggplot2 & purrr

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
```



Business Science University

Our program that will TRANSFORM YOU
in 6-months (or less).

4-Course R-Track System

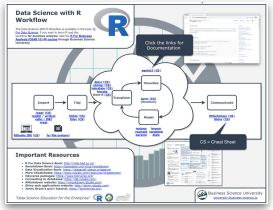
Business Analysis with R
(DS4B 101-R)

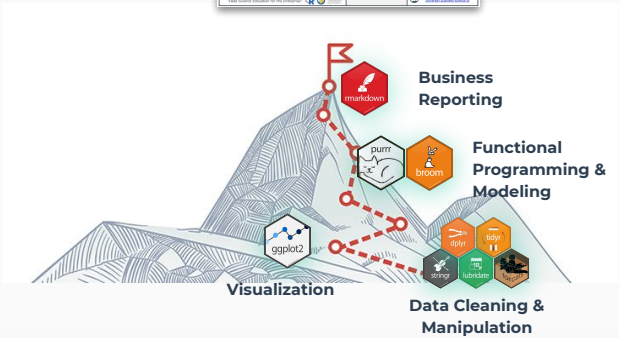
Data Science For Business with R
(DS4B 201-R)

Web Apps & Shiny Developer
(DS4B 102-R + DS4B 202A-R)

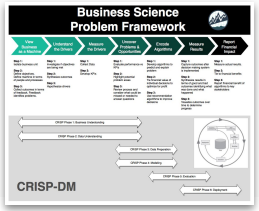
Project-Based Courses with Business Application

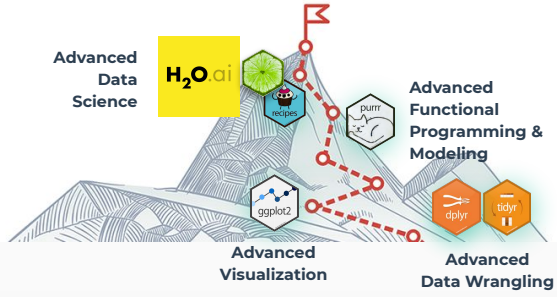
Data Science Foundations
7 Weeks



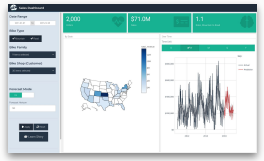


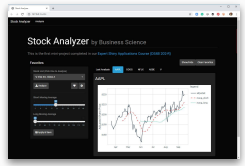
Machine Learning & Business Consulting
10 Weeks

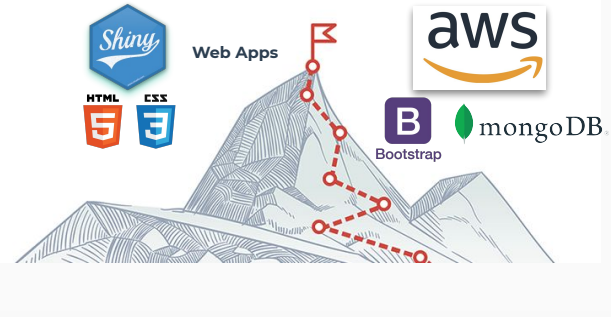




Web Application Development
12 Weeks







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

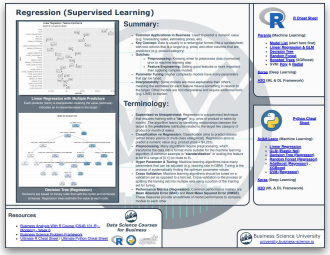
- **Machine Learning - Week 6 (8 hours of Video Lessons)**
  - **Clustering (3 hours)**
  - **Regression (5 hours)**
  - **2 Challenges**

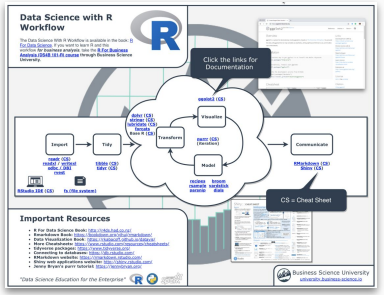
- Learn Business Reporting - Week 7
  - RMarkdown & plotly
  - 2 Project Reports:
    1. Product Pricing Algo
