Evolution of Smartphones

Group 8

Dashboard

SDU

Team member's info:

Student	Mail
Berkan Kütük	Bekut20@student.sdu.dk
Daniel Smidstrup	Dasmi20@student.sdu.dk
Valon Morina	Vamor20@student.sdu.dk
Victor Andreas Boye	Viboy20@student.sdu.dk

Course Information:

Course ID: T520040101
Course Lecturer: Parisa Niloofar
Delivery Date: 18/12-2022

Abstract

Smartphones have become an integral part of daily life. The whole point of modern technology is to make life easier, and smartphones play a significant role in achieving this goal. Today, smartphones serve as personal assistants, media of entertainment, event organizer, etc. While this was not the case 20 years ago, the evolution of smartphone technology has been rapid and significant.

This report examines the evolution of smartphones from 2003 to 2022. To better understand this evolution, we have considered 7 key questions and created a Shiny app to visualize the data.Through this analysis, we aim to provide insight into how smartphones have evolved over the years.

Our findings indicate that the number of smartphones released each year has increased over time, with a peak of 367 phones in 2015. However, the number of smartphones released has declined in recent years, with only 125 phones released in 2021.

Furthermore, we have gained insight into some of the correlations between certain specifications of smartphones. To show these correlations we have created some animations shown in the dashboard.

In conclusion, our study provides an understanding into the evolution of smartphones over the last two decades.

1. Background and Motivation

We chose to study the evolution of smartphones because of our shared interest in this technology and its impact on our daily lives. The evolution of smartphones has been remarkable, with significant advancements in features, design, and functionality over the past years. Our dataset goes all the way back to 20 years ago when phones looked completely different and weren't smart. We have gone from being able to only make calls, pressing buttons several times to bring up a single letter and playing snake as the only game to very powerful computers, which most of us find hard to live without. Today we can easily carry out everyday tasks, such as browsing the internet, navigating to specific locations, internet banking, social media, and paying for goods and services. Therefore for us, working with the evolution of smartphones is exciting, as technology has changed significantly.
We hope that this report can give us an insight into how this evolution has helped drive this change in how we use our mobile devices today.

2. Project Objectives

The overall project objective is to see how smartphones have evolved over the years, by looking at some key features of every model released since 2003. For this, some questions were made in order to make it clear what we wanted to achieve by visualizing and comparing some of those features with each other:

1. Are more Phones being released each year?
2. Are new models released in any specific month?
3. How does screen size relate to battery size?
4. Does Front camera evolution follow primary camera evolution?
5. Which processor brand is the most popular?
6. Which OS is the most popular among all the released models?
7. How have phones evolved over time(mean values)?
    a. Display size, Battery capacity, average battery resolution, OS market share

3. Data

3.1 Data Information

The name of the dataset used for the project is “Smartphones Historical Data” and includes technical specifications for smartphones in the past 20 years. The dataset was found on Kaggle. Kaggle is a website with a huge collection of all kinds of datasets that can be used by everyone. Our specific dataset can be found here: https://www.kaggle.com/datasets/pranav941/evolution-of-smartphones

3.2 Dataset Description

The dataset has 4432 unique entries and 14 technical specifications which are sorted after brand names by default. A list of these specifications alongside their parent category can be seen in figure 1 below:

