JPMC #2 and Index Replication Optimization

AI Studio Final Presentation

Break Through Tech New York @Cornell Tech
December 15th 2022

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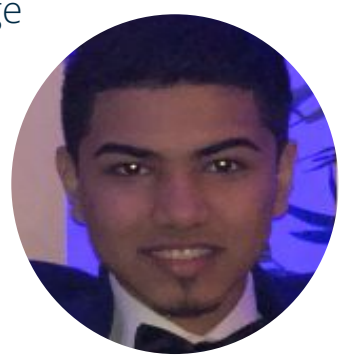

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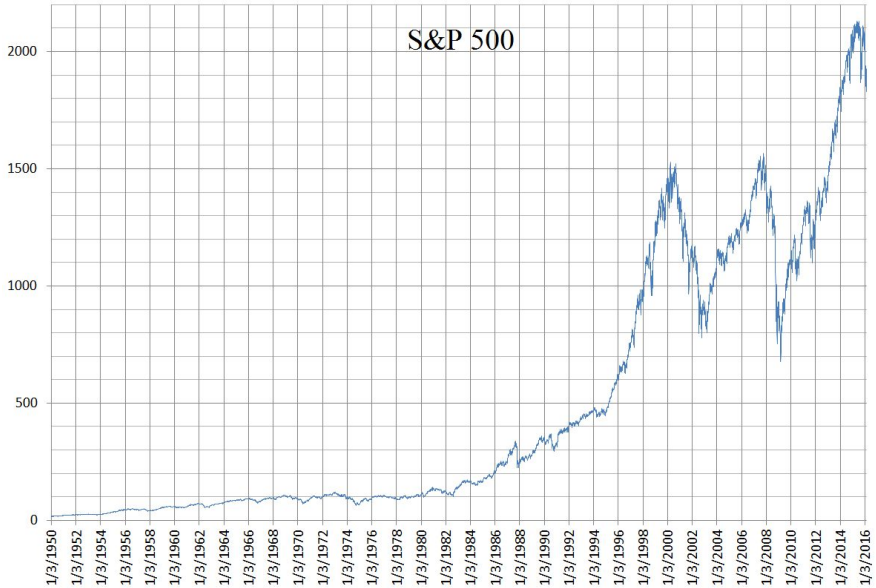
“Our goal is to create an portfolio that replicates the performance of the S&P 500 using Natural Language Constraints and Optimization techniques.”

S&P 500

- The S&P500 is a stock market index tracking the performance of 500 large companies listed on exchanges in the United States
- One of the most followed indices
- Often used as a reference benchmark

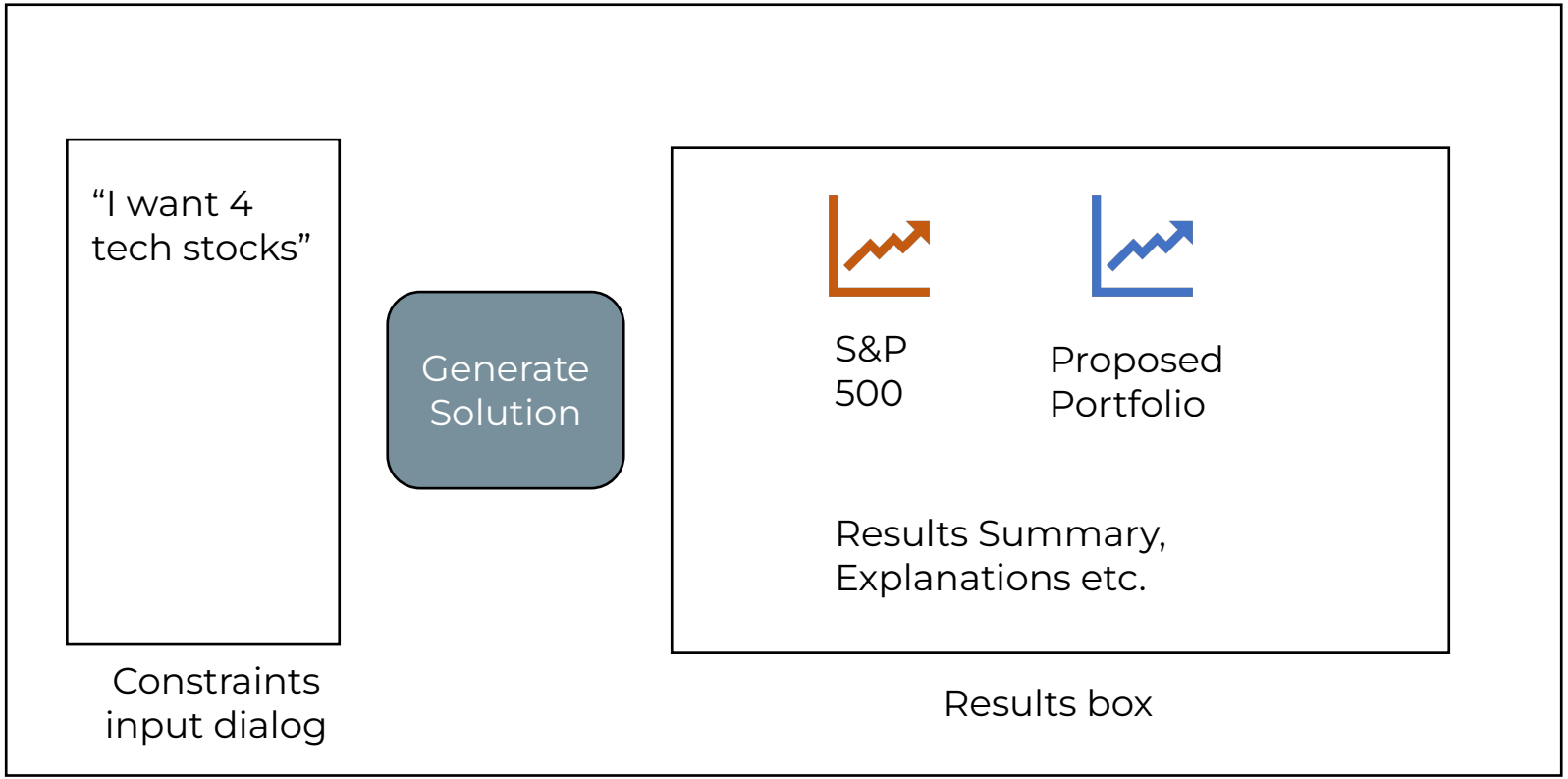
- We would like to create a portfolio to replicate the the S&P 500 performance with:

1. Less companies -> Cost reduction
2. Arbitrary constraints -> User preferences



**historic price movement of S&P 500

Goal


"I want 4 tech stocks"
Generate Solution
S&P 500
Proposed Portfolio
Results Summary, Explanations etc.
Constraints input dialog
Results box

Outcome

User Input:

i want 5 tech stocks

GENERATE SOLUTION

Proposed Allocation

Company	Weight(%)
AAPL	20
ORCL	20
AVGO	20
MA	20
AKAM	20

Correlation to S&P500: 0.9257449380895086

Total Portfolio Return: 75.09%

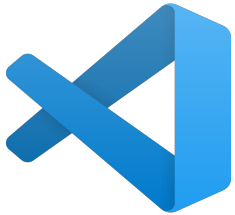
Total S&P500 Return: 46.2%

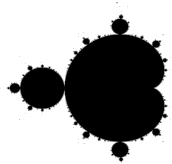
Plan

Task	W1	W2	W3	W4	W5	W6	W7	W8
Create Working Groups								
Get Familiar with Python Libraries and **Data**								
Structure from Natural Language Constraints								
Build, Merge and Compute Similarity between Time Series								
Build MILP **Model**								
NLP and Optimization **Integration**								
Dashboard Integration								

All team members NLP group Optimization group

Resources

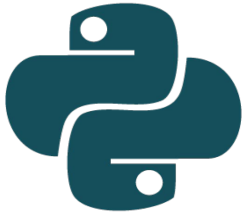




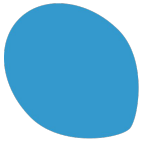
TextBlob

NumPy

plotly



NLTK



Natural Language Processing

The goal of the NLP portion is to extract 3 constraints out of a sentence:

- Number Constraint (3)
- Mathematical Constraint (<=, >=, >, <, =)
- Sector Constraint (Technology, Energy, etc.)

Example Inputs:

- "I want to invest in ***at least 3 tech*** companies" <- 3 (number); >= (mathematical); tech (sector)

Extract Number Constraint

```
def extract_number(inp):
  res = re.findall(r'\d+', inp)
  if len(res) > 0:
    res = [int(res[0])]
  #if it comes here that means the input doesn't have a numeric form and probably word format
  if not res:
    for w in inp.split():
      if not res:
        try:
          res = [w2n.word_to_num(w)]
        except:
          res = []
  return res
```

