Introduction

This project is for us to implement graph visualization techniques on the dataset obtained from the Ministry of Health (MOH) Malaysia GitHub repository and apply the knowledge of graph algorithm to be incorporate into the visualization as well. We are focusing on the people's movement with the spread of COVID-19 cases where the people's movement can be indicated with the number of check-ins through MySejahtera app.

With the number of cases reported in the GitHub repository, we will be able to extract on that to use it for visualization. We are able to observe that the rise of COVID-19 cases during the past years have been increasing drastically in a certain period of time which worries both of the citizens and the health authorities in Malaysia. All of the reported cases are being visualized based on their numbers that ease the people reading understanding compared to plain numbers in excel sheets. There are many websites that offers the visualization on COVID-19 cases in many type of forms, such as line graph, choropleth graph, bar graph, etc. Hence, with the availability of datasets found online, we could also create our own COVID-19 graph visualization in a prototype website.

Objectives

There are two objectives to achieved by the end project:

- To design graph visualisation of COVID-19 dataset based on the selected variables in a prototype website.
- To implement graph algorithm (Dijkstra's Algorithm) in the visualisation.

Roles

The table below shows the roles supported by each of the members.

No	Matric No	Name	Team Role	Signature
1	S2128786	Fatin Raihanah Mokhtar	Main Programmer Documenter	
2	S2115567	Sadia Nur Amin	Ideator Programmer Documenter	
3	S2126689	Sharon Chan Suet Yan	Group Leader Programmer Compiler	

Project Analysis

In order to complete this project with the development of prototype website with graph visualization, Design Thinking process is being bring into the project as a guideline for us to execute. Each of the phase are being elaborated on what it is in general and what is to be done in the next section. Based on the surface understanding of the datasets, there are few assumptions we have towards it:

- Active cases in the cluster contributes to the total number of new cases of the day during the various MCO status (MCO,CMCO,RMCO).
- Observe the spread of COVID-19 cases based on the nearest cities in Sabah.
- The number of checkins could contribute to the number of cases as the number of checkins indicate the people moving around the premises.
- The implementation of various movement control order (MCO) could show a drop in number of cases.
- With the lifted movement restrictions, there is a possibility of spread of COVID-19 cases within the state.

Planning and Execution based on FILA Form

Empathy

Design thinking is a non-linear, iterative approach that allows teams to better understand their customers, challenge assumptions, reframe challenges, and develop and test novel solutions. Empathize, Define, Ideate, Prototype, and Test are the five phases that are most beneficial for tackling challenges that are ill-defined or uncertain.

Empathy: The first stage of the design thinking process is empathy. Design teams perform research to gain a firsthand understanding of the demands of their users. They put their assumptions aside to observe and consult with users in order to gain insights into their reality. They will be able to comprehend the users' experiences, motives, and issues in this manner. In our research, we have first studied what empathy means and then went on to identify a suitable visualization approach incorporating graphs that users prefer to visualize the movement of people and how it is related to the spread of covid-19. To do this, we created a google form and distributed it to random interviewees to get their take on visualization techniques that they thought would be appropriate for this research and accumulated the information. From that, analysis of which graphical approach to use for visualizing this correlation was made.

After the survey that has been handed out to the 6 respondents, we are able to obtain the responses from them and then to analyze the results that are generated by Google Forms in this section.

First of all, Figure 1 shows the results on how the respondents view the importance of the visualization of CoVID-19 with people’s movement. The scale is being determined by 1 - least important whereas 5 as very important.

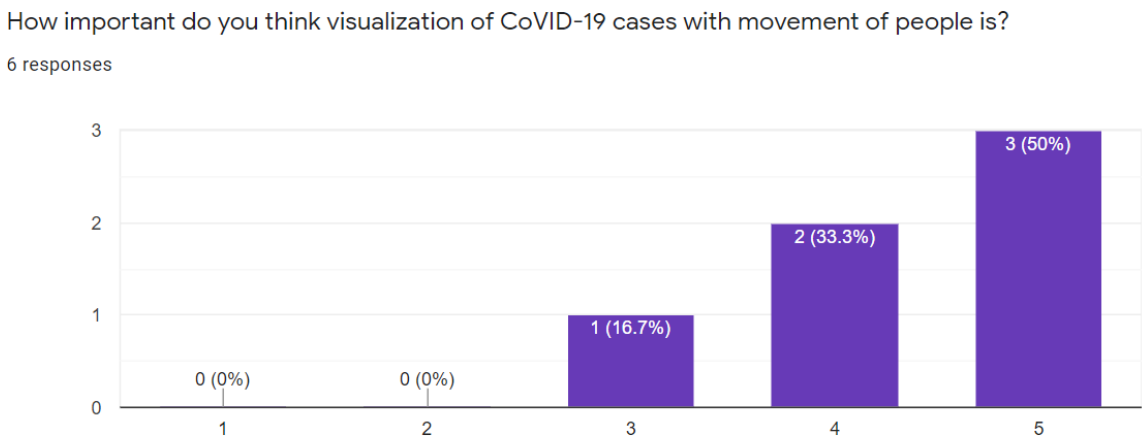

Figure 1: Result of survey question 1

50% of the respondents (3 people) highly think that the visualization is very important whereas the other 3 respondents also think that the visualization is relatively important as well.

Figure 2 presents how well do the respondents know about visualization techniques. This shows the proficiency of their understanding for 1 - Not Familiar, 2 - Little Familiar, 3 - Average, 4- Adequately familiar and 5 - Very Familiar.

