**Buzz S&P500**

Cheng Chen

Ruikang Liu

Puran Zhang

Wenting Zhao

**Introduction and Project Goals**

Nowadays we have seen plenty of stock trading/research apps/sites around the internet but there is no place for us to keep track of only stocks in SP500, the most important index of large cap growth stocks, and dive deep into the sectors and stocks in it. Our Buzz S&P web app is designed for people who are interested to know the detailed composition of the SP500 index and the daily and historical movements of all these stocks, which should be a useful resource for entry level investors who are interested in this topic.

The website will offer an overview of the SP500 composition and provide insights about performance of different sectors and different stocks, you can click into each stock to review its historical performance in any time intervals in the past several years, the key metrics that demonstrate its financial performance and operational performance. There will also be some benchmarking algorithm that shows how this stock performs comparing with the overall market average and the sector average.

Our group members include Cheng Chen, Ruikang Liu, Puran Zhang, and Wenting Zhao.

**Technology**

Our project used a React as our front-end framework and Node.js as our back-end framework. We stored our data in AWS server, and used MySQL to build queries in the back end to retrieve data we need for calculation or display on the pages.

Data processing: Python

Frontend/Backend: React/Node.js

Database: AWS RDS MySQL

**Data**

We used Yahoo Finance API as our data source, and extracts all historical stock data of SP500 stocks for the past three years and populate to our database in AWS.

Yahoo Finance API:

Description: API that contains stock price information and company information.

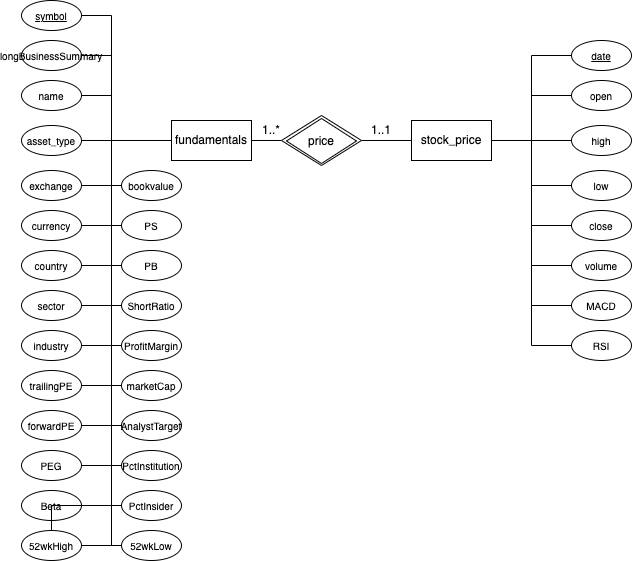
Link: https://github.com/ranaroussi/yfinance

We have done careful and detailed screening on the data. This data has a few tables that can be used across the board. However, it is not clean and contains duplicated variables. As an open-sourced version, this data governance of this tool is not well implemented. Therefore, we have to evaluate the variables and do some cross check with data from other sites so that we can confirm on the availability as well as sanity. Initially we are using AlphaVantage which is more commercially and as a result, it is better in terms of the quality. We choose to move away from it because the high cost of such usage.

We also calculated some fields (technical indicators) directly in our python script as it will complicates the processes if we have to find the data source. It is a better approach as we can control the logic and not to create additional dependencies on the data quality and data availability. It is also more maintainable in the long run.

**Database**

We built two tables, one for stock price metrics, which includes daily prices for all SP500 stocks over the past three years, and another one for stock fundamental data, which includes company info and financial metrics, etc. The price table contains more than 1,200,000 instances and the fundamental contains around 500 instances. ER Diagram is as below (attributes of each tables are a subset version):



**Description of System Architecture**

Below are descriptions of our Buzz S&P500 web pages with information about what the respective pages accomplish:

*Home Page:*

Our home page provides some up-to-date summary information of stock markets as a snapshot. Showing S&P500, Dow, Nasdaq these three major market indices at the top of the page brings a quick overview of the market to our investors. Next, it displays the stock price change trend over time via a line graph, where the user could select different date ranges by dragging the slider below the chart. Also, when the user moves their mouse to a point in the graph, it will immediately show the close price for that trading day. Additionally, there is a Sectors chart at the bottom to share the percentages of both 1-day and 10-day price change at various sectors.

*Stock Page:*

Our stock detail page presents a profile of a certain stock over a specific period with price/volume trendlines. We also provide a brief introduction of the underlying company with several key metrics of fundamentals, which contribute to the company’s value or worth as a business. Investors could also take a look at the price details overtime in the chart at the bottom with customized sort criteria.

