"Cracking the Code"

Demystifying Programming Languages for Data Analytics

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Presentation Outline

Unveiling the Shroud of Complexity

The “Problems” with Programming

A Framework for Addressing the Problem

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Conclusion

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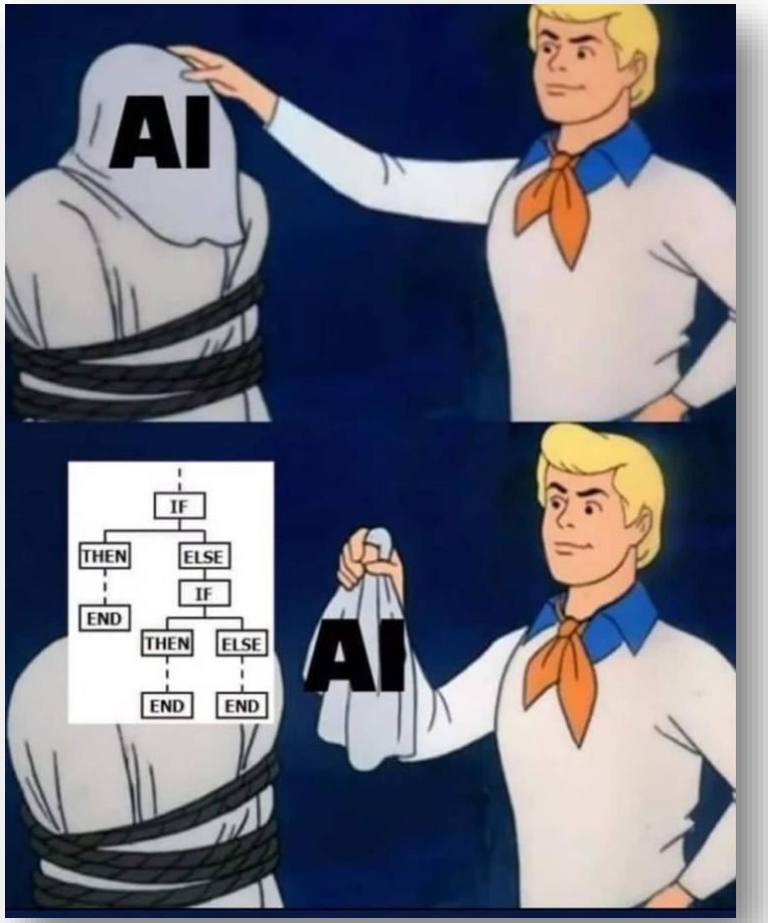
Artificial Intelligence



Big Data


WE'VE DECIDED TO TAKE BIG DATA TO THE NEXT LEVEL...
HUMONGOUS DATA
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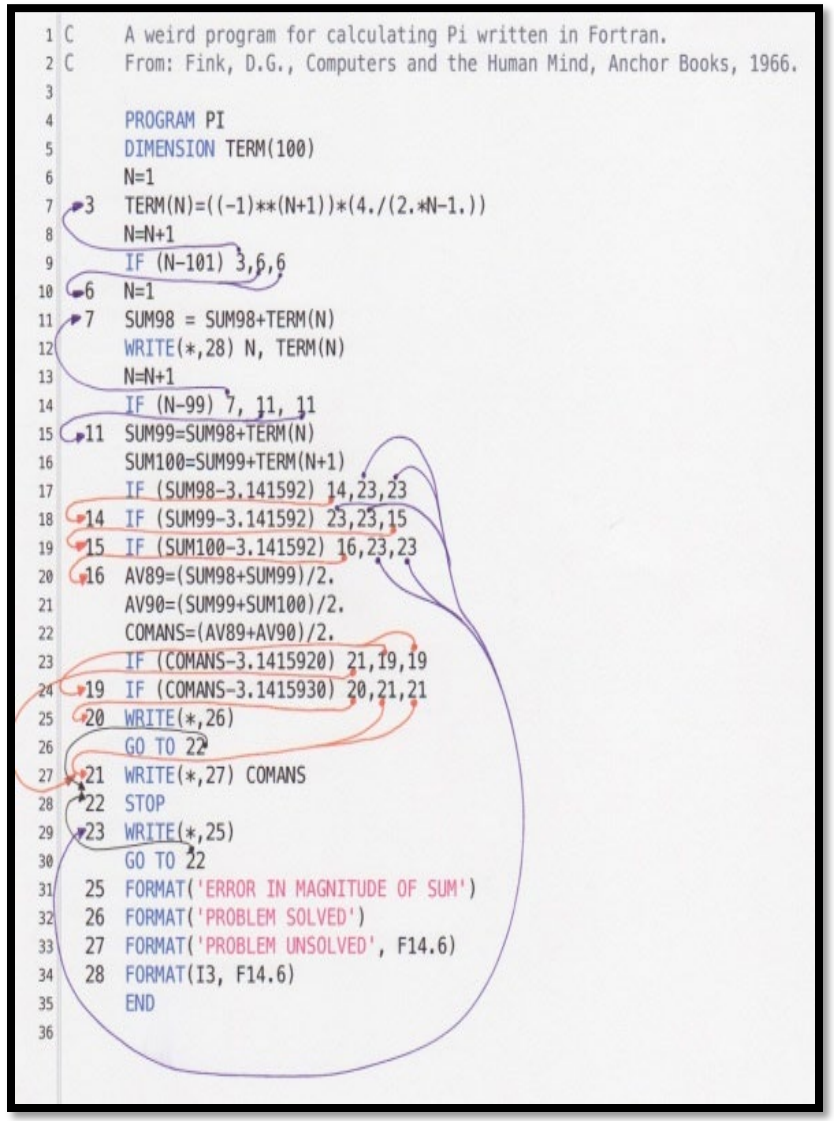
Cool Buzzwords…