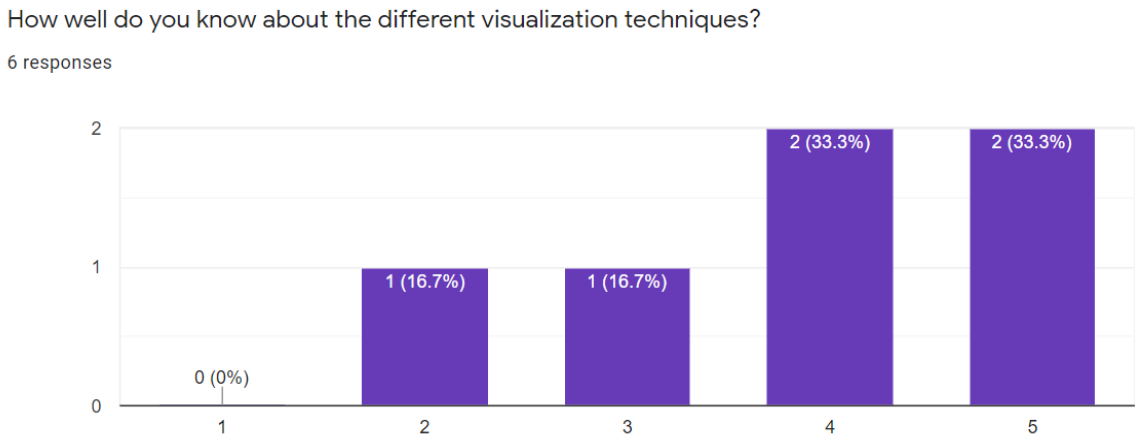

Figure 2: Result of survey question 2

4 of the respondents have good understanding in the different visualization techniques as they have experience on it by their attended course or work related. Whereas there is 1 respondent being a little familiar with it but we are able to know that the 6 of the respondents more or less have the knowledge of different visualization techniques.

Next, Figure 3, 4 and 5 are open questions as we want to let the respondents to be not restricted with the survey answer choices. We have provided a link for the respondents to look at the different visualization techniques for them to answer the survey questions.

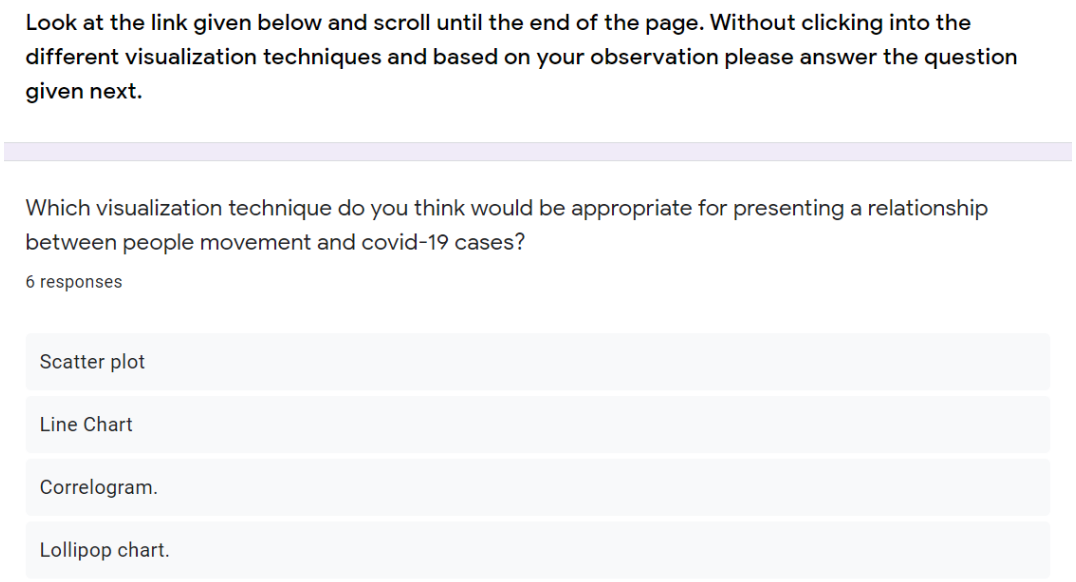

Figure 3: Responds for survey question 3

In Figure 3, we were able to see 4 types of visualizations were listed out by 6 different respondents as there are repeating responses. Scatter plot and correlogram are under correlation visualization techniques, Line chart is under evolution visualization techniques and lollipop chart is under ranking visualization techniques based on the website given to them as reference (URL: https://www.python-graph-gallery.com). We are able to deduce from their selection of visualization for people movement and covid-19 cases, like for example scatter plot and correlogram, it can be used to show the correlation between the variables of people's movement (exp: number of check in) with covid-19 cases (exp: number of new infected cases). It can be observed in the graph to see how positively correlated or negatively correlated between the variables. Line charts can show the datas being linked to see its trend against a time period which is reasonable to use as a visualization technique (Peters, 2021). The Lollipop chart on the other hand is able to allow us to see if a value is outstanding than the other values, for example it can be used to see on which particular day in a month have the most cases infected. The outstanding ones will be very significant especially with the aid of good labeling and color to differentiate.

