DizViz: Visualizing Disneyland Wait Time Data With a Focus on User Experience

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Abstract

Over 15 million people visit Disneyland Resort each year, making waiting in lines an inevitable part of the Disney experience [1]. Through our research, we have found that ride wait times are of great importance to parkgoers. However, current wait time related information visualizations do not present users with an adequate means of making ride and trip planning decisions. In response to this lack of informational tools, our team has designed an interactive system that visually displays wait times along with meta data for each of the Disneyland rides. Using tableau, we display two primary visualizations: a bar graph displaying current wait times and a multivariate, geospatial representation of the theme park. Both visualizations are linked to a table displaying ride closures as well as a line graph displaying ride wait over time. Design decisions throughout the development process where grounded in iterative user research. Likewise, our team utilized best design practices derived from an extensive literature review. Overall, our visualization follows Shneiderman's mantra "overview first, filter and zoom, then details on demand," [2] in order to maximize the effectiveness of our visualization. Our comprehensive dashboard allows users to analyze a variety of Disney data, which has been compiled with careful consideration for the user experience.

Introduction

Disneyland Park has been crowned "the most magical place on the Earth" since its opening in July, 1955 [3]. With various amusement park attractions including rides for all ages, restaurants, shows, and character greetings, Disneyland provides fun and entertainment for the whole family. However, as our early research and personal experiences have shown, the magic begins to dwindle as people realize that they must begrudgingly spend hours in line for their favorite rides and attractions. Frustration and boredom in line, as well as lack of real time information motivated our group to pursue an informative solution.

The goal of our project is to provide an interactive information visualization for people to use while visiting Disneyland. This visualization would ideally provide real time data about rides and attractions to help users best decide where they want to spend their time while at the

park. Our prototype is presented as a dashboard, created using Tableau visualization software. The dashboard offers several filter options to best accommodate the needs of our individual users. These include the ability to filter by a ride's wait time, ride duration, land and ride name. Users may also filter and view a time series of ride wait times over time. However, due to data limitations, the date slider for our visualization can only be filtered across a single, static week rather than years of real-time updating data. Our dashboard is intended to promote informed decision making about where visitors want to spend their time in the park. Overall, we want to help bring back the "magic" of Disneyland and work to eliminate the monotony of waiting in an unusually long line for a favorite ride. Walt Disney once said "You can design and create, and build the most wonderful place in the world. But it takes people to make the dream a reality" [4]. Accordingly,the following section will detail the experts and previous work that we have built upon throughout our design process.

Previous Work

There is a rich history of research in the field of information visualization and no shortage of criteria for graphical excellence. Tufte evaluates graphical excellence as depicting the greatest number of ideas in the shortest amount of time, with the least amount of ink and in the smallest space [5]. Similarly insightful guidelines are provided by Shneiderman's visualization mantra "overview first, zoom and filter, then details-on-demand" [2]. As it happens, an analysis of existing wait time visualizations shows that current tools fail to adhere to these guidelines.

There are a variety of tools that have been created to display ride wait times in Disneyland. These include mobile apps such as "Disneyland Mouseaddict" and "Disneyland Wait Times" [6][7]. The majority of the resources that we found are mobile applications that display data in the form of lists or tables [7]. This format made it difficult for users to interact with data, discover details on demand and draw valuable conclusions about wait time trends. There are a select few mobile applications (currently found in the Apple App Store) that utilize mapping capabilities as well as other visual factors to improve the readability of the data. The application "Disneyland Mouseaddict" by Addict Labs LLC displays wait times utilizing more visual options [6]. Mouseaddict displays a heat map of crowd levels in each area of the park. While this visualization may be praised by users in the comment section of the Apple App Store, it is clear that the graphic would benefit from an exploration of color theory. Yellow crowd level encodings do not lack in contrast and are nearly indistinguishable from a partially yellow background. Similarly, the markings lack definition and suffer from occlusion in some areas of the map (Figure 1).
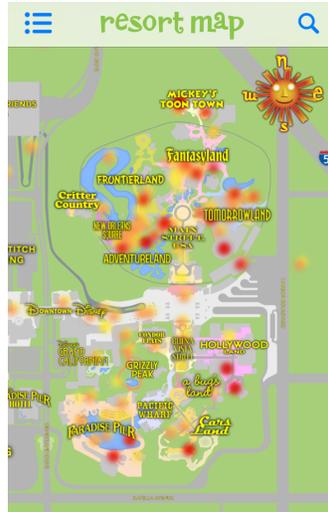
Figure 1: Crowd level heat map by Addict Labs LLC