- But really, how well do we understand these concepts?
  - Do we have a good grasp of their definitions, methodologies, and applicability to our work?
  - How many of us know how to code a simple function… much less develop a machine learning algorithm?
- As the cost community works to incorporate data science into it's body of knowledge, cost estimators should establish a baseline understanding of their own programming capabilities

Unveiling the Shroud of Complexity

What Makes Programming So Intimidating?

- From anecdotal experience:
  - "A computer *language*? I tried learning French in High School and that didn't go very well…"
  - "What are all those random words in parentheses? Why are they all indented differently? How long will it take me to memorize all these blocks of code?"
  - "Don't I have to get a degree in computer science to *really* learn how to program? I don't know if I have the time to become a software engineer"
- At some point in time, we have ***all*** thought along these lines



```
C     A weird program for calculating Pi written in Fortran.
C     From: Fink, D.G., Computers and the Human Mind, Anchor Books, 1966.

      PROGRAM PI
      DIMENSION TERM(100)
      N=1
    3 TERM(N)=((-1)**(N+1))*(4./(2.*N-1.))
      N=N+1
      IF (N-101) 3,6,6
    6 N=1
    7 SUM98 = SUM98+TERM(N)
      WRITE(*,28) N, TERM(N)
      N=N+1
      IF (N-99) 7, 11, 11
   11 SUM99=SUM98+TERM(N)
      SUM100=SUM99+TERM(N+1)
      IF (SUM98-3.141592) 14,23,23
   14 IF (SUM99-3.141592) 23,23,15
   15 IF (SUM100-3.141592) 16,23,23
   16 AV89=(SUM98+SUM99)/2.
      AV90=(SUM99+SUM100)/2.
      COMANS=(AV89+AV90)/2.
      IF (COMANS-3.1415920) 21,19,19
   19 IF (COMANS-3.1415930) 20,21,21
   20 WRITE(*,26)
      GO TO 22
   21 WRITE(*,27) COMANS
   22 STOP
   23 WRITE(*,25)
      GO TO 22
   25 FORMAT('ERROR IN MAGNITUDE OF SUM')
   26 FORMAT('PROBLEM SOLVED')
   27 FORMAT('PROBLEM UNSOLVED', F14.6)
   28 FORMAT(I3, F14.6)
      END
```

Demystifying Computer Programming

- "A computer *language*?"
  - ***Programming languages are easier to learn than human languages***. There is certainly a "vocabulary" (e.g., objects) and "grammar" (e.g., syntax). However, a programming language provides explicit commands to facilitate the execution of computational tasks, without all of the cultural or historical nuance you might expect from, say, French
- "How long will it take me to memorize all these blocks of code?"
  - ***You don't need to***. Programming isn't centered around rote learning. It's more important to understand the objective you are trying to accomplish, and the types of commands you can use to accomplish this objective. If you can't remember the code syntax, just Google it!
- "Don't I have to get a degree in computer science to *really* learn how to program?"
  - ***Absolutely not***. This is akin to saying "*Don't I have to get an English degree to really learn how to write stories?*". A formal education in computer science certainly won't hurt, but programming is a technical skill that anyone can learn!

