# Smartphone Sentiment Analysis

*Client: Helio*

Alert! Analytics

**Overview**

The client for this project is Helio, a smartphone and tablet app developer working with a government health agency to create medical apps for use by aid workers in developing countries. The goal of the application suite is to enable aid workers to communicate with medical professionals located elsewhere in order to receive expert advice and utilize that to diagnose and manage health conditions locally. Alert Analytics has been asked to evaluate user sentiment towards potential handset models to help determine which is best suited for use with the apps (as the government agency is requiring that the app suite is bundled with only one model of smartphone). The potential handset models are the Apple iPhone and Samsung Galaxy.

**Methodology**

*Research Design*

The overall approach to this project was to find and count instances of words associated with sentiment toward the iPhone and Galaxy within relevant web pages. In order to determine the relevancy of specific web documents, a Python script was written that looks for and counts applicable words. Web sites categorized as relevant included those that referenced a smartphone name and also included wording to suggest that the document included a meaningful assessment of the device (e.g. words such as “review” or “critique”). To determine relevant sentiment words, the script looked for references to a device or feature and positive, negative, or neutral words that were within five words of that device or feature. The features included in the script were camera, display, performance, and operating system. The script recorded total device mention counts per relevant web page as well as the number of applicable sentiment words by device and feature.

*Data Collection*

The datasets used in the analysis came from Common Crawl, an open repository of web crawl data that is stored on Amazon’s Public Data Sets. Data was collected and filtered using the methods outlined in the research design. A team of workers went through a list of 12,000 web pages and manually rated the overall sentiment for a device using the following scale:

0 = very negative
1 = negative
2 = somewhat negative
3 = somewhat positive
4 = positive
5 = very positive

Another matrix of 23,400 relevant web pages was compiled for the purpose of modeling; these were not manually rated for sentiment.

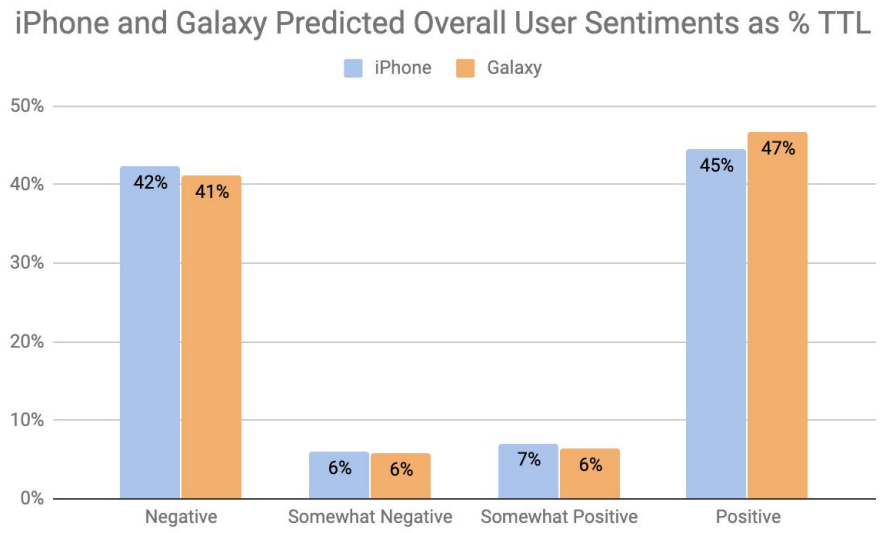
*Data Analysis*

The matrix of 12,000 observations with manually labeled sentiments was used to train various models on the sentiment patterns within the data. The algorithms included in model testing were SVM, C5.0, Random Forest, and KKNN. Additionally, various feature selection methods were tested, including removing near-zero variance features and recursive feature elimination. Different types of feature engineering were also assessed to see if accuracy could be improved. Overall accuracy and precision by class were used to evaluate the various models. Ultimately, the model chosen (for both the iPhone and Galaxy handsets) was a C5.0 model using all original features, but with the user sentiments for each category recoded to a scale with only four categories as opposed to the original six. This model was applied to the larger matrix of 23,400 in order to predict overall sentiment analysis.