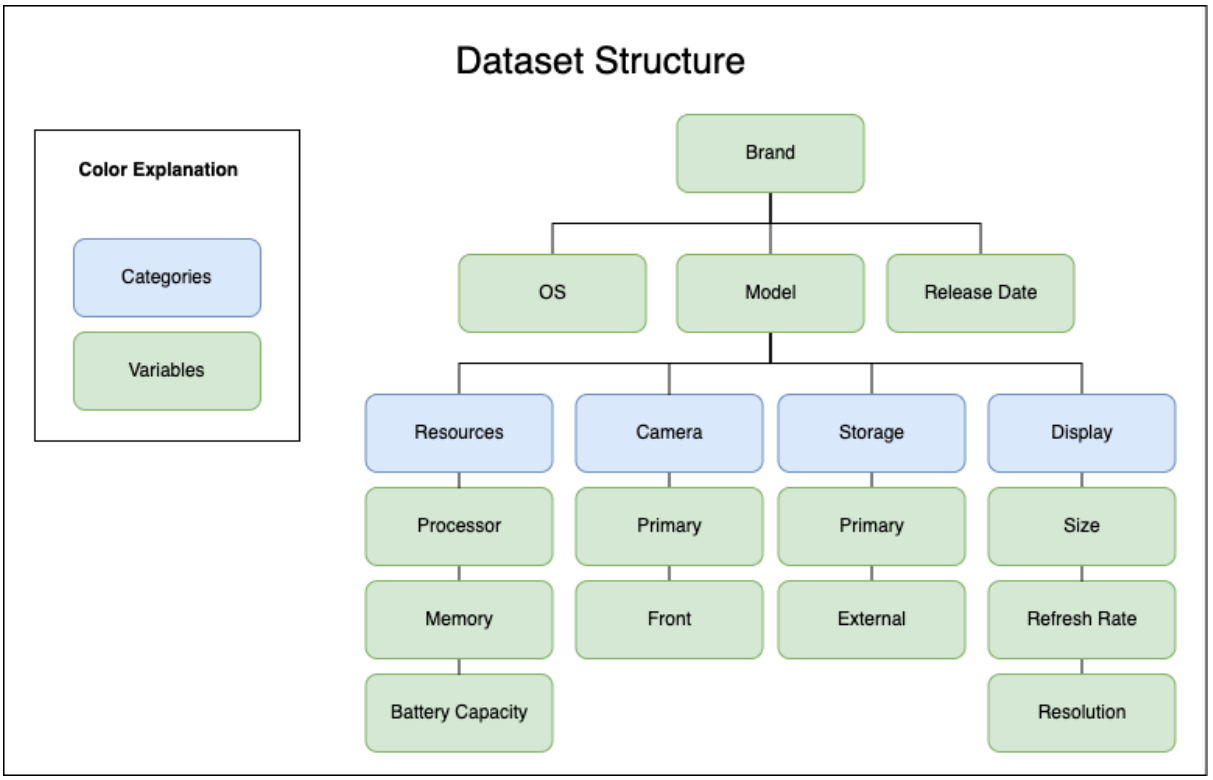


Figure 1: Diagram showing the Dataset structure.

The green boxes in the figure represent all the attributes(columns) in the dataset, which are called variables to make it easier to work with. The type of each variable has been identified and listed in the table below.

Table 1: Table showing the variable types in the dataset

Variable	Type
Brand	Categorical, Nominal
OS	Categorical, Nominal
Model	Categorical, Nominal
Release Date	Numerical Continuous
Processor	Categorical, Nominal
Memory	Numerical Discrete
Battery Capacity	Numerical Discrete
Primary Camera	Numerical Discrete
Front Camera	Numerical Discrete
Primary Storage	Numerical Discrete
External Storage	Categorical, Nominal
Display Size	Numerical Continuous
Display Refresh Rate	Numerical Discrete
Display Resolution	Categorical, Ordinal

3.3 Data Processing

Some of the data in the dataset had to be cleaned up since the format or the values were empty. One of those was the release date, which could have up to 5 different types of formattings:

1. Nov 01, 2015
2. Nov 2015
3. November 2015
4. 2015
5. Null

In order to achieve a common format, a cleanup and date formatting script were made in Python. This ensured that the dataset only could have two values which are a date and a null value. The downside of this method is that smartphones that only

had a release year before the formatting would be defaulted to have a release date of the 1st of January that specific year. To get around this issue, another date formatting could be done, so the figures/diagrams only used the release year and not the day and month to show the data.

To achieve the wanted format, a loop was made to check for one of the aforementioned five formats. If the loop evaluated an entry as empty, the string N/A would be appended. Otherwise, if the loop finds a date, then it would perform a cleanup in order to get a common date format.