Demystifying Programming Languages

- A common misconception of would-be programmers is that it can take numerous years to develop proficiency in a specific language
  - Following this rationale, it's easy to believe that learning a *variety* of programming languages can take decades
  - After all, why else do software engineers or data scientists command such high salaries?
- Learning to program is certainly not "easy", but it's also not as time-consuming as you might think:

Learning Style	Definition	Duration
Casual Learner	"I'm not in a rush, just learning at a consistent pace"	**2-3 years**
Career Advancer	"This will help me with my work"	**1-2 years**
Career Changer	"I need this to qualify for a new job"	**6 months – 1 year**
Coding Bootcamp	"I'm drinking water from a fire hose!"	**3 months**

Some industry recognized "rules of thumb" for developing programming proficiency

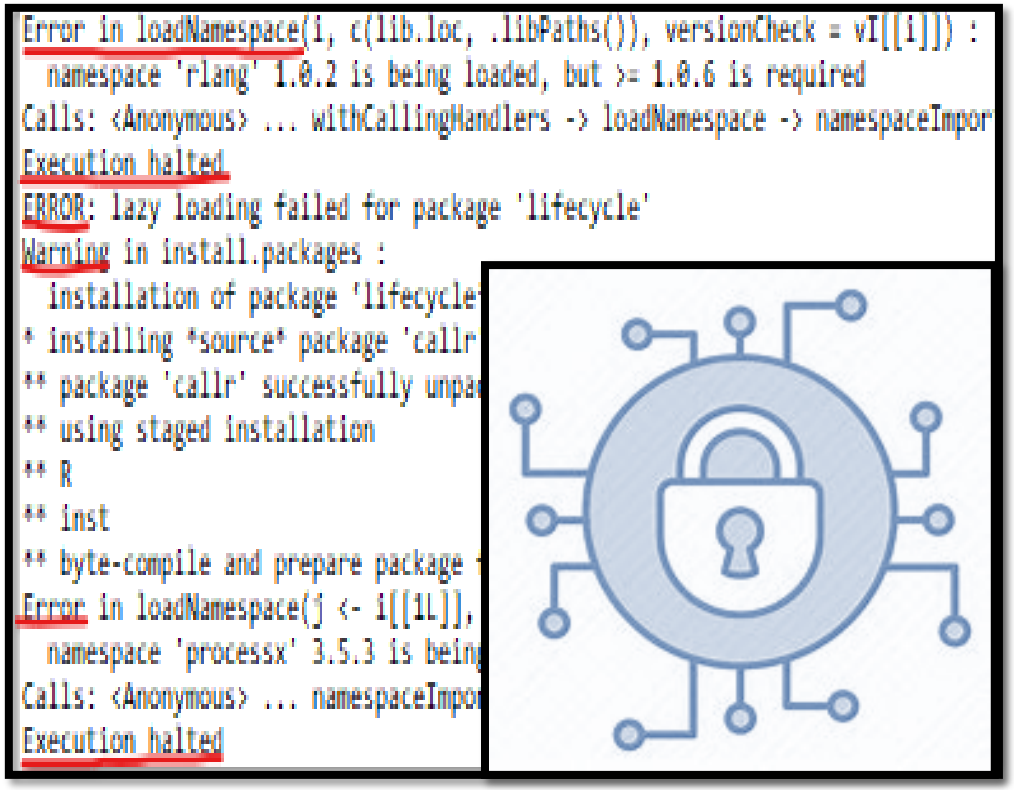
The "Problems" with Programming

Yes – Programming can be Difficult

- But… what *actually* makes programming languages difficult to learn?
- Several factors contribute to this:
  - Confusion about which learning approach to follow
  - Not understanding which available resources are relevant for you
  - Starting with a code base or a programming concept that's too advanced
  - Attempting to memorize code vs. understanding the underlying commands being executed
- In short, learning how to program can feel overwhelming!

Programming in a Secure IT Environment

- Navigating enterprise IT requirements can be a challenge
  - Software requirements for an integrated development environment (IDE) might not align with approved configurations as defined by IT policies
  - Certain open-source packages/add-ons may not be allowed, which can inhibit analysis and/or development activities
  - Similarly, enterprise IT architecture might not be properly configured to facilitate developer privileges needed for open-source data collection
- Open-source data accessibility vs. enterprise cybersecurity requirements can often be at odds



A Framework for Addressing the Problem

A Framework to Address Anxiety

Example Problem Statement:
I have unstructured data that I want to analyze and understand
I have customers that want me to “tell a story” with the data
I’m new to programming, and have anxiety around being able to use a programming language to structure the data and understand it