**Findings**

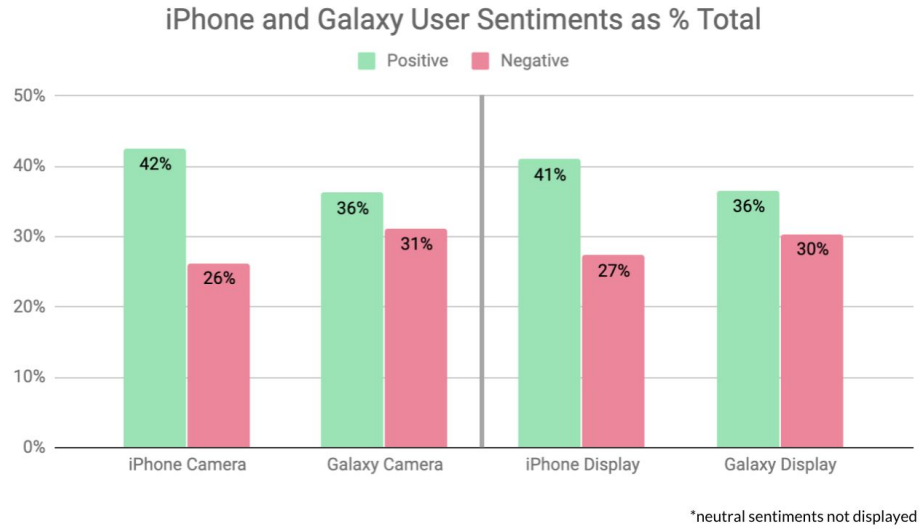
1. *Overall user sentiments towards iPhone vs. Galaxy*

   Based on the sentiment predictions from the top-performing model, most users have very extreme feelings about the iPhone and Galaxy handsets. In 42% of web pages, the model predicted very negative overall sentiment for the iPhone, compared to 45% of web pages where the model predicted very positive overall sentiment for the handset. Similarly, the model predicted a very negative overall sentiment for the Galaxy in 41% of web pages and a very positive overall sentiment in 47%. Conversely, moderate feelings towards the iPhone were predicted in only 13% of web pages and in only 12% of web pages for the Galaxy. The clustering of ratings at both extremes suggests a polarity of attitudes towards both the iPhone and Galaxy; when it comes to overall sentiment for each device, reviewers either love it or hate it.



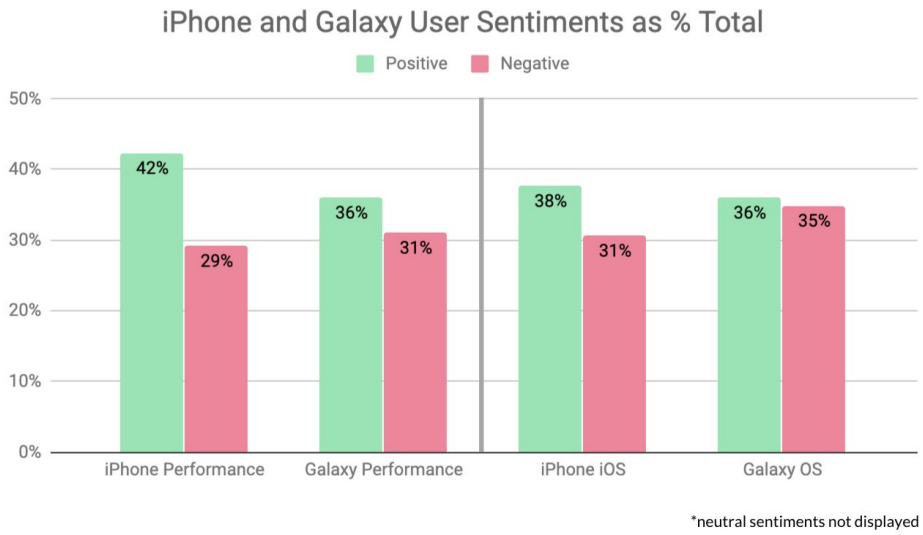
2. *User sentiments by feature - camera and display*

Although the data doesn't suggest a clear favorite when it comes to sentiment towards the overall devices, a deep dive shows some interesting differences in how the various features of the iPhone and Galaxy are perceived by users. The four features measured for sentiment in the research process were camera, display, performance, and operating system. The data shows that attitudes towards each phone's features are almost as polarized as those towards the handsets themselves. However, the difference between the percentage of positive and negative sentiments is telling. For example, the difference between positive mentions of the iPhone camera (at 42% of total mentions) and negative mentions (at 26%) is 15%, compared to the 5% difference between the total number of positive and negative mentions of the Galaxy's camera. A similar spread can be seen in user sentiment regarding the display of each device. This suggests that the advantages of the iPhone camera and display are more likely to stand out to users, whereas the benefits and drawbacks of the Galaxy camera and display are noticed with more equal frequency.




3. *User sentiments by feature - performance and OS*

When it comes to handset performance, there's a similar story. Positive and negative mentions of the Galaxy's device performance are very similar at 36% and 31% of total mentions, respectively - a delta of only 5 percentage points. Alternatively, positive mentions of the iPhone's performance capabilities represent 42% of total mentions, compared to the 29% categorized as negative mentions (for a difference of 13 percentage points); there is a more significant difference in the amount of iPhone performance mentions that are classified as positive vs. negative. This implies that iPhone users are more likely to find the model's performance more favorable than not, while it's more of a toss-up what a user's experience with the Galaxy performance will be. However, with regards to the operating system (OS) performance, both models had a similar breakdown of positive and negative sentiments.