In a slightly more effective approach to a wait time table, Mouseaddict also displays wait time in a stacked list enhanced with a contrasting color encoding. Unfortunately the table's color encoding has no key, making it difficult for users to identify its meaning (Figure 2).
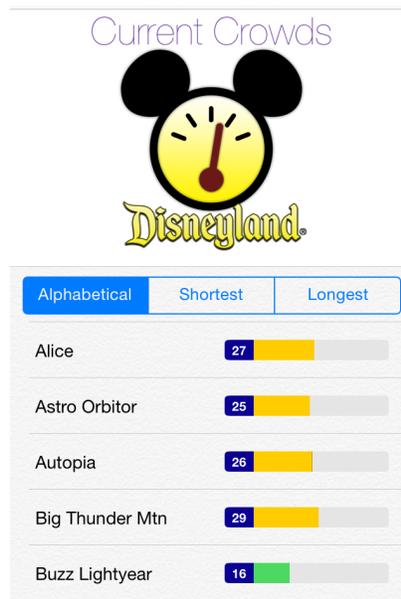

Figure 2: Color encoded wait time visualization by Addict Labs LC

In a similar area of work, visualizations for other amusement parks such as Six Flags and Knott's Berry Farm demonstrate equivalent design choices. Some of these applications are "Ride Hopper - Theme Park Wait Times and More" and "Wait Times for Six Flags Magic Mountain" [8][9]. These applications are comparable to the Disneyland applications where location, color, other useful visual elements were not utilized. A common complaint for consumers of this type of information was that the inconsistency of data (largely self reported) makes these visualizations difficult to read and unreliable.

Design Process

Subsequently, our visualization improves upon these previous designs by displaying reliable, consistent data in an intuitive format. Our research shows that Disneyland guests already take the time to learn how to read the Disneyland brochure map, meaning that a geospatial visualization is especially usable for our target users. This idea is further enforced by positive feedback received after users interacted with the geospatial design created by Addict Labs LC.

We further improved our design by using clearly labeled, high contrasting color encodings and warding against the occlusion of data points. Finally, our graphical layout follows Shneiderman's mantra of overview, zoom and filter, details on demand to provide users with a superior means of analysis [2].

Phase 1: Brainstorming

The first part of our project began with a team brainstorming session. We knew that we each had a passion for Disney and a passion for User Experience. Nonetheless, it was necessary that we objectively gather design requirements for our users in order to create a truly viable solution. The primary focus of this session was to identify target users and outline a protocol for user research. Target users (Disneyland visitors) were divided into three groups:

1. People who regularly visit Disneyland Resort (2+ visits in the last 6 years)
2. People who are new visitors to Disneyland Resort (first visit in the last year)
3. People who have planned a trip to disneyland for a group of people

Phase 2: Initial Research

To begin, we aimed to acquire feedback about user wants and needs when visiting Disneyland as well as information about the tools that are currently used within the park. To collect this data, we sent out a qualitative survey to members of our target user group. The survey contained a series of open ended, qualitative questions including "What kinds of information are important to you when visiting Disneyland?" "What tools do you use to acquire this information?" "What are your main goals when visiting Disneyland?" and "How do you decide what rides to go on while visiting Disneyland?"

We received responses from eight members of our target audience and used these findings to set the scope and requirements for our visualization. When asked what information was most important while visiting disneyland, all respondents listed ride wait times as a key factor. Showtimes, park hours and food prices were also popular. Furthermore, one newcomer requested descriptions of what each ride is.

Another important finding was that users chiefly rely on wait time postings above individual rides when visiting the park. There is one comprehensive sign near the entrance to adventureland. Otherwise, users are unable to analyze all ride wait times at once. The one remedy to this inconvenience is the availability of Disneyland wait time related mobile applications. Three respondents explained that they had tried downloading a wait time

application but rarely used it while in the park. After following up with these users, we were told that the applications are "hard to understand" and "unreliable" in cases where self reported data is used.

Phase 3: Sketches and Mock-ups

Drawing from the findings of our initial research, we decided to focus our efforts on creating a comprehensive visualization of Disneyland wait time data. While waiting for a response from Disney about the acquisition of data, we began generating sketches of our ideal wait time visualization. Our top design utilized a geospatial mapping, which aligned with our user's traditional way of thinking about the park (Figure 3). Wait times were encoded in using colored labels which rested within each ride marker. Short waits are encoded in green with medium waits in yellow and long waits in red. This encoding provides added value by mirroring a traffic light design idiom.

Clicking on a ride marker would open an additional view displaying ride metadata and ride wait times over time for analysis and trip planning purposes (Figure 4). Wait time history could be viewed throughout a single day or expanded to cover several years. As an added feature, we included a second vertical dimension, which marks the times of Fantasmic, parades and firework shows. This feature was intended to highlight a potential correlation between different factors such as shows and a change in wait times throughout the park.