4. Visualization/Dashboard

We wanted the dashboard to be easy to overview and one of the ideas to achieve this was to have different pages with a focus on one or two questions per page and giving each page a relevant title. This meant that we decided on a navbarPage.
We also wanted to make sure the dashboard is easily readable for all people, which meant that we chose the color scheme “Paired” from RColorBrewer, as it is a colorblind friendly color scheme[1].

For the first page, “Yearly Releases”, we started by making a horizontal bar chart showing the number of phones released by each brand. This bar chart was chosen because it uses length as the visual channel, which is very accurate from actual intensity to perceived intensity[2].
This chart has a slider input allowing the user to choose which year to see releases from. The user can also choose to highlight a specific brand to easily follow the evolution of a brand, or check a checkbox to see the total number of phones released by the brand up until the selected year. This chart and the input for it can be seen in Figure 2.

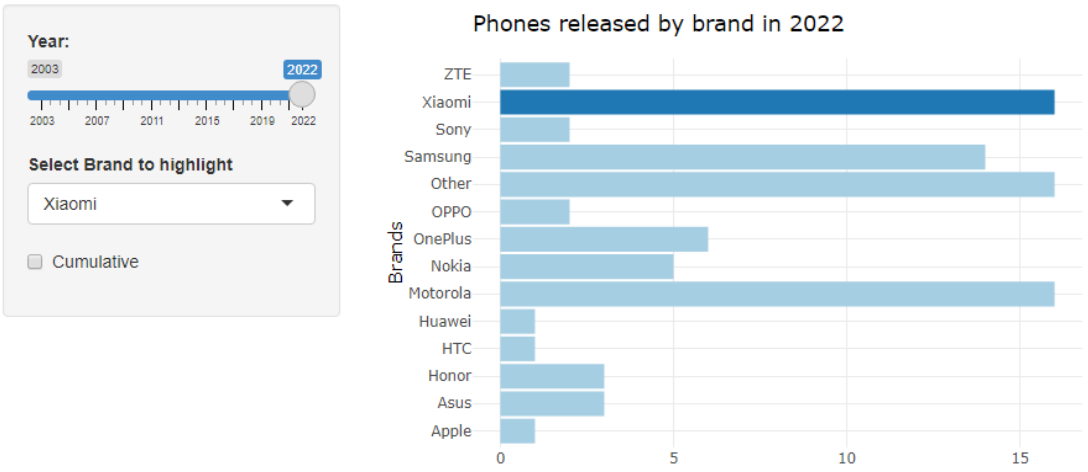


Figure 2: Horizontal bar chart showing releases by brand in 2022 and input box for the chart.

Next, we added a calendar heatmap to the page. This was to answer our question about whether or not there were any release patterns by brand. The user can choose a brand with the same selection box as the horizontal bar chart, making the page more cohesive.

We chose a sequential color scheme for this so that it is easy for the user to see a low value compared against a higher value[3]. Finally, for the page, we also added a line chart to show the releases over time. The chart can also be changed with the same input panel. This line chart is hoverable to allow the user to get a more precise view of how many phones were released in a specific year. These two charts can be seen in Figure 3.