**Confidence**

When evaluating potential classifiers, accuracy and precision were the key metrics used to compare results. Overall **accuracy** refers to the percentage of predictions that were correct out of all predictions (how often was the model right?), while **precision** conveys how often a positive classification is correct and is measured by class (if the model predicted "Very Negative", how likely is that to be correct?). The model with the best combination of accuracy and precision (for both the iPhone and Galaxy) was a C5.0 algorithm using all of the original features, and with the sentiments recoded to a scale with only four sentiments as opposed to the original six. The best model for the iPhone had an accuracy of 84.8%, while the best Galaxy model had an accuracy of 83.2%. The precision for each class ranged from 82-95% for the iPhone and 81-88% for the Galaxy.

| | | iPhone | Galaxy |
|---|---|---|---|
| **Accuracy** | | 84.8% | 83.2% |
| **Precision** | *Class 1 - Very Negative* | 95.9% | 83.5% |
| | *Class 2 - Somewhat Negative* | 95.2% | 88.2% |
| | *Class 3 - Somewhat Positive* | 90.1% | 81.4% |
| | *Class 4 - Very Positive* | 82.9% | 83.3% |

As with any data collection and analysis, there was some potential for error in different parts of the process. For example:

- the script used to scan web pages was looking for examples of positive, neutral, and negative words, although it could have missed more uncommonly used words that fell into those categories but were not written into the script.
- Also, the script counted sentiment words that were found within five words of the target word (e.g. "camera"), but depending on sentence structure, it's possible that the sentiment word was out of context, or that relevant sentiment words were more than five words away.

- Lastly, the user sentiments in the small matrix used to train the models were entered by a team of workers, which adds an element of human error as overall sentiments were decided by various individuals with possibly different interpretations. For example, one person could have coded a sentiment as "Very Positive" that another would have coded as "Somewhat Positive". This could skew the results in the smaller matrix and, by extension, the models that were trained on it.

It's also worth noting that there were far more instances where the iPhone and its features were found on relevant web pages than the Galaxy. There were seven times as many websites that mentioned the iPhone as the Galaxy, and three times as many websites that mentioned iPhone features as Galaxy features; the total number of web pages containing mention of iPhone feature sentiments was 6,709 and only 2,085 for the Galaxy. While this was not an issue for modeling or analyzing trends, it's worth noting that the higher number of iPhone and iPhone feature mentions could indicate that more users are aware of the device and that it's likely a more popular model to own, which is something that could influence the decision regarding which phone to use in bundling the apps.

| Review | iPhone (Count) | Galaxy (Count) |
|---|---|---|
| Camera (Positive) | 1,837 | 659 |
| Camera (Negative) | 1,136 | 566 |
| Camera (Unclear) | 1,354 | 595 |
| ***Total*** | **4,327** | **1,820** |
| Display (Positive) | 2,977 | 849 |
| Display (Negative) | 1,985 | 708 |
| Display (Unclear) | 2,308 | 773 |
| ***Total*** | **7,270** | **2,330** |
| Performance (Positive) | 3,053 | 854 |
| Performance (Negative) | 2,108 | 737 |
| Performance (Unclear) | 2,055 | 779 |
| ***Total*** | **7,216** | **2,370** |
| OS (Positive) | 1,848 | 1,145 |
| OS (Negative) | 1,503 | 1,111 |
| OS (Unclear) | 1,549 | 926 |
| ***Total*** | **4,900** | **3,182** |

If further analysis is done, it would be interesting to see what other features are important to users and how the iPhone and Galaxy rate in user sentiment in those areas. For example, battery life and price are often considered when purchasing a phone, and user sentiment in those areas could impact overall customer perception of a handset, and, by extension, their decision to purchase.

**Implications**

Based on the results from the data analysis, there is no clear winner between the iPhone and Galaxy when it comes to overall user sentiment. Although the percentage of predicted positive sentiment is slightly higher for the Galaxy than the iPhone, the difference is minimal and could vary given another sample. What is clear from the data is that most sentiments towards the two devices fall on the extreme ends of the spectrum - nearly 90% of users have a very positive or very negative overall sentiment. User sentiment towards individual features is also very polarized, but the data shows that the iPhone has a small but significant edge over the Galaxy when it comes to positive sentiment about the camera, display, and handset performance. Since the phones paired with the app suite will be utilizing the camera and display to take and view photos that will be used in medical diagnoses, this is worth keeping in mind when deciding which handset to choose. Additionally, performance is likely important given that the phones selected for use will be utilized in developing countries, where there is limited access to phone diagnostic and repair centers to fix any bugs that might appear. The raw data also demonstrates that the iPhone is either better known or more widely used than the Galaxy, appearing in seven times as many websites as the latter. This could suggest that the model is more commonly purchased than the Galaxy (regardless of sentiment). Since there are some proprietary applications that only work on phones of the same model, installing the app suite on the most popularly used handset (in this case, the iPhone) could make it easier for the end users to communicate with various medical professionals around the world.