    2. Customer Segmentation

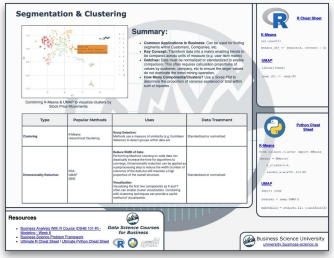
Business Analysis with R (DS4B 101-R)

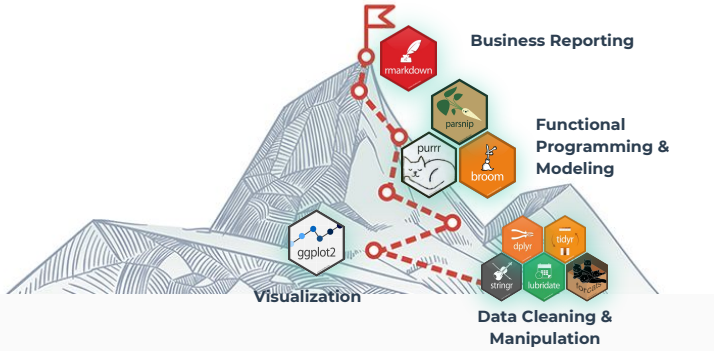
Data Science Foundations

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**

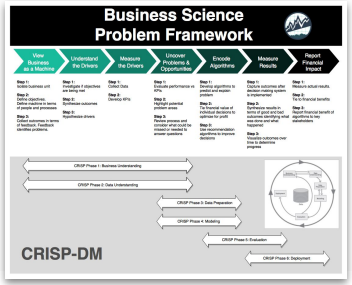
Return-On-Investment - Weeks 7, 8, 9

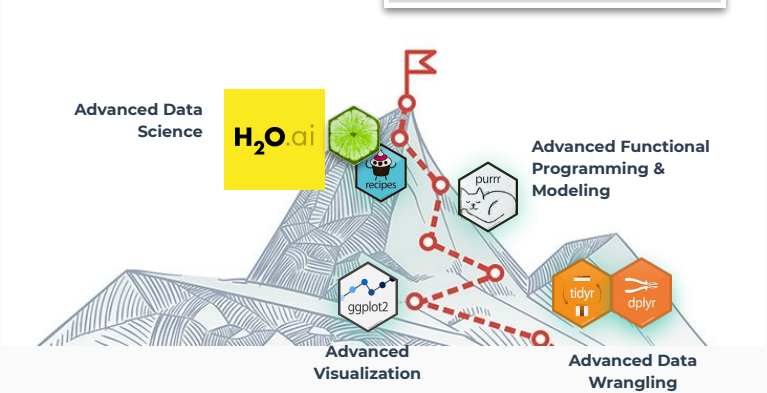
- **Expected Value Framework**
- **Threshold Optimization**
- **Sensitivity Analysis**
- **Recommendation Algorithm**

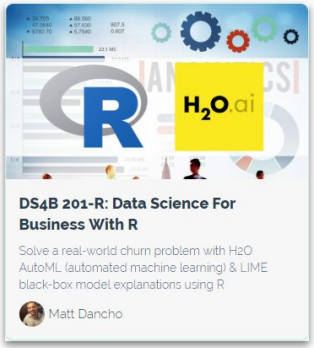
Data Science For Business (DS4B 201-R)

Machine Learning & Business Consulting

10 Weeks







Key Benefits

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

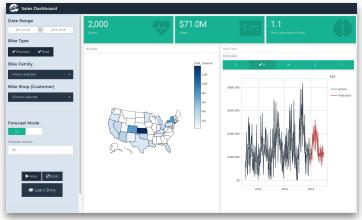
App #1: Predictive Pricing App
- Model Product Portfolio
- XGBoost Pricing Prediction
- Generate new products instantly

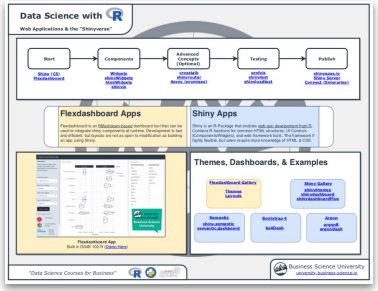
App #2: Sales Dashboard with Demand Forecasting
- Model Demand History
- Segment Forecasts by Product & Customer
- XGBoost Time Series Forecast
- Generate new forecasts instantly

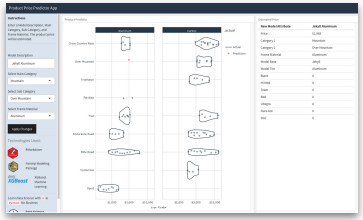
Shiny Apps for Business (DS4B 102-R)

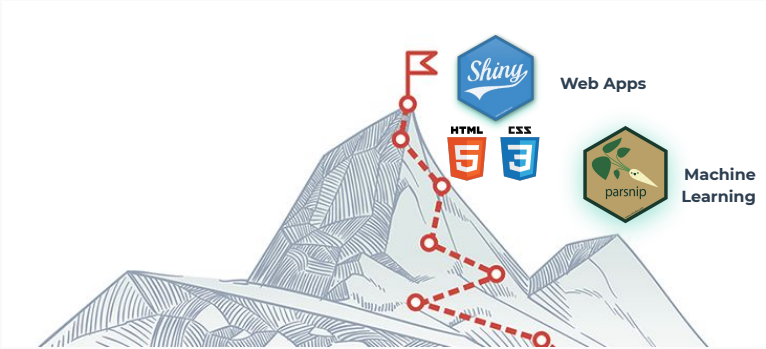
Web Application Development