High Level Solutions:
As with anything, structure your approach. What is your end goal for this data?
Determine what about your problem requires a programming language vs. what can be solved through other known tools
Rely on *your* skill sets, rather than the skill sets you think your customer wants. Manage expectations – i.e., under-promise and over-deliver

Addressing the Problem

- It's important to note that not all data analysis problems call for the utilization of a programming language
  - As analysts, remember that we are ultimately responsible for developing *practical* solutions and reports, with no obligation to develop fancy models that may end up being unnecessary
  - No matter what tools you end up using, always start with a question to answer
- One common pitfall of the budding data scientist is to provide awesome data driven answers to questions no one is asking
  - Generally, it is better to have a question in search of data, then have data in search of a question
  - Your analysis should always be centered on your ability to answer a given question. Let that be your anchor
- Understanding the problem and your ability to solve it is generally agnostic to any programming language or data you can use

Tackling the Problem

Get to Work!

- Lets assume you now have a well understood question, and you have access to unstructured datasets that can help you answer it
- You may think that structuring datasets and preparing your analysis using a programming language looks something like this:

1.	Code a program to scrape the data source for relevant data
2.	Run a standard tidying script of the data (based on data structure)
3.	Run a series of standard statistical algorithms
4.	Run standard unsupervised learning algorithms
5.	Compile your results into a nicely knitted HTML format
6.	After a solid hour of work, put a lid on it
7.	Pat yourself on the back for a job well done

- Looks pretty thorough, right?
  - In practice, a lot of this may not be necessary…

Work Smart, Not Hard

- Generally speaking, a programming language is not the silver bullet for your program
  - No matter what tool you use, “garbage in = garbage out”
  - Sometimes Excel is the best tool to work with your data
- If using a programming language makes sense, other options exist to help structure and analyze large datasets more efficiently
  - Don’t reinvent the wheel! A large variety of pre-developed packages can help you run various analyses quickly and efficiently
  - Despite your proficiency in a language, your patience to code will most likely be tested. Expect roadblocks, as a majority of time spent coding involves debugging
- Regarding programming syntax, don’t dwell on what you don’t know
  - If you’re unsure about a code’s syntax, remember that Google is your friend!
  - Online communities like Stack Overflow often have an answer to your question

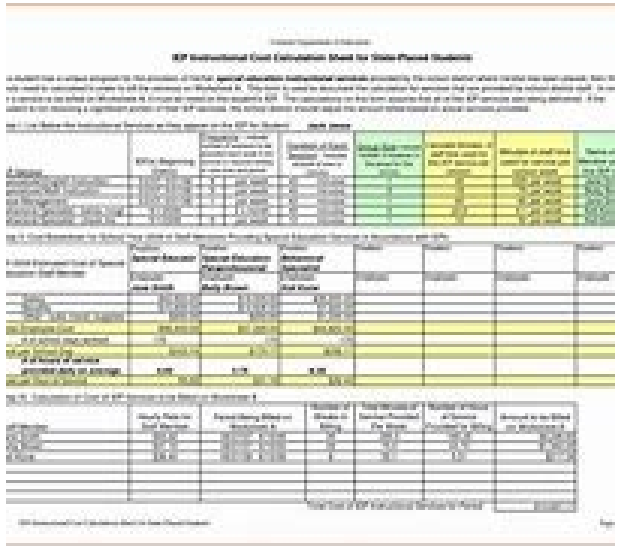
Programming for Cost Analysis

- Numerous programming languages offer similar tools for building, analyzing, and modeling datasets
  - Try not to fret over the right language to use. Again, focus on the question at hand
- Before choosing a language to use, start with a few basic steps:
  - Visualize your data. A scatterplot is worth a thousand data points!
  - Evaluate the statistics of your dataset (i.e., mean, standard deviation, coefficient of variation, R^2, etc.) to determine its usefulness
- At this point, we can choose the language that best suits our analytical requirements
  - Does data need to be structured to facilitate dynamic visualization?
  - Do we need to develop an automated model that calculates numerous iterations, and aggregate the results for predictive analytics?
  - Do we need to develop a dashboard or app that allows end-users to filter data inputs/outputs or upload unique datasets for automated analytics?