*SearchStocks Page:*

Our SearchStocks page as a stock screener provides a tool that allows investors and traders to quickly sort through over five hundred available stocks according to the investor’s own criteria. By selecting a set of parameters, this page makes investors be able to find those stocks which fit their own methodologies, and benefits both longer-term and short-term traders. Furthermore, it will direct investors to the stock detail page by clicking a certain ticker name in the chart.

*MarketView Page:*

Our MarketView page…

**Queries**

For the stock detail page:

The most sophisticated query is the Stock\_Outperformance Query:

WITH target AS (

SELECT p.Symbol, f.Sector, p.Change,p.Volume, AVG(p.Change) OVER() AS avgChange, AVG(p.Volume) OVER() AS avgVolume

FROM Price p JOIN Fundamentals f ON p.Symbol = f.Symbol

WHERE Date = (

SELECT MAX(Date)

FROM Price

)

),

compute AS(

SELECT f.Sector, AVG(p.Change) AS sectorChange, AVG(p.Volume) AS sectorVolume

FROM target p JOIN Fundamentals f ON f.Symbol = p.Symbol

group by f.Sector

)

SELECT t.Change, t.Volume, t.Change - cp.sectorChange AS beatBySector, t.Volume - cp.sectorVolume AS beatVBySector, t.Change-t.avgChange AS beatByAll, t.Volume-t.avgVolume AS beatVByAll

FROM target t JOIN compute cp ON t.Sector = cp.Sector

WHERE t.Symbol = '${symbol}';

This query is used to calculate for each stock, how did it perform in price movement and in active trading volume comparing with the average of the overall market and average of stocks in the same sector it belongs to. With this query, we show these metrics in the benchmarking section in the stock detail page when user checking into a specific stock.

For the landing page:

The most advanced query is the sector performance table.

WITH a AS (  
 SELECT symbol, date, p.close, p.change,  
 ROW\_NUMBER() over (PARTITION BY symbol ORDER BY date desc) as rk  
 FROM Price AS p  
 WHERE DATEDIFF((SELECT MAX(Date) FROM Price), date) <= 20  
 ), b AS (  
 SELECT a1.symbol,  
 a1.change AS d1\_change,  
 (a1.close-a2.close)/a2.close AS d10\_change  
 FROM a AS a1  
 INNER JOIN a AS a2  
 ON a1.symbol = a2.symbol  
 AND a1.rk = 1  
 AND a2.rk = 11  
)  
SELECT f.sector,  
 CONCAT(ROUND(100 \* AVG(b.d1\_change), 3), '%') AS d1\_change,  
 CONCAT(ROUND(100 \* AVG(b.d10\_change), 3), '%') AS d10\_change  
 FROM Fundamentals AS f  
 INNER join b  
 ON f.symbol = b.symbol  
 GROUP BY f.sector;

This query is to compute the one-trading-day and ten-trading-days performance of each sector. This is used as an overview in the landing page in order to show the trend based on sector. For example, usually when oil or gas prices go up, it is very likely that energy sector will see an increase gradually. Also, when money tends to go to tech companies in recent days, that will show that technology sector is comparatively more bullish. Similarly, when fed rate goes up, the financial services sector might see a gradual jump too.

For the search page:

The most complicated query is the search result table.

WITH temp AS (

SELECT p.Symbol, p.Close AS Price, p.Change, p.Volume

FROM Price AS p

WHERE date = (SELECT MAX(Date) FROM Price)

), MC AS (

SELECT m.symbol,

CASE

WHEN m.marketCap between 0 and 2000000000 THEN 'SmallCap'

WHEN m.marketCap between 2000000000 and 10000000000 THEN 'MidCap'

WHEN m.marketCap between 10000000000 and 100000000000 THEN 'LargeCap'

ELSE 'MegaCap'

END AS size

FROM Fundamentals AS m

)

SELECT row\_number() OVER (ORDER BY f.symbol) NO,

f.symbol AS Ticker, shortName AS Company, sector AS Sector, industry AS Industry, country AS Country, size AS Size, ROUND(f.marketCap, 0) AS MarketCap,

ROUND (trailingPE, 2) AS PE, ROUND (Price, 2) AS Price,

CONCAT (ROUND (100.00 \* temp.Change, 2), '%') AS 'Change',

ROUND (temp.Volume, 0) AS Volume

FROM Fundamentals AS f

INNER JOIN temp ON temp.Symbol = f.symbol INNER JOIN MC ON MC.Symbol = f.symbol

ORDER BY f.symbol;

This query is a subquery of filtering certain stocks with investors’ own criteria. Since there is one field about market capital in the original dataset, I add a temporary table with “case…when…” by grouping stocks into 4 categories based on their market capital size. Therefore, our users could pick the size they like in the drop-down list instead of manually enter a specific number for the market capital field.