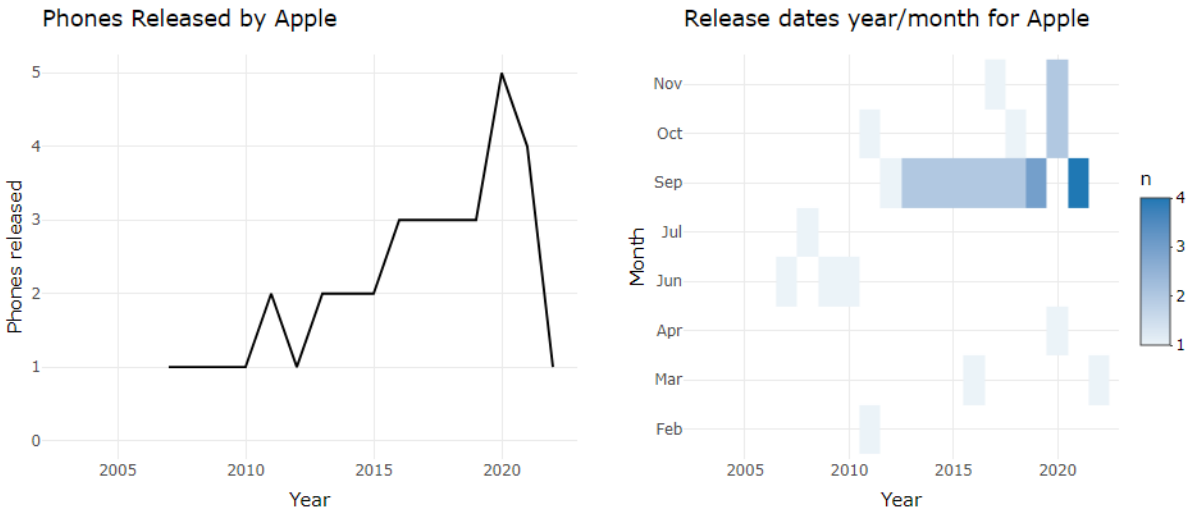


Figure 3: Line chart showing released phones by Apple per year(left) and a calendar heat map showing released phones by Apple(right).

For the second page we also wanted to have some animations to better visualize the

evolution to the user. We decided on two scatterplots with a trendline that are animated by the year. The first scatterplot shows the correlation between display size and battery size, and the second scatterplot shows the correlation between the primary camera resolution and the front camera resolution. The animations are synced so that they start and restart at the same time, allowing the user to better keep a grasp on the timeframe for the animations. The trendlines for the graphs aren't there to show the overall evolution of smartphones but rather the evolution of those variables within a given year.

On the third page, we wanted to show the popularity of certain specifications of released phones, specifically the OS and the processor brand. To show the popularity of processor brands we chose to use a tree map. Tree maps use the area as a visual channel to show the difference between the different brands, in order to make the difference apparent to the user we chose to also include the number of phones released with the specific brand. The tree map can be seen in Figure 4.

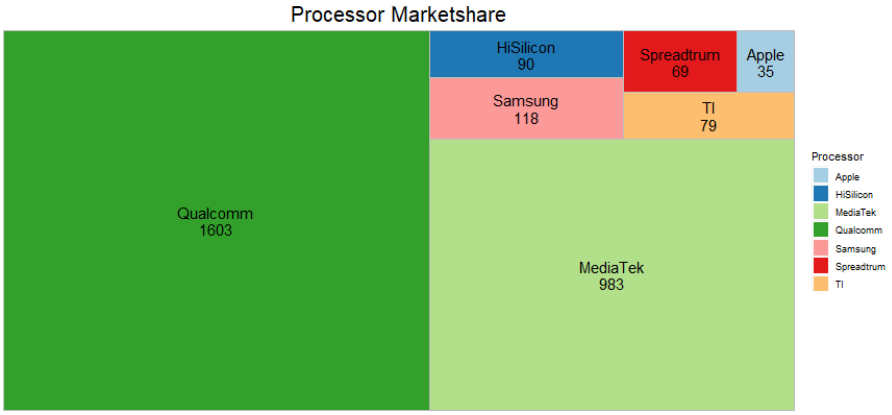


Figure 4: Treemap showing the popularity of processor brands in released phones.

To show the popularity of the OS we chose to use a pie chart to show the part-to-whole relationship and then we added a bar chart to better visualize the OS difference. We chose to do this because length is a better visual channel for differences in amount compared to area. We made sure to make the color map the same color to better help the user compare the two visualizations.

On the last visualization page, we wanted to show more overall evolution. Here we decided to have four line charts for the user to choose between, where each graph was a phone specification over time. The user can hover over a point on the line to

see the specific mean value of the specification for that year. Underneath this, we also chose to show OS distribution over time. We chose to visualize this using a stacked bar chart with the user being able to hover and zoom in. This chart uses length to show the number of phones with a specific OS and color to show the OS.

Finally on the last page of the dashboard is a link to the Kaggle where the dataset was found, but also a button to download the dataset after we had cleaned it as mentioned in Chapter 3.3. On this page there is also a link to download this report.