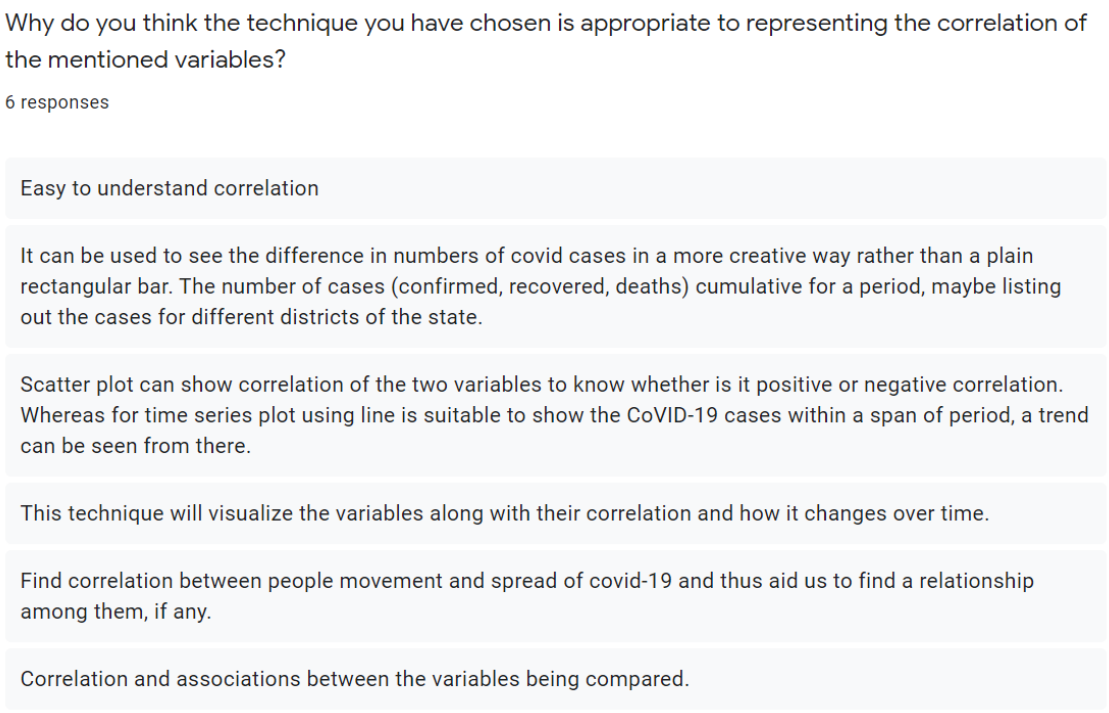

Figure 4: Responds for survey question 4

Figure 4 are the reasons why the respondents have chosen their visualization techniques based on the website link given. It is very informative for us to know their expectation on what to be observe from the visualization.

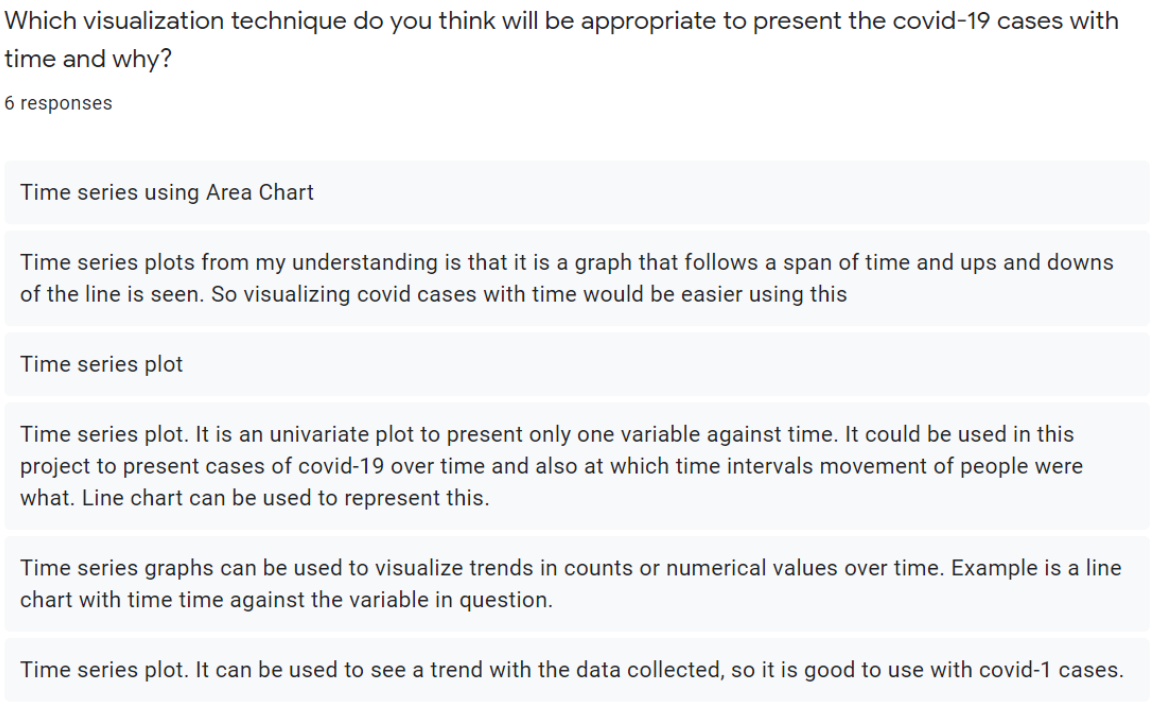

Figure 5: Responds for survey question 5

Figure 5 shows the respondents' responses towards covid-19 cases against time. All 6 of the respondents write out time series plot. Time series plots are able to see a trend using one variable with the other axis being as time in an appropriate scale (exp: hours, days, months) (Dunn,2022). So we can understand why time series plots are chosen by the respondents when they see that time is needed to be as one of the variables.