Programming for Cost Analysis

Example Problem:

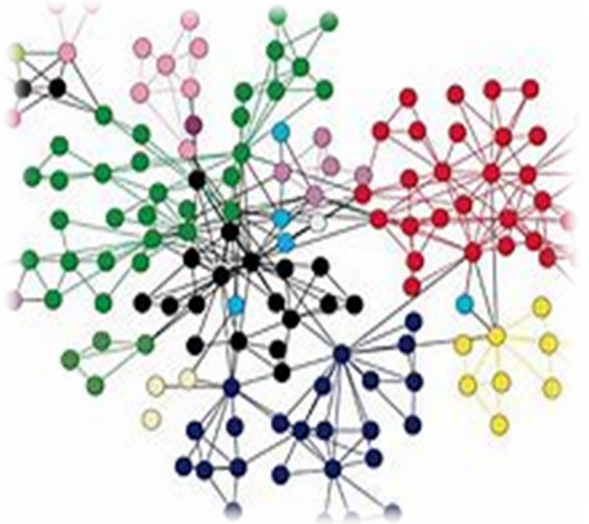
I have **unstructured cost data** on avionics components that I want to normalize and analyze. My customer wants me to use the historical data to **develop a predictive model** for future costs, complete with a risk calculation that **aggregates 5000 unique iterations** of my inputted uncertainty parameters



Programming for Cost Analysis

Example Solution – Step 1:

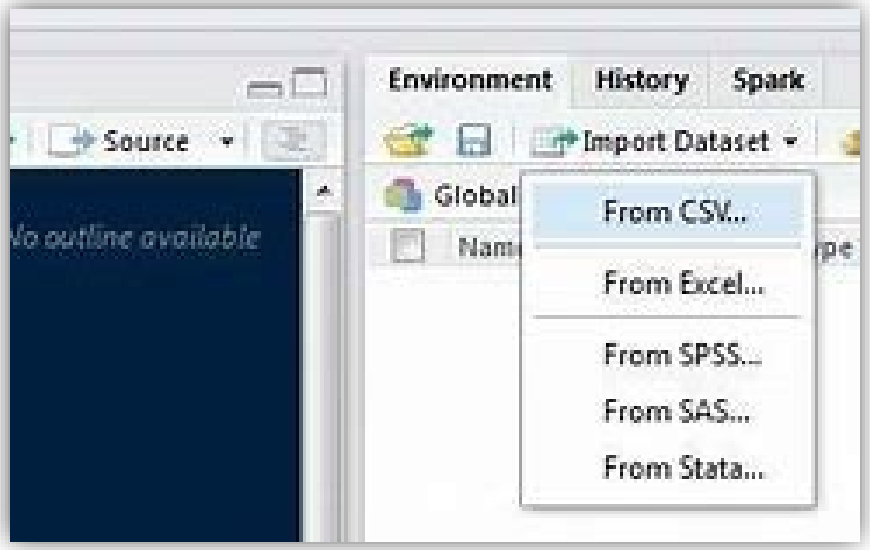
I realized I could use **Excel** to normalize and structure my data using a pivot table, which gave me a clear picture of historical component types, the year they were developed, and the associated development costs incurred

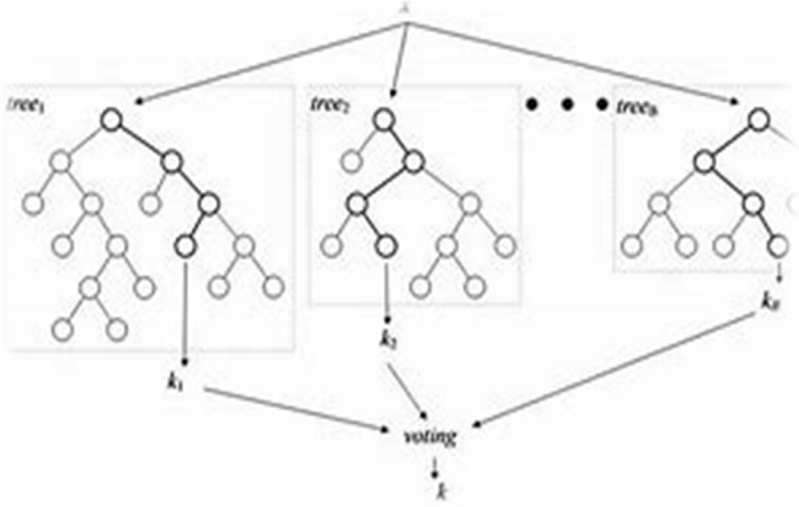


Programming for Cost Analysis

Example Solution – Step 2:

I came to the conclusion that a predictive model with 5000 automated uncertainty iterations required an algorithm too complex and time consuming for Excel. As a result, I imported my structured Excel data as a CSV file into **RStudio,** and developed an automated iteration algorithm using tools provided by R's "purrr" package