In conjunction with the map view we also decided to implement a bar graph of current wait times for quick and easy comparisons (Figure 5). As is supported by Ware's work on understanding visual perception, it is easier for users to accurately interpret length encodings than a size encoding on a bar graph [10]. Additionally, this visualization enabled an alphabetical search by ride name as well as by wait time.
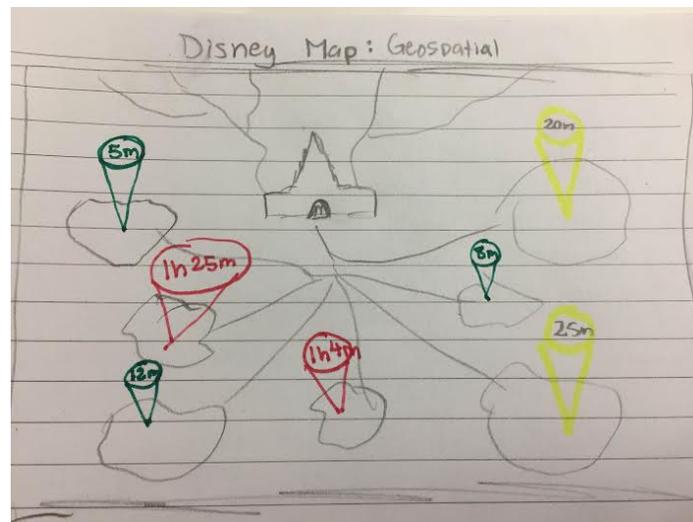

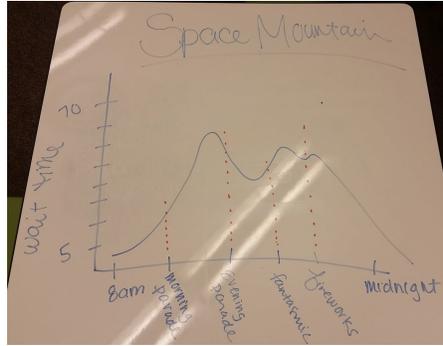*Figure 3: sketch of geospatial visualization*

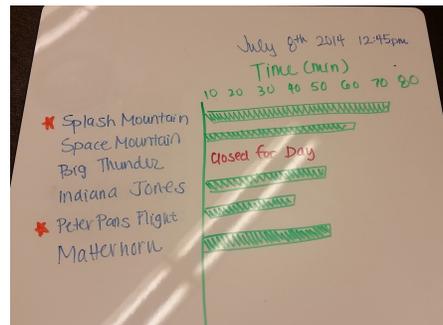*Figure 4: sketch of time series visualization*

Figure 5: sketch of bar graph visualization

To further clarify our concept to users, we created mockups of our geospatial visualization using Adobe Illustrator (Figure 6, Figure 7, Figure 8). Users enjoyed the visual clarity of the geospatial visualization and were interested in seeing the design implemented. We also learned that our overview of wait times by land (Figure 6) was not as important to users. In fact, they preferred an overview of crowd levels for the park as a whole.

Figure 6: overview of wait times by land, color encoded by length of wait

Figure 7: zoomed map view, highlighting wait time and position of individual rides
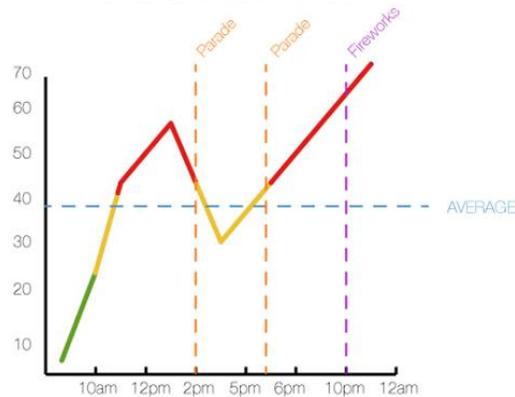

Figure 8: time series of Space Mountain wait times over the course of one day

Phase 4: Acquiring Data

Following this initial brainstorming phase, we realized that getting actual data about Disneyland wait times would prove difficult. After reaching out to a second department associated with Disneyland data and development, we began searching the internet for scraps of data that we could begin manipulating in Tableau.

Knowing that the park continuously displays wait times to the visitors, we felt confident that we would be able to gain access to a spreadsheet if not an API. Unfortunately, we scoured many sources to no avail. We discovered that most third party applications were not acquiring data directly from disney and that their self reported data was largely inconsistent. Eventually, a lack of response to our emails led us to reach out to Disney recruiters that attended this year's iSchool career fair. Unfortunately, they were not in a place to help us promote our cause. A few days later we received a response to our emails stating that Disney could not provide us with wait time data. As a result, our development process was delayed considerably.

Luckily for us (and our project), one night we finally came across a data source called TouringPlans.com. Touring Plans is a trip planning service which offers users their own data for wait times, ride descriptions, ratings, and other helpful metadata. We decided to email their team to see if we could get our hands on their data for free since this was a paid service site. The next morning, we were contacted by one of their developers wanting to set up a Skype

call with our team as soon as possible. This Skype call eventually led us to gaining full access to TouringPlans.com as well as excel spread sheets of wait time and ride metadata.