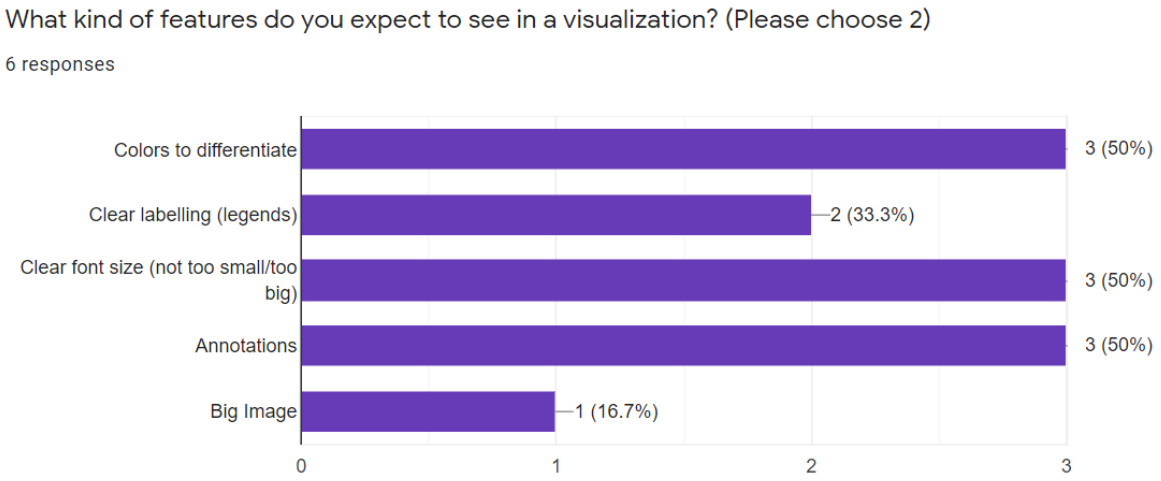

Figure 6: Results for survey question 6

As in for figure 6, we bring in the consideration of what kind of features they would like to see in a visualization. This is because producing a good visualization to the users is essential as poorly designed visualizations will distort the visualization information, fail to grab attention and are unable to bring a meaningful conclusion to the users (GoodData,2020). From this survey, we could see the colors, fonts and annotations are voted as the important features needed in the visualization for the respondents. So we will take these features into consideration for the latter implementation of our project.

Ideate

Ideation (I) is the phase that comes after Empathy(E) of the Design Thinking Process. After Empathy (E) has been carried out, the Ideation phase will be conducted to address the problems/questions. In general, Ideation is where the participants gather around together to come out with as many ideas as possible to address a problem statement in a judgment-free environment (Stevens, 2021). The participants also needed to be open-minded as well to not restrict other people's thoughts because there is no such thing as bad ideas. This will not intimidate the participants to give out their idea during the ideation session. A facilitator and a creative environment can help in managing an ideation session by setting some ground rules to allow the participants to challenge themselves and allow them to explore any possible idea that can be used in the later phase of Design Thinking (Dam & Teo, 2019). There are various types of ideation techniques that help during the ideation session such as brainstorming, brain dumping, mind mapping, sketching, etc.

Thus, through the understanding of how ideation works, we take in one of the ideation techniques which is brainstorming during the identification of variables to be used to visualize

people's movement with CoVID-19. Those variables will be later used as an input to the graph algorithm. An online meeting was set up for us to sit down to conduct the brainstorming session. Everyone voices out their ideas on which variables from the three different datasets to be selected and used for visualization. Even though the ideas being listed out by each of us differs from one another and some would be put into the reject list, we are still able to come to a consensus calmly and have decided on the selection of the variables. The reason why the variables are selected will be justified in the latter section of the documentation.

Then, as the graph algorithm is required to be implemented on our visualization of the variables chosen, a network graph will be used and it can be done by using the existing package in Python which is Networkx. The network graph could be extensive with the values of the selected variables; hence the graph algorithm can help to find a node in the shortest time/path. In the next section, we will be looking into the available graph algorithms that can help us to understand how the algorithms work for the network graph we will be generating later in the next phase of design thinking.

It is significant to see that the implementation of ideation techniques helps in obtaining ideas from different individuals without being scared of being judged. This creates a diversity of ideation being generated that can contribute to addressing the problem statement/questions stated to achieve project completion.

Design

During this phase of design thinking, we are to identify which variables and also the algorithm to be implemented in the prototype website. The dataset is obtained from the official Ministry of Health (MOH) Malaysia GitHub repository where we would further elaborate what we are about to work on it in the later section.

We have chosen to use data from three datasets named **clusters.csv**, **checkin_state.csv**, and **cases_state.csv**. After extensively studying all 5 datasets, we chose these 3 because they seem to have relevant information which can be used for our research. As we are going to visualize the relationship between people movement and covid-19 cases in Malaysia, we decided to use:

checkin_state.csv:

- checkins
- state
- date

cases_state.csv:

- date
- state
- cases_new

clusters.csv:

- date_announced
- state
- cases_new
- cluster

cases_new: cases reported in the 24h since the last report

date: yyyy-mm-dd format

state: name of state

State in clusters.csv: The state is represented by numbers, the same as the middle two digits of Malaysia IC where it indicates the place you were born.

date_announced: date of declaration as cluster

checkins: number of checkins at all locations registered on MySejahtera

Graph algorithms

Graph is a non-linear data structure that is made up of nodes and edges and there are many types of graph algorithms, which includes Depth First Search (DFS), Breadth-First Search (BFS), Dijkstra Algorithm, etc.

Among the different graph algorithms, we will be looking into the different aspects of it including the pros and cons, time complexity, and how it is used for.