The dashboard can be seen here:
https://dasmi.shinyapps.io/DV_E22_group08_Dashboard/
We also have a video going through the dashboard that can be seen here.

5. Story/Results

Smartphones evolve over time like any other part of our modern society. Using an R Shiny dashboard we wanted to showcase this journey while allowing a user of the dashboard to explore various changes to acquire knowledge. Our main story is to showcase how smartphones have evolved over time when looking at different specs for the released smartphones in our time period 2003 to 2022.

Our first point of interest was to see if *more and more Phones are being released each year.* Under the Yearly Releases page in our dashboard phone releases over time can then be investigated. Our data showed that beginning in 2003 more and more phones were being released until they peaked in 2015, and the number of released phones has then declined from the peak of 367 phones in 2015 to 125 in 2021. This was different from what was expected, as we expected a continual increase and thought a peak would be closer to 2020 or later. We have not personally noticed a decline in new releases, but the data tells another story. Using a dropdown menu the story for each brand can then be further investigated. For each brand, trends will be very different, but the general trend was a peak of new phones being released in 2015.

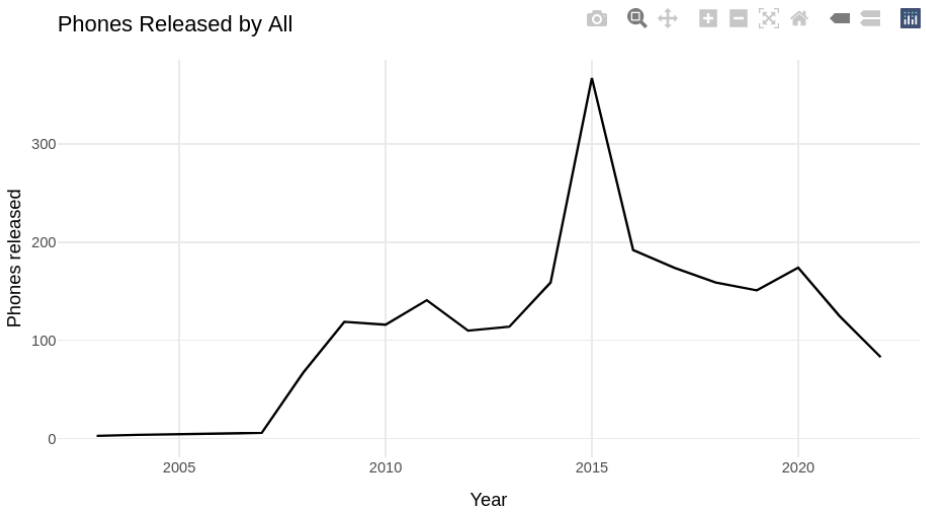


Figure 5: Graph showing phones being released from 2003 to 2022

When looking at phones released over time, this also allows the creation of a heat map showcasing the phones released based on months for each year. The heatmap then allowed us to investigate if there *are new models released in any specific month*. When looking at most of the brands the release months seem very random, but for some brands like Apple, there seemed to be a pattern. Apple release heatmap looks as follows:

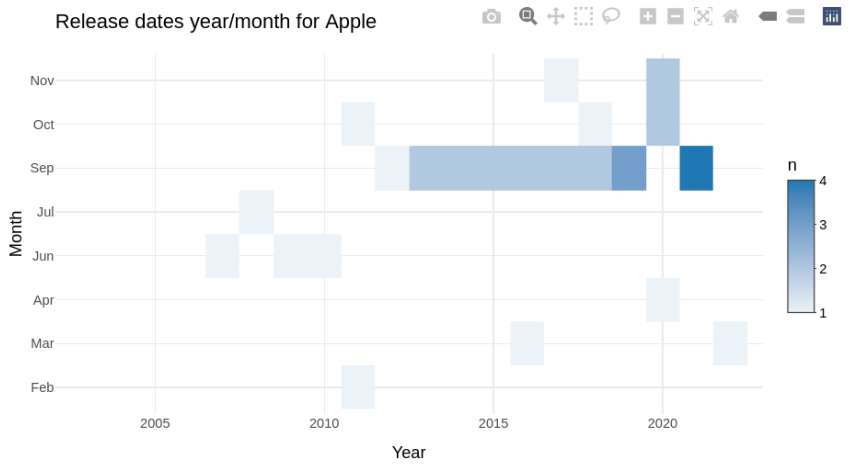
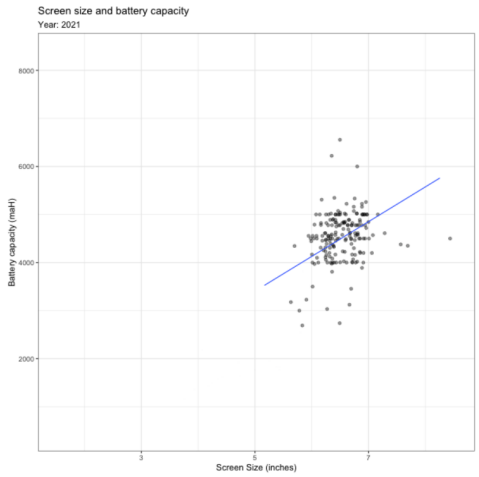


Figure 6: Heat map showing Apple phones released by month from 2007 to 2022

This heat map clearly showcases that there is a pattern of apple phones being released in September. We expected most phone brands to have patterns of when they released their phones but were clearly convinced by the data that most brands release phones more or less at random, which also makes sense for larger brands releasing many phones they just simply spread the release dates throughout the year.

To showcase how *screen size relates to battery size* and *Front camera evolution follows primary camera evolution* we decided to create two animations to showcase these changes over time. These animations are then also synchronized to show data for the same year, which then allows for a general journey through time to get a better understanding of how smartphones changed. The main takeaway is that both screen size and battery size have been steadily increasing from 2007 until 2022. We can not determine if screen size caused a larger battery size or the opposite, but we can conclude there seems to be a correlation which makes sense with a larger screen as a larger battery is required for bigger screens and a bigger battery makes it possible to have bigger screens.

How does screen size relate to battery size?



How has primary and front camera followed eachother?

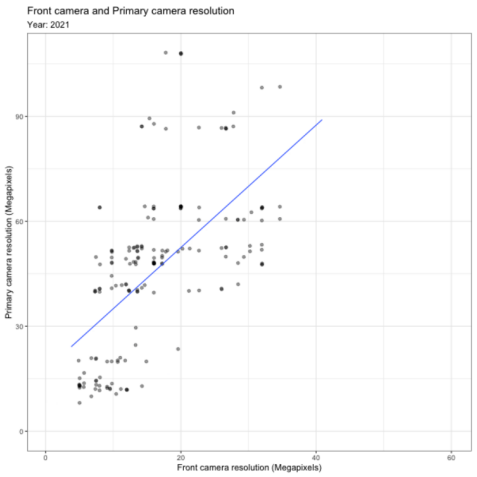


Figure 7: Screenshot of animations from the dashboard

The second animation then compared the primary to the front camera resolution to see if we could find a correlation. But this comparison showed less of a correlation. However, it is clear that cameras have been improving over time, but it is very interesting to see how we keep making phones with bad cameras even though we have the option not to. Where most phones keep getting bigger and have better batteries, phone cameras are not following the same trend. This tells us camera quality might not be as important as battery size and screen size.

We also wanted some general information showing *which processor brand is the most popul*ar. This allows us to tell the story of a few large processor brands having most of the market share of newly released phones as a brand like Qualcomm is in about half of all the newly released phones.