After creating a master spreadsheet and optimizing it for tablea, we ended up working with 27,378 rows and 58 columns of wait time data and metadata across 58 different attractions. Data was collected by Touring Plans as well as self reported by its users. Wait time data was collected in 15 minute increments and spans the course of one week from 4:00 PM on 2/10/15 to 3:45 PM on 2/17/15.

Phase 5: User Research

Now equipped with a functional dataset, we began development in parallel with additional user research. Initially, we wanted to know what filter options would be most desirable for users. We asked three members of our target user group (one from each subcategory) to look through our list of available metadata and point out which variables were most valuable. Ride wait time, land, ride name, ride duration and whether a ride is open during Magical Mornings made the top five most popular filter options.

Once we discovered that five filter options simply did not fit on our dashboard, we returned to users to narrow down to a top four. Accordingly, magical mornings was cut as a quick filter on our dashboard. One user noted that most rides do not open during Magical Morning anyway and that she was not put off by the loss of the filter option.

Phase 6: Development

To avoid further delays in learning an entirely new programing language, our team decided to implement our designs using Tableau visualization software rather than utilizing the flexibility of D3. In short, we implemented a customized map visualization using a park map retrieved from Disney Wiki [11]. The coordinate positions of each ride on the map were determined using a grid system in Tableau after adding the image as a custom map background and entered as new columns in our data spreadsheet. Current wait times were encoded using size and mapped to specific lands using color. Through interaction with the dashboard the map would zoom and display only the user's targeted areas of interest (Figure 9, 10). Conveniently, land labels were already included in the background map image and become prominent as the view zooms to a single land.

Title — Disneyland Map with Ride Wait Times

Caption
Average of Longitude vs. average of Latitude. Color shows details about Land. Size shows average of Posted Time. Details are shown for Ride Name. The data is filtered on Date & Time, average of Duration, maximum of Posted Time and Action (Land,Ride Name). The Date & Time filter ranges from 2/14/2015 11:00:00 AM to 2/14/2015 11:00:00 AM. The average of Duration filter ranges from 1 to 45. The maximum of Posted Time filter ranges from 0 to 95. The Action (Land,Ride Name) filter keeps 58 members. The view is filtered on Exclusions (Land,Ride Name), Land and Ride Name. The Exclusions (Land,Ride Name) filter keeps 58 members. The Land filter keeps 9 of 9 members. The Ride Name filter keeps 51 of 58 members.

Figure 9: geospatial visualization of current ride wait times created in Tableau
map template from http://disney.wikia.com/wiki/Disneyland_Maps_Gallery
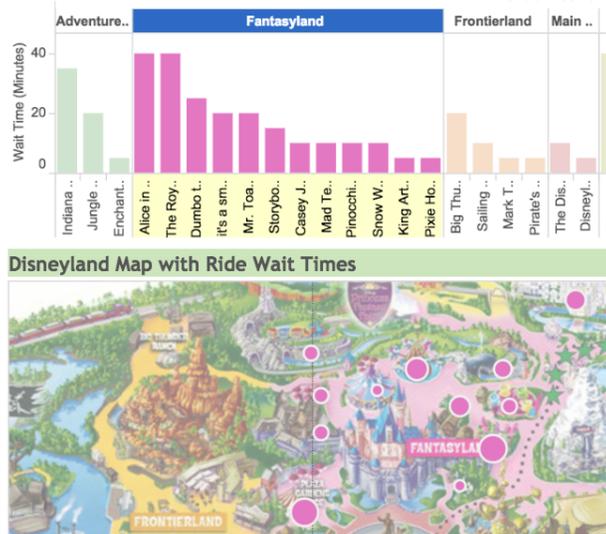

Figure 10: the view when the user clicks a specific land, when the adventure's land is highlighted and the map zooms in on that land

Our second visualization features a bar graph of current wait times, we grouped the rides by respective lands to increase the readability of the display. Additionally we mirrored each land's color from the map visualization; this pattern is carried throughout the rest of our visualizations (Figure 11). When we decided to create a display with wait times for each of the rides, we first thought about the variables we were going to be displaying. Wait time is a ratio variable and the ride names and their lands are both nominal. We decided based on Bertin's "Levels of Organization" that this visualization would be best shown as a bar graph due to the of the nature of its variables [12]. Since viewing wait times was our users highest priority, we