1. BFS
2. DFS
3. Minimum spanning tree - Kruskal
4. Johnson algorithm
5. Dijkstra's algorithm

BFS:

BFS (breadth-first search) is a method for graphing data, searching trees, and traversing structures. This approach explores all nodes nearby to a single node (initial or source point) in a network. After visiting and marking the beginning node, the algorithm moves on to the next unvisited node and analyzes it. All nodes are indicated once they've been visited. These iterations continue until all of the graph's nodes have been visited and tagged correctly.

There are a number of reasons why we should use the BFS Algorithm to search for a dataset.

- In comparison to other algorithms, the BFS algorithm's outcome has a high level of accuracy.

- The iterations in the BFS algorithm are smooth, and there is no way for this method to get stuck in an infinite loop.
- BFS is useful for evaluating nodes in a graph and determining the shortest path to traverse them.
- BFS can traverse a graph with the fewest amount of iterations possible.

Real life applications of BFS:

- P2P Networks: In a peer-to-peer network, BFS may be used to locate all of the closest or nearby nodes. This will help you discover the information you need faster.
- Web Crawlers: Using BFS, search engines and web crawlers may simply create many tiers of indexes. The BFS implementation begins with the source, which is a web page, and then proceeds through all of the links on that page.
- Navigation Systems: BFS can assist in locating all of the nearby places from the primary or source location.
- Network Broadcasting: The BFS algorithm guides a broadcast packet to identify and contact all of the nodes for whom it has an address.

Time complexity: The Time complexity of BFS is O(V + E) when Adjacency List is used and O(V^2) when Adjacency Matrix is used, where V stands for vertices and E stands for edges.

Advantages:

- It is used to determine the shortest path between vertices.
- Always seeks out the best options.
- Because BFS searches level by level, there is no such thing as a wasted path.
- In less time, finds the closest goal.

Disadvantage:

- All linked vertices must be saved in memory. As a result, it uses more RAM.

DFS:

When a dead end occurs in any iteration, the Depth First Search (DFS) method traverses a network in a depthwise motion and utilizes a stack to remember to acquire the next vertex to start a search. The edges that go to an unvisited node in DFS are known as discovery edges, whereas the ones that link to a previously visited node are known as block edges.

Real-life applications:

- Weighted graph: DFS graph traversal provides the shortest path tree and least spanning tree in a weighted graph.
- Detecting a Cycle in a Graph: If we find a back edge during DFS, the graph contains a cycle. As a result, we should perform DFS on the graph and double-check the back edges.
- Path Finding: The DFS method may be used to find a path between two vertices.
- Topological Sorting: This method is typically used to schedule jobs based on the relationships between groups of work. It is utilized in instruction scheduling, data serialization, logic synthesis, and selecting the order of compilation processes in computer science.

Time complexity: The time complexity of DFS if the entire tree is traversed is O(V) where V is the number of nodes.

Advantages:

- It uses up less RAM.
- It takes less time to find the greater distant element (from the source vertex).

Disadvantage:

- It's possible that you won't be able to locate the best answer to your situation.
- It's possible to become caught up in a fruitless quest.

Kruskal's Algorithm:

A well-known greedy algorithm is Kruskal's Algorithm. It's used to figure out what a graph's Minimum Spanning Tree (MST) is. The supplied graph must be weighted, linked, and undirected in order to use Kruskal's approach. For a linked weighted graph, Kruskal's Algorithm is used to discover the smallest spanning tree. The algorithm's main goal is to locate a subset of edges that may be used to visit every vertex of the graph. Instead of focusing on a global optimum, it uses a greedy method to discover an optimal solution at each stage.

Time Complexity: The time complexity of Kruskal's algorithm is O(E logE) or O(V logV), where E is the no. of edges, and V is the no. of vertices.

Applications where Kruskal's algorithm is generally used:

Landing cables, TV Network, Tour Operations, LAN Networks.

Advantages:

- Simple to comprehend.
- Gives a decent outcome when there are a lot of vertices and edges.

Disadvantages:

- It's slow and difficult to program since it's difficult to evaluate whether arcs form cycles.
- The complexity may be increased by using the same weight.

Johnson Algorithm:

Johnson algorithm is another dynamic graph algorithm aside from Floyd's algorithm, Bellman Ford algorithm and Djikstra's algorithm. It is being used to find the shortest path in the graph between every vertices pair in a given weighted directed graph where the weights can be in the form of negative numbers(Shah,2022). Within the Johnson algorithm, it make use of two algorithms which are the Dijkstra and Bellman-Ford algorithm.

Time complexity:

The time complexity of the Johnson algorithm is determined by the implementation of two algorithms. Bellman-ford algorithm is called once whereas Dijkstra's algorithm is called for V times, where V is the number of vertices. Time complexity of the Bellman-Ford algorithm is O(VE) and Dijkstra's algorithm is O(V log V), hence the overall time complexity for Johnson algorithm is O((V^2) log V + VE) (GeekforGeeks, 2017).

Advantages:

- The negative weight values being reweight by the Bellman-Ford algorithm will become non-negatives.
- It is good to use in sparse graphs, where the number of edges is lesser than the possible number of edges .

Dijkstra's algorithm:

Dijkstra's algorithm on the other hand makes use of the edge's weight to find the path in the graph that minimizes the total distance (which is indicated by weight) from the source node to all other nodes (Tyagi,2020). This algorithm is different from minimum spanning trees as the shortest distance found in the graph may not involve all the vertices.