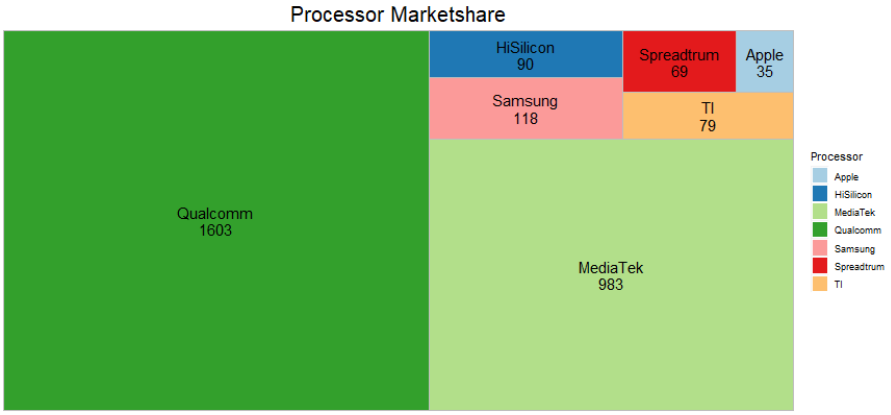


Figure 8: Treemap showing the popularity of processor brands in released phones.

Other than processor, an interesting choice for phones is *which OS is the most popular among all the released models.* On our distribution page, we can see how android is by far the largest player being the OS for more than ¾ newly released phones.

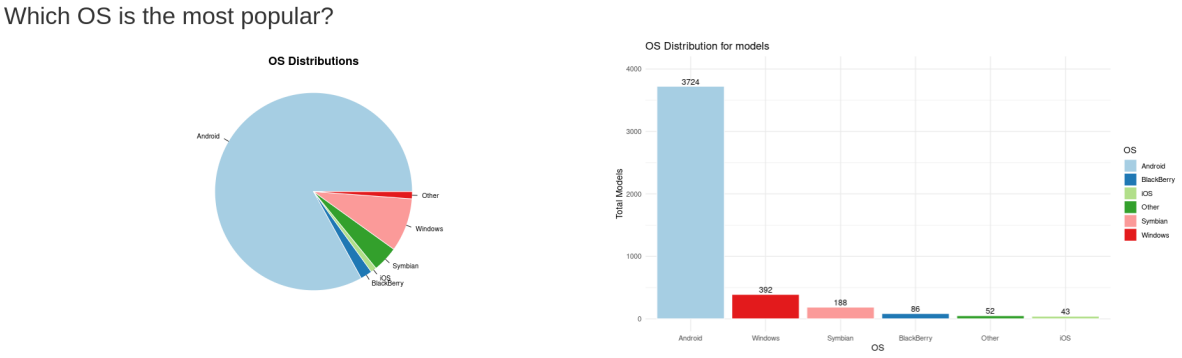


Figure 9: OS Distribution pie chart on the left and bar chart on the right

The OS on smartphones has however changed over time. On our Evolution page, quite a few variables can be shown as evolving over time. But particularly the OS over time is interesting because we can see how windows used to be a large player in the first years of smartphones being released, but in 2011 things seem to change and Android ends up being the main player being the primary OS for newly released phones.

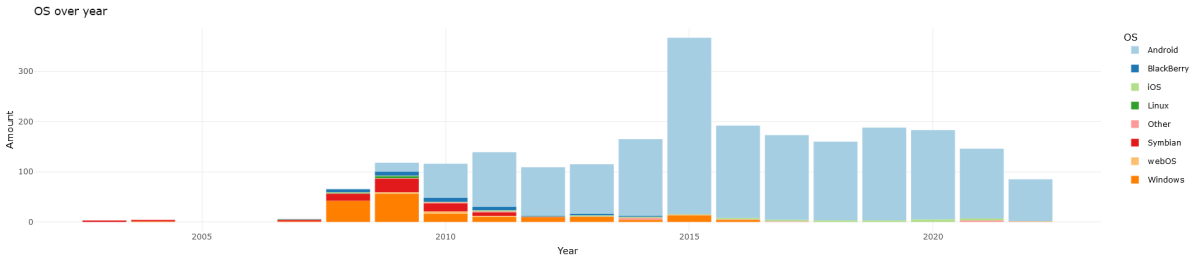


Figure 10: Stacked bar chart showing OS change from 2003 to 2020

The information we showed in our animation can now individually be extracted and seen as a line chart over time using a dropdown menu, which allows the user to further investigate what they found interesting.