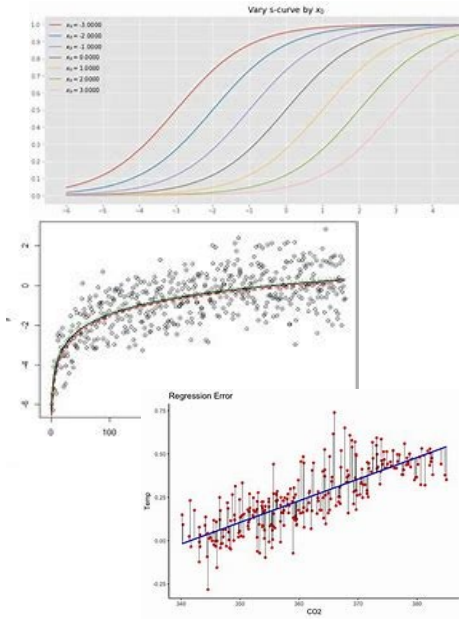




Programming for Cost Analysis

Example Solution – Step 3:

I visualized my predictive model with calculated risk using R's "ggplot2" package, but found the visualizations to be too "busy". As a result, I decided to import my R script into **Power BI** to develop a dynamic dashboard, complete with a data slicer that visually compares all child-level historical and projected avionics costs by individual fiscal years




```
1 # The following code to create a dataframe and remove duplicated rows is always executed
  and acts as a preamble for your script:
2
3 # dataset <- data.frame(Year, Quarter, Month, Day, BackupType, Database)
4 # dataset <- unique(dataset)
```

Programming Languages: Give Me the BLUF!

So Many Choices…

- We've discussed some challenges associated with learning to program, high level ways to address these challenges, and actionable steps we can take towards understanding how to incorporate programming into our analytical work
- This begs the question – ***based on my requirements, what language should I use?***
- Some related, and important, questions include:

What are the most popular programming languages?
What language is best suited for cost estimation?
What languages are my customer using and/or asking for?
Are there specific skills I need for different languages?
Which languages are open-source? Which are COTS?
Are programming languages approved/available via my enterprise IT infrastructure?

The "Quick" Answers

- There are a wide variety of programming languages, each generally comparable in capabilities yet well suited for uniquely specialized tasks
- For data analysis, the most popular are arguably SQL, Python, and R
  - **SQL** is designed for database management, analysis and reporting
  - **Python** is great for general workflow automation and machine learning
  - **R** is great for statistical analysis, modeling and machine learning
- It is important to note, however, that ***all of these languages are practical and useful***, with each featuring unique benefits and limitations
  - In addition to your objective, the decision to use one language over the other often comes down to dedicated resources, availability, and customer preference or familiarity

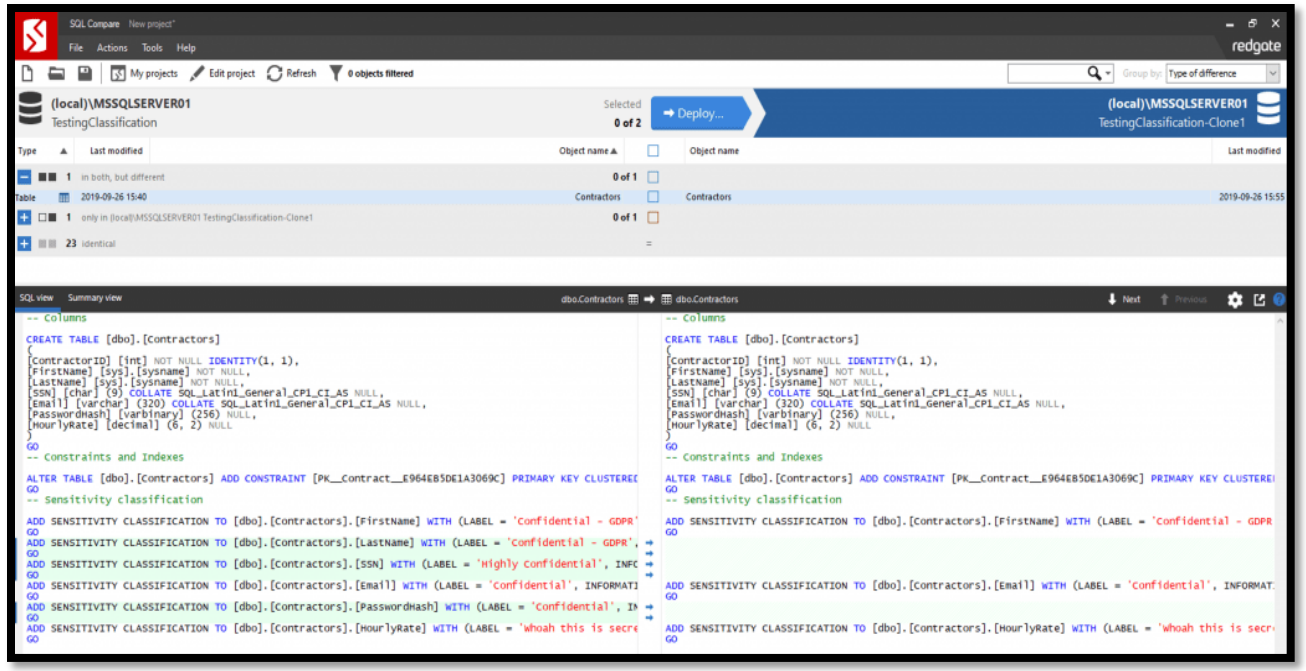
Structured Query Language (SQL)