Time complexity:

Dijkstra's algorithm time complexity varies depending on the usage of heap and priority queue. If fibonacci heap is implemented than the time complexity will be O(|E|+|V|log|V|), whereas using binary heap will result in O(|E|log|E|) and priority queue will be O(|E|+|V|^2) (Baeldung,2021). |E| and |V| are the number of edges and number of vertices respectively.

Applications of Dijkstra's algorithm:

Link-state routing protocol - It is used to calculate the shortest path to each network for each router and that information will be stored in a route table (Venkat, 2014).

Traffic information system - This is used to track the starting location (source) and destination that ease the road users (Venkat, 2014).

Advantages:

- Able to obtain the least weight path to all the permanently labeled nodes.
- It has the order of N^2, hence it can process relatively large problems efficiently.

Disadvantages:

- Its implementation induces blind search that consumes a lot of time and waste unnecessary resources.
- It does not handle negative weight values on the edge as it will lead to acyclic graphs and would not be able to obtain the shortest path.

Why is Sabah selected as our target state and December 2020 - February 2021 as the targeted period of month?

In this project for identifying the relationship between the people' movement in Malaysia and covid-19 cases, we need to set a target state to conduct this identification of the mentioned relationship with a graph algorithm.

Sabah is our selected target state which is pointed out during the brainstorming session. This is due to the election campaign that was ongoing in the latter half of the year. How this is related to the people's movement is because the voters that stayed in the Peninsular of Malaysia or any part of the country will need to travel over to Sabah to cast their votes at their respective parliamentary constituency. Although there are many concerns of allowing the voters to travel despite the standard operating procedure (SOP) and Movement Control Order (MCO) , the voters have the constitutional rights which makes it difficult to not restrict their movement (Geraldine, 2020). She reported in her article that Minister Datuk Seri Masidi Manjun added that the last election in Sabah contributed to a lot of new CoVID-19 cases where the voters went back to Peninsular after they had cast their votes and passed the virus to the others. Thus, this would actually make a good representation of using network graphs to show the relationship between the voter's movement with cases during the campaign period.

With the issue considered above, that also influences the period to be taken into the project and we are setting the time frame from September-December 2020. After the election

that has been held during the latter half of the year, that starts around September 2020. We do keep in mind that the CoVID-19 symptoms showed up around 2-14 days after the day of exposure, but some may develop the symptoms slower than the expected 14 days of incubation period (Bell, 2020). Incubation period is the period between the exposure towards virus or bacteria and the symptoms' appearance. So, we need to take a span of period to see the number of cases with the CoVID-19 cases incubation period in mind.

Although we intend to take the dataset period starting from September 2020 until December 2020 based on the starting of the election campaign for the three mentioned datasets, due to the limitations of the clusters.csv dataset does not contain the records for the month of September until November, we are taking the records from December 2020, January 2021, and February 2021 as our target period on our selected region instead.

Prototype

After gathering various ideas within a team and have decided on the idea to be implemented into the project, Prototyping phase in Design Thinking process will be bringing into the things that have been discussed in the previous phase and to make a prototype out from it.

Prototype is a scaled-down version of the real product where a sample or simulated version of the product allow us to test our idea and designs (Stevens, 2021). It can be in any form from hand drawn or being done on a digital platform. Prototypes can vary from low-fidelity prototyping to high-fidelity prototyping, and the tools to be implemented can be as cheap as to do it on a paper. As for this phase, we will be doing a website prototype based on the ideas that we were able to identify in the previous Design Thinking phase.

We would want to achieve in building a website prototype that consist of the visualisation of graph between the people's movement with COVID-19 cases that is interactive and capable of conveying the message we would want the end users to understand. Aside from that, the relevant documents that is needed will be uploaded on the website as well for the end users to download it will also be part of the prototype. The tools to develop the prototype, we are focusing on the uploading our HTML file, which is named as index.html into our GitHub repository and generate a free online website with GitHub Pages. All the necessary documents are also being uploaded into the GitHub repository as well. Once the prototype is completed, we will be bringing this prototype to the next phase of Design Thinking process which is Testing, where we will need to let users to test on our prototype and obtain feedbacks from them.

Figure below shows the some of the snippets from the prototype of our website with visualization being embedded in it.

Team Members

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Related Document

Week 1: Download Week 1 zip file | Week 1 video link | Download Week 1 FILA form

Week 2: Download Week 2 zip file | Download Week 2 FILA form

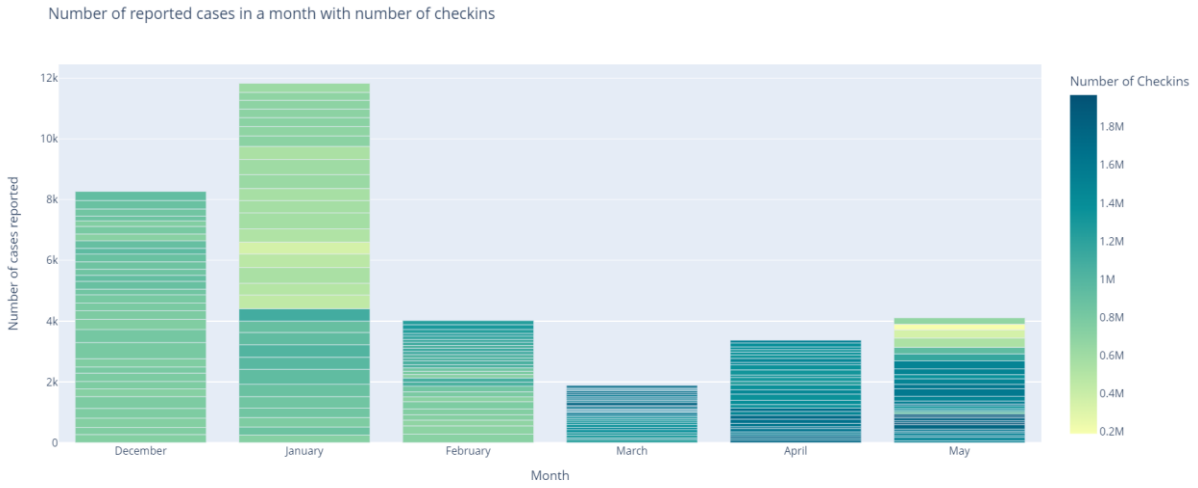
Week 3: Download Week 3 zip file | Download Week 3 FILA form