Extract Mathematical Constraint

```
def extract_mathematical(inp):
  #dictionary of key words for inequalities
  d = {
      "=": ["only", "exactly"],
      ">=": ["at least", "minimum", "no less than", "no fewer than", "greater than or equal to"],
      "<=": ["at most", "maximum", "no more than", "not above", "does not exceed", "less than or equal
to"],
      ">": ["more than", "exceeds", "over", "above", "greater than"],
      "<": ["under", "below", "fewer than", "beneath", "less than"]
    }
  res = []
  for key, value in d.items():
    for w in value:
      if w in inp.lower():
        res.append(key)
  return res
```

Extract Sector Constraint

```
def extract_cat(inp):
  sectors = {
      'Industrials': [],
      'Health Care': [],
      'Information Technology': ['technology', 'tech', 'game'],
      'Communication Services': [],
      'Consumer Staples': [],
      'Consumer Discretionary': [],
      'Utilities': [],
      'Financials': ['bank'],
      'Materials': [],
      'Real Estate': [],
      'Energy': ['green', 'green-energy', 'energy']}
  res = []
  #the parts of speech we want to extract
  pos_wanted = ["NN", "JJ", "JJS", "JJR", "NNS"]
  words = nltk.word_tokenize(inp)
  #tag words with their part of speech
  tagged = nltk.pos_tag(words)
  for word,pos in tagged:
    if pos in pos_wanted and ps.stem(word) != "stock" and ps.stem(word) != "compani":
      for key, val in sectors.items():
        if word.lower() in val:
          res.append(key)
  return res
```

Word2Vec Model

```
model = Word2Vec(sent, min_count=1,size= 50,workers=3, window =5, sg = 1)

model.similarity('Health Care', 'Industrials')
-0.23644204
```

Optimization

Purpose: Understanding our clients needs by taking their numerical and sector constraints from our NLP side, and using them to return the most optimal portfolio (most similarity to S&P500 and best returns)

Example:

- Portfolio 1 (Apple, Tesla, Microsoft) → 70% similar to S&P500 | 50% return
- Portfolio 2 (Google, Palantir, Meta) → 60% similar to S&P500 | 30% return

General Steps For Optimization:

1. Compute log returns of daily stock price
2. Create a correlation matrix of the log returns of each stock
3. Feed correlation matrix into K-Means algorithm to give us the best stocks
4. Creating a portfolio of stocks given market cap weighting

Computing Log Returns

“A sequence of data points that occur in successive order over some period of time.”
- Investopedia

- Computing Log Returns is not only an industry standard but is essential in creating the correlation matrix for our stocks.
- Calculate the log of returns: ***Log((Closing Price (Day2) - Log(Closing Price (Day 1))*** plotted over a course of a 2 year period.

Computing K-Means

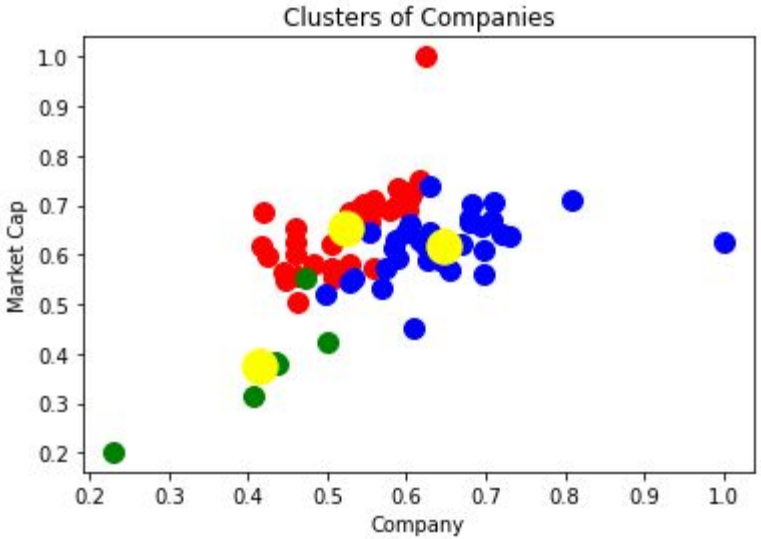
How do we manage to output the highest valued companies from each industry?

K- means: Based on a graph with clustered data points, and using a specific distance formula calculate similarity.

- Works best with scattered data
- Created clusters for each industry and returned the stock with the highest market cap from each cluster.