chose this display to be at the top of our dashboard. We organized the wait time bars in a descending order because our users were interested in seeing which rides had the longest waits. This rationale came because Disneyland is established in a western society where citizens read left to right, we thus felt that within each of the land categories it would be important to have the most important information (the longest wait time) sorted to the left. Additionally "Perceptual Properties" by Mackinlay told us that length is a good method of encoding to use when one is wanting to make comparisons [13]. We feel this visualization follows Mackinlay's rules and is easy to comprehend. Users can quickly discern which rides have long waits and make the comparisons as to which ones have short waits.
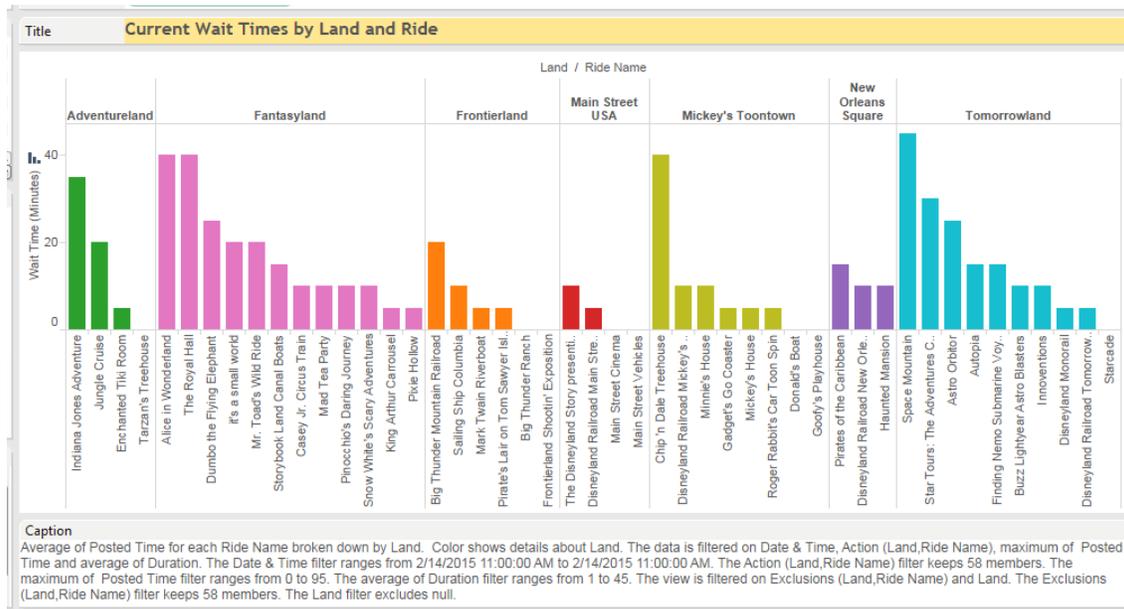

Figure 11: bar graph visualization of current wait times created in Tableau

Our third view of this data is a time series of ride wait times (Figure 13-15). Wait times for each ride are plotted over time in a line graph visualization. The variables being displayed in this visualization are both ratio variables. In addition, the relationship from point to point is continuous, so we determined that a line graph would be an appropriate representation of the data [12]. This visualization shows relationships and trends of ride wait times over one day at the park (typically, park hours are 8am to midnight) [14]. The visualization is filtered by: the users interactions on either of the aforementioned visualizations or any of the other filters, so this graph only shows a few rides at a time. Each ride has its own color because according to Bertin's "Levels of Organization" color is a good method of encoding quantitative data [12]. A single item can be selected and the graph is filtered further; on a hover state will then show additional details (Figure 14). In our final visualization, we allowed users to drag a slider to change the line display. This information was tertiary in importance to our users, which is why we placed it towards the bottom of our visualization. It was also important for our users to be able to filter the data being displayed. We chose to use a slider filter for our final visualization because it was better understood by our users, demonstrations of the variation in this filter are shown in Figures 12 and 13. The graphic enables users to analyze a single ride (Figure 14) or compare multiple rides (Figures 12 and 13) in the same view. To avoid introducing false

trends, any point on the graph where a data point was not reported for a 15 minute increment (or more) is shown as a break in the continuous line. This prevents users from thinking that a ride's wait time dropped to zero minutes when, in fact, the ride was closed. The date and time axis may also be extended to show the full range of wait time data. Due to data limitations this range is capped at one week. However, ideally, one could explore wait time trends over the course of several months or even years. Trend lines included in the line graph help guide this analysis of wait time trends, especially when the x-axis is expanded to cover at least one week. As shown in Figure 13, a user might use the trend line to notice that the average weight time for the Indiana Jones ride gradually increases as the weekend approaches. Perhaps they should plan their vacation over a Tuesday rather than a Saturday.
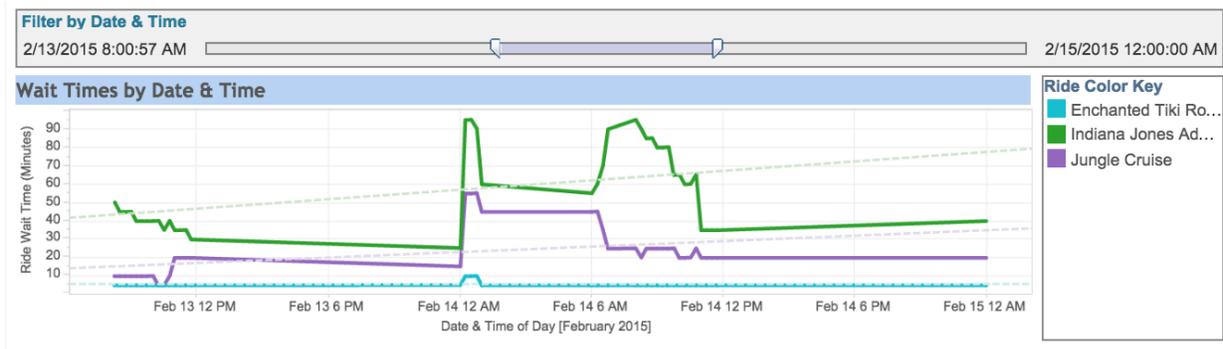