Week 4: Download Week 4 zip file | Download Week 4 FILA form

Group Contract: Download Group Contract

Source Code: Download Source Code

Interactive Graph

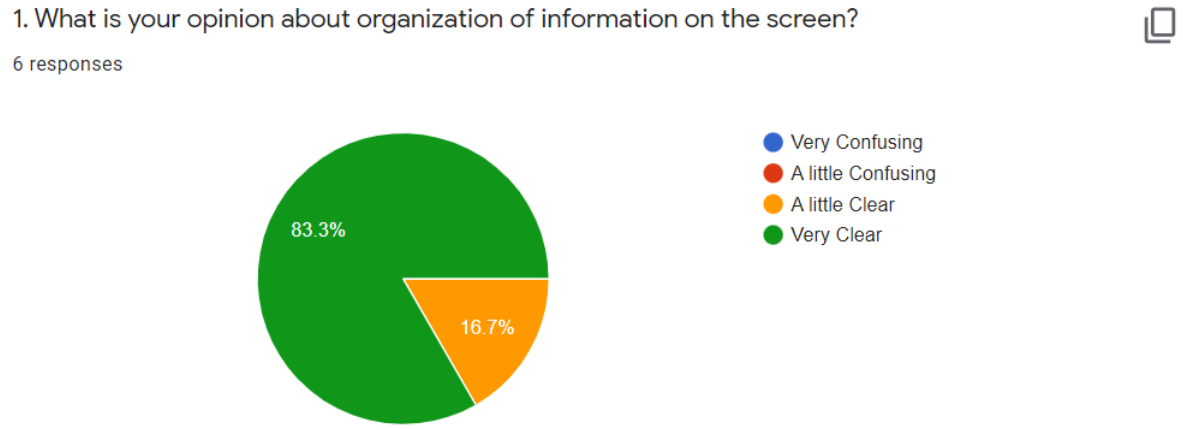


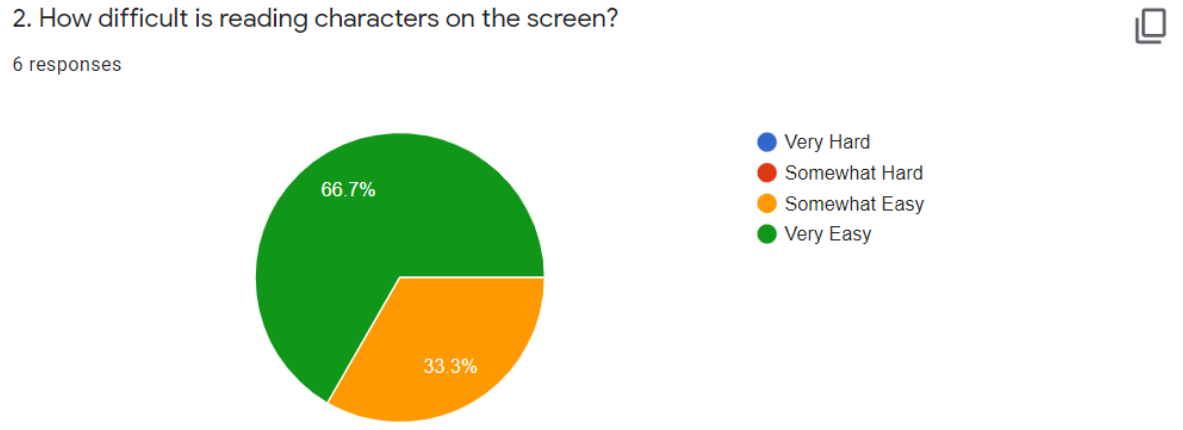
Test

After the prototype is built in the previous process, it is now reach to the final step of the design thinking process which is Testing. Testing is a process where the users will experience with the developed prototype without a hint of guidance from the team that designs it (Lucas, 2018). Then, the users will generate feedback to the team regarding on their experience of using the prototype. Testing also help to identify the problems that are not being considered in the previous phases (Dam & Teo, 2021).

In this process, we have prepared a survey form along with the link of our prototype website for the users to test on it and then learn from the feedback that is obtained by the users. We will not give the instructions to the users on how to use the website, but rather allow them to explore on their own. These feedbacks from the user experience on their interaction with the website will serve as a note to ourselves in any development in the future for similar projects.

Figures below shows the feedback obtained from the respondents based on their experience in the prototype website.