4 Weeks









Key Benefits

Frontend + Backend + Production Deployment

Frontend for Shiny
- Bootstrap

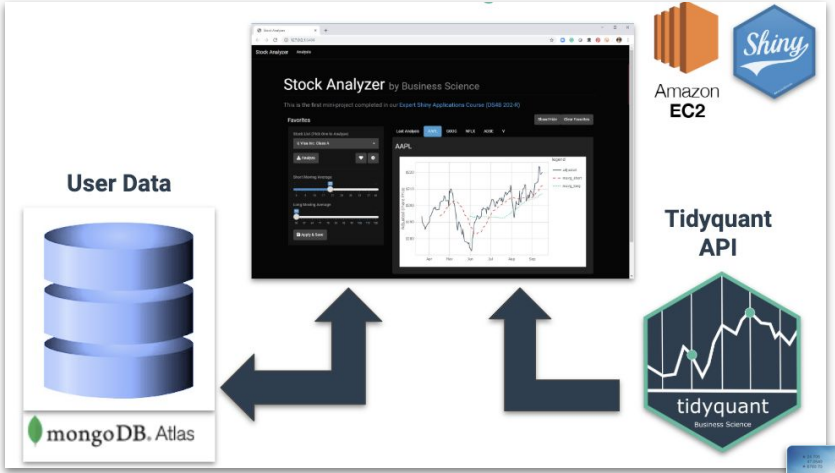
Backend for Shiny
- MongoDB
- Dynamic UI
- User Authentication
- Store & Write User Data

Production Deployment
- AWS
- EC2 Server
- VPC Connection
- URL Routing

Shiny Apps for Business (DS4B 202A-R)

Web Application Development

6 Weeks



aws

Bootstrap

mongoDB.

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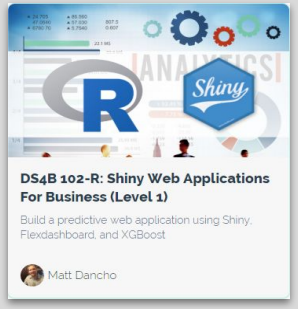
DS4B 101-R: Business Analysis With R

Your Data Science Journey Starts Now! Learn the fundamentals of data science for business with the tidyverse.

Matt Dancho



DS4B 102-R: Shiny Web Applications For Business (Level 1)

Build a predictive web application using Shiny, Flexdashboard, and XGBoost

Matt Dancho

DS4B 201-R: Data Science For Business With R

Solve a real-world churn problem with H2O AutoML (automated machine learning) & LIME black-box model explanations using R

Matt Dancho

DS4B 202A-R: Expert Shiny Developer with AWS

Learn how to build Scalable Data Science Applications using R, Shiny, and AWS Cloud Technology.

Matt Dancho

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