Figure 12: the hourly wait time of the 3 rides selected between February 13, 2015 at 8:00 AM and February 15, 2015 at 12:00 AM
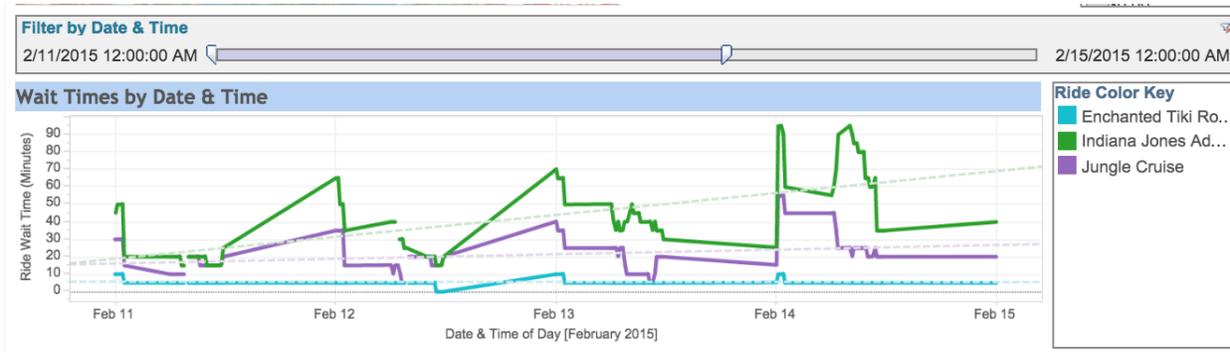

Figure 13: the same rides as Figure 12, but between February 11, 2015 at 12:00 AM and February 15, 2015 at 12:00 AM
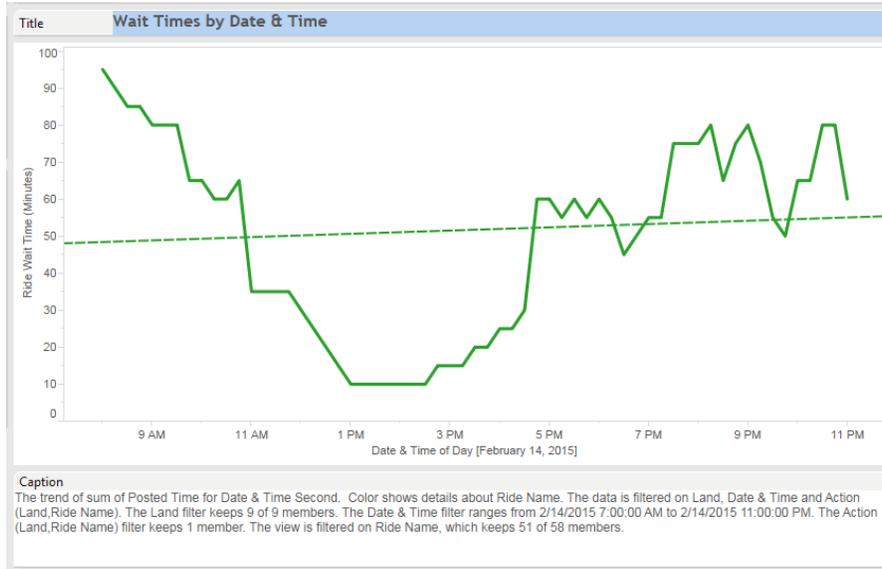
Figure 14: time series visualization of a single ride (Indiana Jones) wait times on 2/14/15 created in Tableau
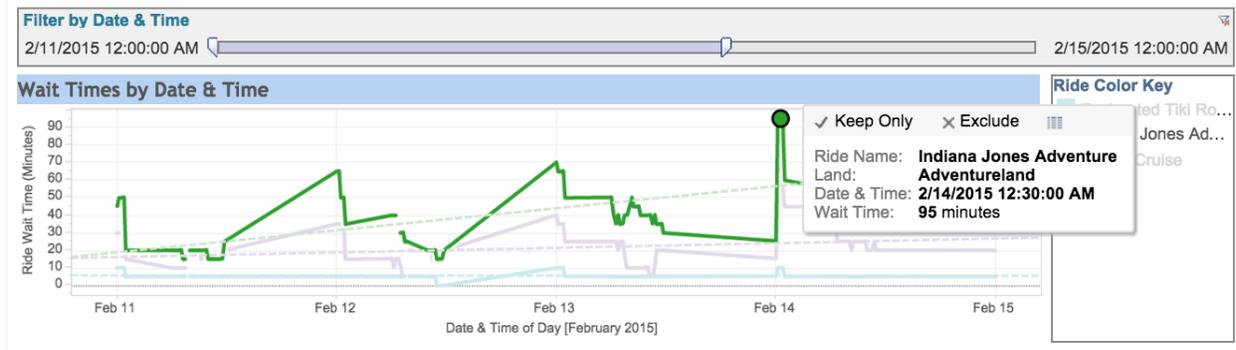