Computing K-Means Continued

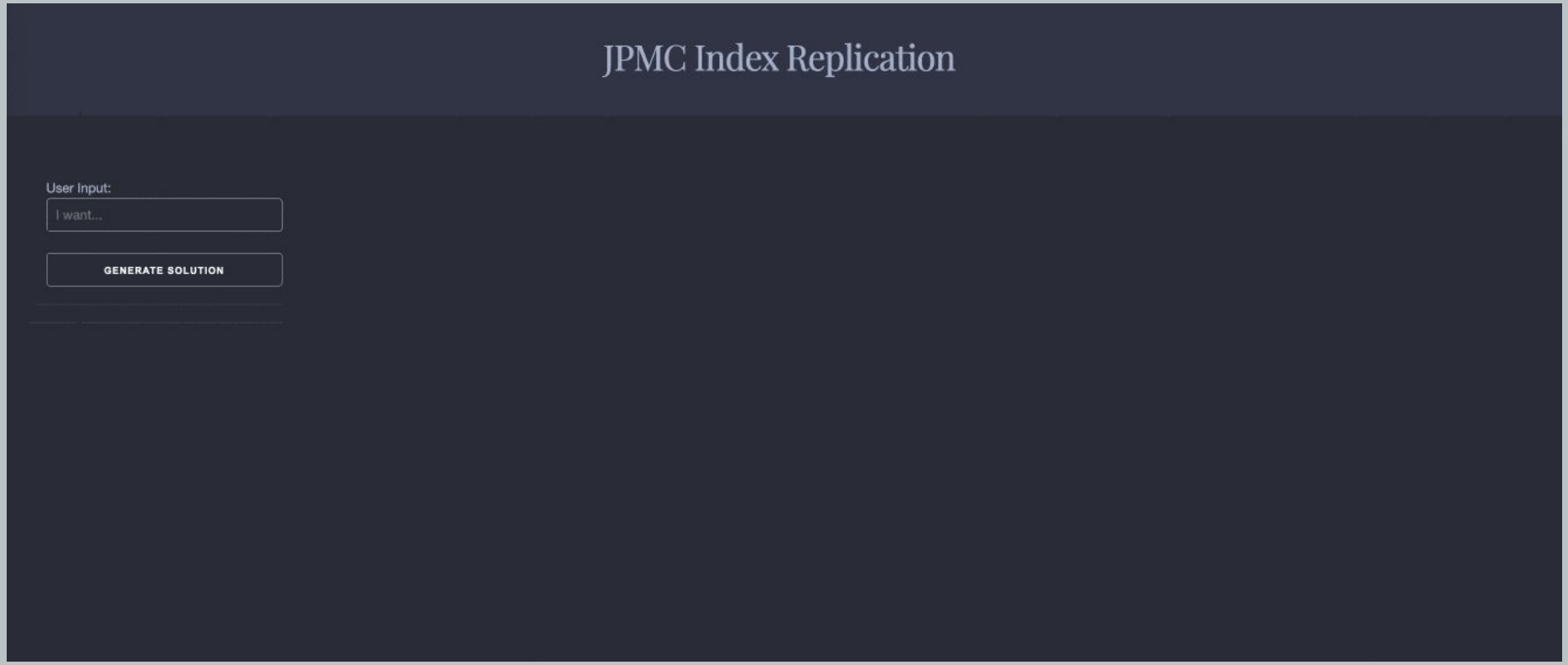
- Each cluster is directly correlated to the number constraint given to us by our client. And will be the number of stocks our k-means algorithm returns.
- The centroids are denoted by the yellow circles. Which basically signifies the center of each cluster.



Optimization Model

```
def optimization(mth, sector = "Information Technology"):
    df = pd.DataFrame()
    #initializing the resulting list of companies
    res = []
    #creating the matrix based on sector
    matrix = create_matrix(sector)
    #this gives us the list of companies within the matrix
    companies = matrix.index.tolist()
    df.index = companies
    #pulling all values from matrix correlation
    X = matrix.values
    #fitting Kmeans model and using math constraint as the number of clusters
    kmeans = KMeans(n_clusters = mth).fit(X)
    df['cluster'] = kmeans.labels_
    for i in range(mth):
        cluster_companies = df[df.cluster == i].index.tolist()
        filt = mkdf[mkdf['Symbol'].isin(cluster_companies)]
        maxx = filt['marketCap'].max()
        res.append(filt[filt['marketCap'] == maxx]['Symbol'].tolist()[0])
    return res, df
```

Demo


JPMC Index Replication
User Input:
I want...
GENERATE SOLUTION

Future Improvements

- **Input:** NLP model to handle more complicated sentence structures
- **Data Processing:** Automate data collection/processing via API
- **Model:** Find/test other ML models to improve optimization process
- **Frontend:** Improve UI/UX of dashboard, incorporate more features (buttons, charts, layout etc.)
- **Code:** Clean up code for more readability


Questions?