When it comes to database management and reporting, SQL is the industry standard

- Dynamic relational databases are necessary for structuring large volumes of messy data, making a database language such as SQL very important
- SQL is a "non-procedural language". This means that it does not require the use of traditional programming logic, making SQL ***more intuitive to use compared to other languages***
- Anyone developing or managing a relational database should have proficiency in using SQL

IF/ELSE statement in SQL to check if the text string ***"Sample SQL text"*** contains the substring ***"SQL"***:

```
IF (CHARINDEX ('SQL',
 'Sample SQL text') > 0)
      PRINT 'TRUE'
ELSE
      PRINT 'FALSE'
```



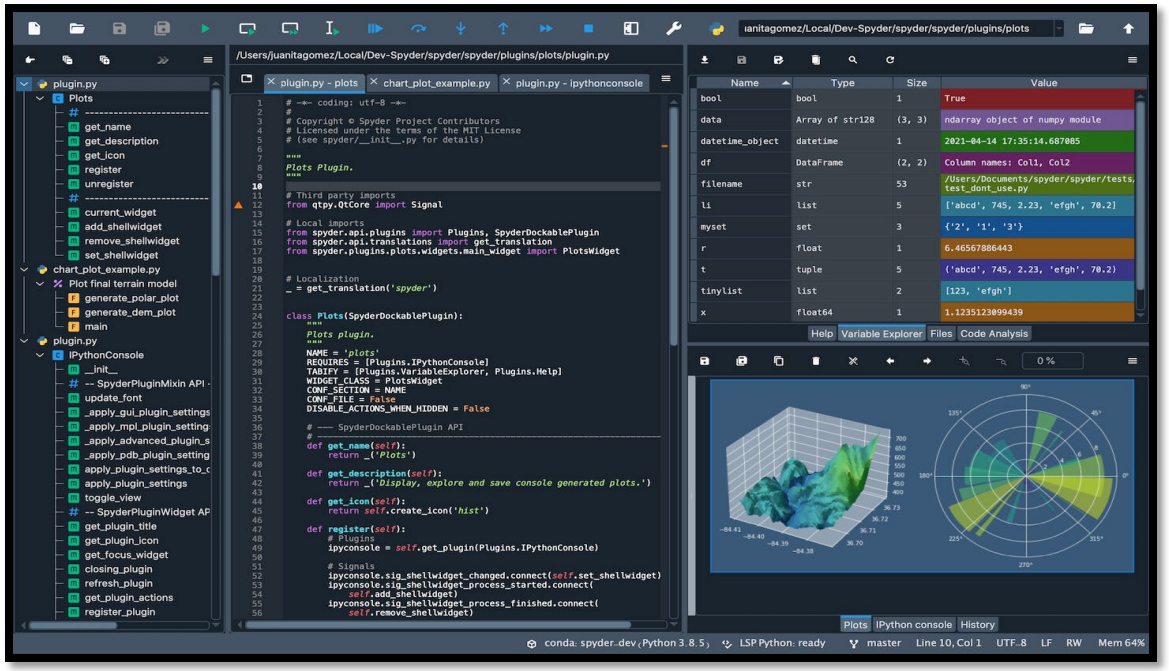
Python

Python is arguably the most popular programming language across all STEM fields

- Python is often the go-to choice for tasks ranging from software development, data engineering, machine learning, and general data analysis
- Python's appeal is in it's ***general usability, flexibility and simplicity – without sacrificing computational power***. Whether you need to develop functional software or perform predictive analytics, Python can help you
- Python is "object-oriented", meaning functions and workflows are centered around defined objects with assigned values

IF/ELSE statement in Python to check if the text string "***Sample Python text***" contains the substring "***Python***":

```
if 'Python' in 'Sample Python text':
     print ('TRUE')
else:
     print ('FALSE')
```