**Performance Evaluation**

In stock detail page, for the query of stock performance benchmarking, we originally split the calculation into multiple queries, for example, there was one query designed for stock performance in price movement vs market average, and another one for stock performance in price movement vs sector average, and similar two queries for volume change comparison. Each of these four queries have a complex structure of joins and temporary tables, which in turn makes the stock page loading very slowly, on average around 10 seconds to display all metrics because these four metrics requires four queries to run sequentially. Then we noticed that we can actually combine these queries into one, because for the comparisons of volume and price change, we can actually apply one query with just two more attributes to get the calculation for both at once. And for the comparisons of sector and overall market, we can still use temporary table to do the aggregation for sector but for overall market we can simply use OVER() to perform the aggregation in the original table, thus saved our time to run another query on the same page. In this way we combined the original four queries into one, and the stock page now can be loaded in less than 2 seconds on average.

In the example of 1-day and 10-day query, we do some optimization to eliminate the intermediate data that is used. Since stock doesn't simply trade on calendar days, we cannot simply do the calculation to get 1 day and 10 day directly through date. We need to order the date information and get row number of each so that we can compare. Note that there is an optimization that we do in the common table expression of "a", so that it will only do the sorting to a reduced amount of data (because we filter on the date in the where clause since regardless of what, it is guaranteed that any 10 trading days is within 20 calendar days). Therefore, by doing this the sorting cost will be significantly reduced. This small change alone helps reduced 50% the total query time, from 7s 500 ms to 1s 600 ms on average. We are just using 2,500 trading days, which is a little more than 10 years historical data. However, if we want to store the entire history, and a significant proportion of stock would have more than 40 years of historical, this would mean an even larger query time improvement, considering the sorting is nlog(n) operation.

In the stock search page, we firstly used \* in the SELECT statement when displaying the result table since we wanted to show stock information as much as possible to users. However, the result table was too wide to be showed within one page width without cutting some digits. By specifically adding the names of columns in the query, not only do we generate a nicer table with key fields for investors, but also dramatically save time of getting response and achieve a better query performance. The runtime is decreased to 3 seconds from 5 seconds on average.

**Technical challenges**

When we are building the stock price table and charts, one of the key obstacles is formatting of the data, since most of our original data is in float, when we display the result directly in the page, it does not look professional because the numbers are either large without comma separated, or percentage shown as too many decimal places. But when if we change data format in the source or back end, it will cause a problem that the front-end functions may not be working, for example, sorting in table, display of charts, etc. Therefore, we figured out that we should do the formatting in the front end, we researched a lot and finally found a solution to use toLocaleString() method to format our data in the front end so that we can display our data and charts in any format we need for the scenario without conflicting with the sorting and chart functions.

One technical challenge on the data is that we spend lots of time on collecting the data. In the beginning, we are trying to use a stock API provider which is called AlphaVantage. However, the free tier only limits to 500 requests per day and 5 requests per minute. Think about it, if we do this with a single IP, it means 100 minutes for each type of API for all S&P 500 stocks. And we just need to use 5-6 types of API. This is a great limitation for us as we need to get different data (meaning different API calls) for each of the 500 stocks. Since we are a group of four, technically we can call 4 API per stock. If we don’t try to abuse that system, which we should not do as well, we can ask our friends’ help too. But this would create a lot of dependencies and inflexibility for the project, and it is not what it should like for sure.

We try this way in the beginning, sometimes we didn’t manage the pace well so it will return empty result and we have to implement new functions, just to detect and rerun the data fetching job. We cannot simply rerun everything because we have a limitation on the speed as well the total quota. Even like that, our IP was blocked by the system.

So later on, even though we have built lots of abnormal value detection and retry functionalities, we decide to turn to open-source packages for help. That significantly reduce the workload. The downside is that we have no guarantee on the data quality because it could be considered as a free version which is not supervised by some profitable institution, and we have to do lots of screening on the data quality because it has many data variables that are overlapping with each and some of them have poor quality.

When we work on the stock search page, we must consider a tradeoff between the volume of information within one page and user-friendly characteristic. If we include more rows with more stocks within one page, users could click “next page” less time to browse all target stocks. However, it will make user harder to see the criteria they apply on the top of the page. We tried some ways like showing only 5 rows per page or fixing the criteria parts, but the page still looked clumsy. In this dilemma, we come up with an idea by adding a “Top” button at the right-lower corner of the page. This "scroll to top" button will become visible when the user starts to scroll the page. Besides on the stock search page, we apply this button to all our 4 web pages. It does improve user experience and make our webpage look more professional.