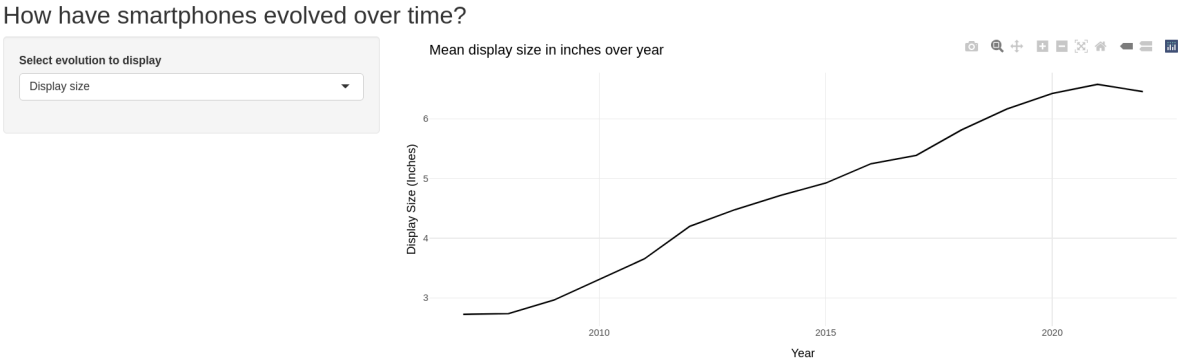


Figure 11: Dropdown section allowing investigation into how smartphones evolved over time

Finally, all of our questions can be answered using our dashboard. The dashboard is constructed in a way where the reader needs to investigate and find their own desired results, as they are not directly highlighted and forced on the reader. Most of our graphs are interactable and can be hovered and zoomed to get more clear information. The dashboard could in the future be improved to better guide the reader through our story and fascinating results through more explanatory text.

6. Conclusion/Discussion

In order to effectively visualize the evolution of smartphones, we obtained and cleaned a dataset from Kaggle. Data cleaning is an essential step in data analysis, as it ensures that the data is accurate and consistent. In this case, cleaning the data involved standardizing the date formatting, which was a challenging but necessary task to ensure the reliability of our results.

In addition to cleaning the data, we also faced the challenge of creating graphs that were both visually appealing and easy to understand. This required multiple iterations and discussions, as we sought to achieve the best possible outcome for our graphs. Overall, the process of cleaning and visualizing the data was challenging, but it was essential to ensure the accuracy and usefulness of our analysis.

From the visualizations we have seen patterns in some brands' release cycles and the rise and fall of other brands.
Furthermore, our results indicate that there is a positive correlation between screen size and battery size. We have also observed that front cameras are following the same trend as primary cameras. To illustrate this trend, we have created animations that show how these features have evolved over time. These animations provide a visual representation of the data, making it easier to understand and interpret the findings. Moreover, we have seen how certain brands of processors and OS’s are more prevalent in newly released phones.

Course Evaluation

We believe that the course could be improved by incorporating more individual exercises to reinforce the material covered in class. Additionally, providing students with a clear plan for the project phase starts, would enable them to better organize and plan their work, resulting in a more successful project. Overall, these improvements would enhance the learning experience for students and enable them to achieve better outcomes.

7. References

[1] Monigatti, Leonie. *Why Your Data Visualizations Should Be Colorblind-Friendly.* towardsdatascience.com,12 July 2022. https://towardsdatascience.com/is-your-color-palette-stopping-you-from-reaching-your-goals-bf3b32d2ac49

[2]Stevens, Stanley Smith, and Lawrence E. Marks. *Psychophysics: Introduction to its perceptual, neural, and social prospects*. Routledge, 2017.

[3] Anderson, Cary. *Types of color schemes*. PennState College of Earth and Mineral Sciences, 2020. https://www.e-education.psu.edu/geog486/node/607

8. Appendix

Work contribution

Student name	Overall project contribution
Berkan Kütük	100%
Daniel Smidstrup	100%
Valon Morina	100%
Victor Andreas Boye	100%