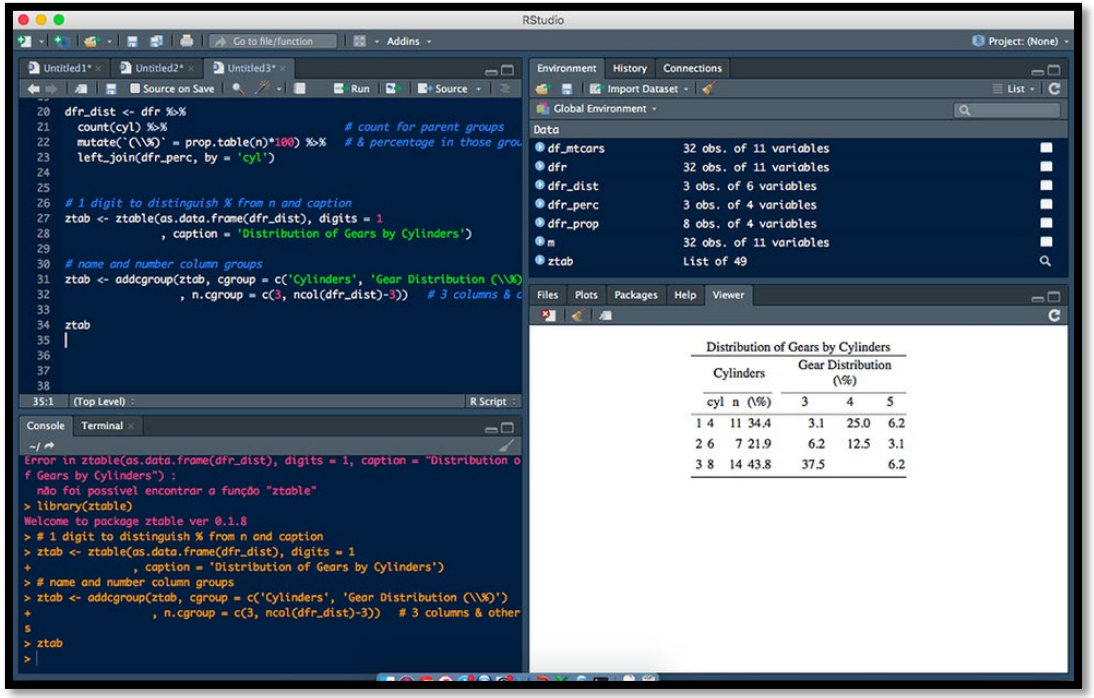
R is a comprehensive language that supercharges statistical operations

- R specializes in large and complex numerical data sets, ***especially powerful when performing statistical analysis and modeling***
- R has numerous benefits including open-source availability, large community of users, quality visualizations, as well as impressive machine learning capabilities
- R is quickly rising the ranks as one of the most popular programming languages for numerical data analysis, most popular among the mathematics, finance/economics, and medical research communities

Vectorized IF/ELSE statement in R to check if the text string ***"Sample R text"*** contains the substring ***"R"***:

```
result <- ifelse(grepl('R', 'Sample R text'),
'TRUE' , 'FALSE')

print(result)
```



Conclusion

Lessons Learned

- Learning to program can be challenging. Learning to apply programming skillsets can be even more challenging
  - ***However***, don't let this discourage you!
  - The time you dedicate to developing programming proficiency will pay huge dividends through amazing opportunities for advanced analytics and modeling
- Motivate yourself by aligning learning to the skillsets you need
  - When starting out, don't focus on trying to learn how to develop machine learning algorithms or perform Big Data analytics, as those skillsets come with time and practice.
  - You don't need to become a ML engineer if you're mainly concerned with data visualization
- Recognize small achievements that lead to growth over time
  - "Rome wasn't built in a day"
  - Don't set unrealistic goals. No one is expecting you to become a data scientist overnight!

Lessons Learned

- Learning how to work with unstructured data and new programming languages is a process
  - As you develop programming competencies, you'll gradually start to understand more advanced concepts as well as how to incorporate them into your work
  - Don't use a high stress or "hot taskers" to learn these new capabilities. Start with something low stakes, so you can take the time you need to develop a quality product
- Be mindful of your own interests and map out what you want to get out of programming
  - After all, the best way to get good at something is to enjoy the work involved
- Make sure to ask for help!
  - Don't be afraid to "suck" at something new
  - The only "bad" question is the one you don't ask. Also, search engines don't judge ☺
  - Online communities most likely have an answer to your question, especially if you're a beginner

Thank You!

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