Figure 15: the same visualization as Figures 12 and 13, but with Indiana Jones Adventure highlighted at February 14, 12:30 AM with details on demand

Each of these three visualization types were included in the first draft of our dashboard and modified after usability testing. After our first round of usability testing, we generated a fourth and final visualization of ride closures within the park (Figure 16). Due to limitations with Tableau color codings, closures were depicted in a simple table listing the names of closed rides. As with the bar chart, all lands are grouped by land for added clarity. Overall, the addition of this graphic was intended to prevent introducing false trends in the bar graph view. Before the closures table was created, closed rides deceptively appeared to have no wait time.

Figure 16: table of ride closures created in Tableau

Phase 7: Usability Testing

With the first draft of our interactive dashboard came an important round of usability testing. Our prototype was bare bones and disorganized as we worked to learn Tableau's visual design system. However, the tool was functional, displayed multivariate data in a variety of views, utilized several zoom and filter options, enabled tooltips for details on demand and offered consistent brushing and linking across graphics (Figure 17).

Figure 17: initial prototype of the DizViz Dashboard

To assess the usability of the graphics and ensure that our tool successfully filled a need, we again asked three users (one from each subgroup) to complete a series of tasks using our visualization. The tasks included:
1. Determine which ride currently has the longest wait time
2. Determine the location of Space Mountain
3. Determine which rides have a 15 minute wait time
4. Determine which two attractions you can explore for the longest amount of time
5. Determine when the line for your favorite ride is the shortest

Despite a lack of visual design, users were able to complete four out of five tasks with relative ease, utilizing both filter sliders and on-click filter interactions. Nonetheless, users struggled with using the calendar view date filter to select a single day. In part, this confusion was caused by the limitations of our data. In order to view a trend line, users needed to either select "previous month" or calculate exactly how many days had passed since Valentine's Day. In theory, having several years of live updating data would have remedied this confusion and provided valuable filter options.

In addition to completing tasks, we asked users to provide general feedback about the look and feel of the dashboard. User's commented that they liked the multiple views, the linking across graphs and the selection of colors that distinguished rides from different lands. Conversely, users were uncertain about which keys and filters where intended for each graph. Additionally, one user exclaimed "why isn't anyone in Critter Country," noticing that all Critter Country rides were displayed with a wait time of zero in the bar graph. As it happens, Critter Country was closed during Valentine's Day, 2015. Overall, these findings illustrated the need for a new means of visualizing ride closures as well as a need for clearly labeled graphics and a more intuitive date filter.

Phase 8: Redesign

Guided by the feedback that we received during usability testing and aided by a plethora of Tableau tutorials, we set out to organize our polish our dashboard. To begin, a ride closures table was added under the bar graph to eliminate false wait time trends created by ride closures. Closed rides were likewise filtered out of the bar graph. To create visual clarity, each element was banded with a clear border and color coded to further highlight relationships between content. Each visualization title was filled with a unique color. Accordingly, the titles of keys were given the same color text as the visualization they represented. Similarly, all filters were shaded in light gray to help them stand out from both the keys and the visualizations (Figure 18).

Figure 18: redesign of the DizViz Dashboard

The last major improvement to the dashboard was the implementation of a date slider to replace the calendar style filter option. By displaying the full range of possible dates in one place, date selection was more intuitive considering our data set. Further in line with guidelines for graphical excellence, we gave each graph a meaningful title, labeled our axes, relabled variable names to clarify their meaning.

All participants from our usability testing agreed that the dashboard was greatly improved and easy to understand. With these finishing touches in place, we concluded by uploading our visualization to Tableau Public where interested parties may easily access and interact with the visualization.

The DizViz Dashboard can be accessed at the following URL: https://public.tableau.com/profile/publish/HCDE411-DizViz/WelcometotheDizVizDashboard#!/publish-confirm.

Discussion

Due to the limitations of Tableau visualization software, many changes had to be made to our design during the development phase. Unable to implement animation between different map views, our team decided to create alternative views and use extensive brushing and linking to highlight the relationships between graphics. Our bar graph became our new wait time overview, spanning the top of the screen and serving as an on-click filter for all graphics.