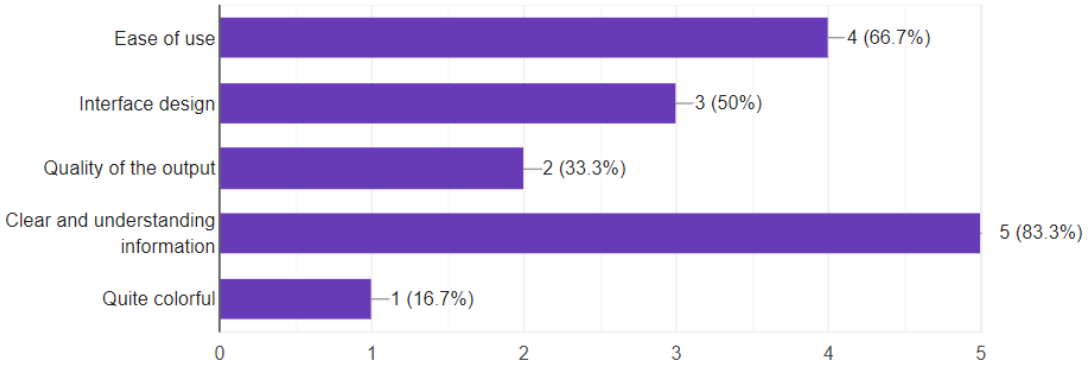


3. Position of messages on the screen is consistent.

6 responses

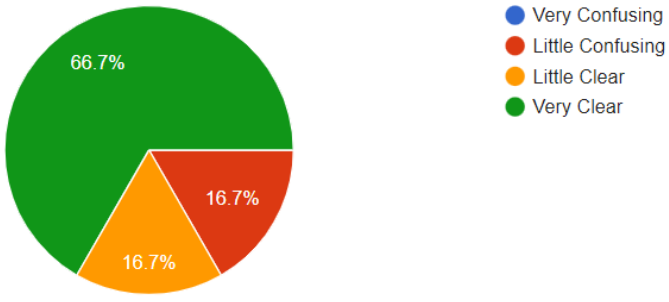
4. What do you find best about our website?

6 responses



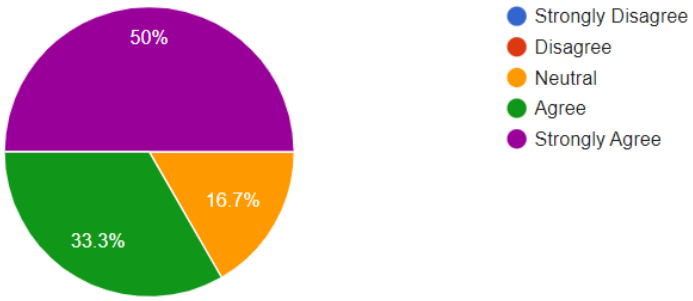
5. What do you think of the visualization between people's movement and COVID-19 cases?

6 responses



6. Do you think the visualization between people's movement and COVID-19 cases is important?

6 responses



7. What can be further improve in the visualization between people's movement and COVID-19 cases?

5 responses

Maybe increase the time span to a year to get a more clearer visual.
Increase location to more than one. Here, only Sabah was presented. Maybe increase districts.
Would have been better if the names of the places in Sabah has been quoted out.
Provide information about more districts
Providing vaccination status of the population would be helpful

8. Are there are comments/suggestion that can help us improve the user interface?

6 responses

None
None.
Add a daily periodic cases table showing cases frequency daily in Sabah.
Categorize the information
visually good

We were able to see that most of the feedback obtained is relatively satisfying, but at question number 5 where we asked the respondent on their view towards the visualization of people's movement with COVID-19 cases, 2 out of 6 respondents reply as little confusing and little clear respectively. Then, the two open questions replied by the respondents are worthwhile for us to inspect to as it can be useful to be referred for any related projects in the future. In addition,

if there is more information or variables that can be accessible, we would be able to improve on the visualization as well to present more information to the end users.

Overall reflection of the experience working on the project

We are able to realize that the assumptions that we have made in the beginning were able to be visualize in a various kind of graph with the available dataset. Although some data such as the date of movement control order and the specific location of district in Sabah is not available in the GitHub repository, we are given the choice to explore on our own to enhance the visualization. If the check in information from MySejahtera are more specific on each ID then we would be able to pinpoint better on the movement of the users and to determine the spread of COVID-19 cases with their movements. In addition, adding in the graph algorithm, Dijkstra's algorithm into the visualization was a bit challenging at first as it was a first for all of us, but we are able to incorporate it. We also do realise that the Design Thinking process practiced during the project execution is iterative as we revised each of phases in order to enhance the visualization such as initially we only set to get the data within the time frame of December 2020 to February 2021, however we revised and decided to take the time frame within year 2020 and 2021 to get a bigger picture on the dataset to see the fluctuation on the number of cases and checkins.

Aside from that, we also learn cooperation and time management during the execution of the project with the help of FILA form. This helps to remind us on the task we are supposed to do and it is must be completed by the deadline set. We also learn to communicate with each other better during the project implementation whenever we faced any obstacles or problems. Thus, we can resolve it and ensure the project flow to be smooth.

Conclusion

We are able to observe that MCO are capable of restricting people's movement which also indirectly decreases the number of confirmed cases as seen in the graphs. Aside from that, once the ease on movement restriction is lifted, there is a significant increase in confirmed cases as it allows the people to move around that could also be an indicator that the COVID-19 disease spreads with their movement. Plus, the general election that happens around September 2020 in Sabah state also contributes to the rise of cases in the subsequent months due to the incubation period of the virus that can take up to 14 days to surface in a human body (Bell, 2020). The number of check-ins through the MySejahtera app also inform us that the people are moving around a lot, from one premises to another can contribute to the spread of virus as well. With the usage of Dijkstra's Algorithm in the visualization, we are able to find out the possibility of COVID-19 cases spread in the affected districts in Sabah that is contributed by the people's movement. Thus, this project serves as a stepping stone that can be further improved in the future with more datasets that can be obtained to enhance the visualization.

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