Selecting a ride or land from the bar graph automatically zooms into the selected area on the map and filter options further adjust this view across all graphics. When hovering over a ride element, a tooltip also appears, listing ride name, land, ride description and wait time in text. It is in this way that our visualisation adheres to design best practices and exemplifies Shneiderman's mantra "overview first, zoom and filter, then details on demand" [2].

While our dashboard does add value for our target users, we recognize that there are limitations to our data as well as our visualization. Delays caused by difficulties optimizing our data for Tableau and learning how to import a custom map meant that our dashboard remained relatively simple in concept, though clear and functional. Additionally, there are a few flaws in our interface that we were unable to remedy. The word "null" is unexplainably a member of our lands filter despite the absence of a null value in our spreadsheet.

Other features that could be improved include the default view of our time series visualization. With all rides displayed at once, the time series is cluttered and suffers from occlusion (Figure 19). In fact, it is only intended as a comparison tool for a handful of rides at a time. We feel that it would be more beneficial if we could set the default view to show only the two rides with the longest and shortest wait times in the park. Alternatively, we could show a ride with an atypical wait time trend based on some kind of mathematical algorithm.
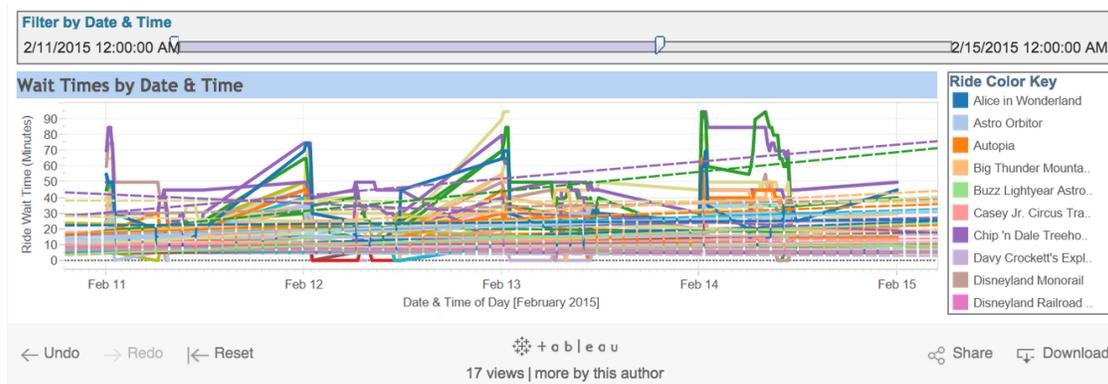

Figure 19: the default view of the time series visualization appears cluttered due to limitations in space and software

Finally, it should be noted that our visualization does not connect with live updating wait time data. Instead, the visualization uses a static view that simulates what it would be like if someone checked the visualization at 11:00 AM on 2/14/15. In an ideal scenario, the overview graphic would update every fifteen minutes and add a datapoint to the time series below it. As is, our visualization only adds a fraction of the value that it has the potential to provide.

Further Work

For future work on our visualization, we would like to move away from Tableau and, instead, generate our own graphics using the D3 libraries. Ideally, this would get us one step closer to accomplishing our end goal of making our tool a mobile application for use within the park. Currently, our tool is limited to one week of data from TouringPlans. Accordingly, another goal is to incorporate live data from the park so that the visualization can be more robust and update in real time.

Along with live updating data, our team is interested in adding the geographic of our user to as a variable within our visualizations. By collecting GPS coordinates from the users mobile device, we could visualize their park location using a special marker on the map view (Figure 20). Rides could then be sorted based on wait time as well as their proximity to the user.

Figure 20: mock-up of a visualization that incorporates the GPS location of users

Our team is also interested in allowing users to keep track of their interactions with the visualization. One beneficial addition would be a schedule table where users could pull out ride names and times that they discover through the time series visualization. This would be especially helpful when paired with the predicted wait time data that is generated by TouringPlans statisticians. In a similar light, users may also benefit from ride alerts that analyze specific trends automatically. For example, a user may wish to be notified when their favorite ride drops to a wait time below 20 minutes. We could also imagine a feature that uses storytelling to highlight the best time of day to visit each ride within the context of our existing visualization.

In terms of accessibility, our next step will to be to implement a color blind view which transforms land colors into a modified grey scale. This way all users could reap the benefits of our current color encoding system. As it happens, we also have access to accessibility related

metadata. In future research we would recruit users with various disabilities to learn what accessibility variables would be useful additions for details on demand.

Conclusion

Overall, our team has created a potentially valuable visualization for Disneyland visitors. The DizViz Dashboard compiles a variety of multivariate data and presents it through a variety of views. Most importantly, the visualization goes to great lengths to follow established guidelines for graphical excellence despite the obstacles encountered during development. In essence, this project was a fast paced exploration of information visualization that is applicable to industry as well as academia. Our design process highlights both the importance of user research and deep understanding of visual perception.

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