Canyon Accident Cause Analysis Interactive Information Visualization

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1 INTRODUCTION

This project visualizes the canyon accidents, the accidents associated with canyoning (canyoneering). Canyoning is an X-sport that requires professional skills, experiences, and fortune. Each mistake can lead to serious injury; a series of mistakes is more likely to result in fatality. Therefore, the visualization tool aims to help professional canyoneers to explore the risks of canyon-related activities. By answering the causes and the correlations between each cause, the tool helps canyoneers to avoid making the same mistakes in the future.

I designed for myself. The motivation for building this visualization is that the tool can help my friends and me avoid canyon accidents. I am a river trekker, which is also a canyoneer in the broad sense. Most of the time, canyoning involves traveling downstream in the canyon, while river trekking typically means traveling upstream. Both activities share a similar environment and techniques. Since canyoning becomes more and more popular in my community and globally, I believe the visualization can help all the canyoneers analyze accident reports and respond to unexpected situations.

The tool is built by `HTML`, `SCSS`, and `JavaScript`, with the use of JavaScript library `d3.js` to support visualization tasks. I used Visual Studio Code and its extension to compile my work.

The data comes from International Canyon Accident Database and Ropewiki. The International Canyon Accident Database collects canyon accidents from people who published their experience online or self-reported the accidents to the database. Each accident includes location, time, cause, injury type, narrative description and analysis. Since I believe that the canyon difficulty is an important factor in analyzing accidents, I integrated the canyon data in Ropewiki to provide the canyon rating for users.

2 FEATURE DESCRIPTION

The tool contains two screens. The first screen provides an overview of causes and their correlations. The second screen provides a detailed view of each accident and its causes in terms of the selected cause.

2.1 Main Chart

Figure 1 shows the screenshot of the main chart. It is a network diagram with the use of force-directed layout. Reference can be seen in Observable. The size of the nodes is encoded as the frequency of the causes that were identified in the accidents; the color of the nodes is encoded as the type of causes; the width of links is encoded as the count of the linked causes resulting in one single accident.

The network diagram helps the canyoneers to see the big picture of causes. They can quickly identify which cause occurred more frequently and hence be more careful while facing a similar situation in the future. The links between causes help canyoneers to understand that one cause can associate with other causes. While one mistake is made, what kind of mistakes they need to avoid after to prevent accidents happen.

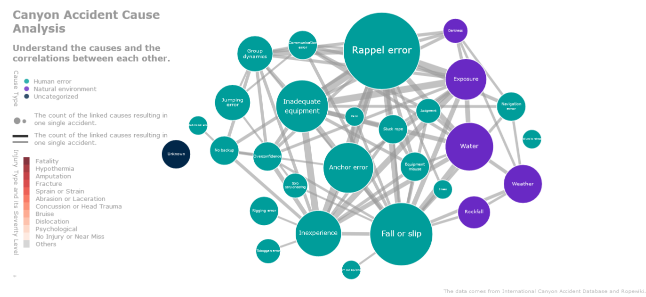
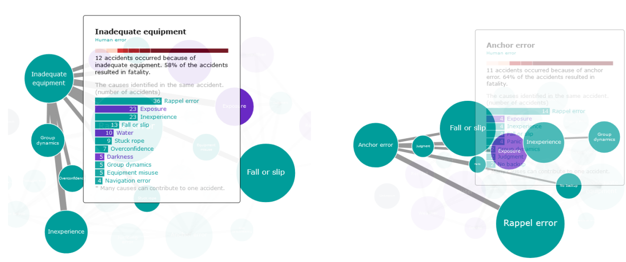


Figure 1. Main Chart

`draw` and `getNetworkData` are the two essential functions to draw this chart. Since the raw data is accident base, I need to transform the data into node-link json object to draw the chart.

The most amazing interaction in this chart is that users can manipulate the positions of the nodes by drag and drop actions. The nodes will move to certain position based on simulated force. Therefore, the positions of the nodes and links are not fixed.



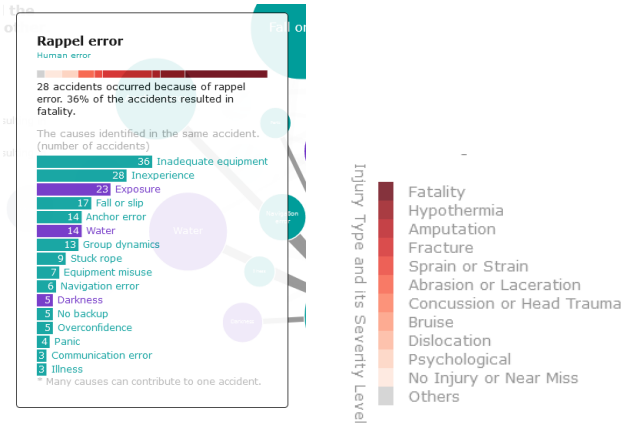
(a) Hover **(b) Dragging**

Figure 2. The interaction in main chart

In addition to the interaction from reference layout, I added the hover effect to help users focus on the causes and the associated causes (See Figure 2a). While hovering on a specific node, the associated causes and links will stay clear, and other non-related nodes and links will turn lighter. A tooltip of the focused cause will show while hovering. It will turn lighter while users are dragging since users would like to see the relationship between each cause rather than the detailed information while dragging (See Figure 2b).

The tooltip provides detailed information for those who want to know more about the specific cause. It contains a single stacked bar chart and a horizontal bar chart. (See Figure 3a)

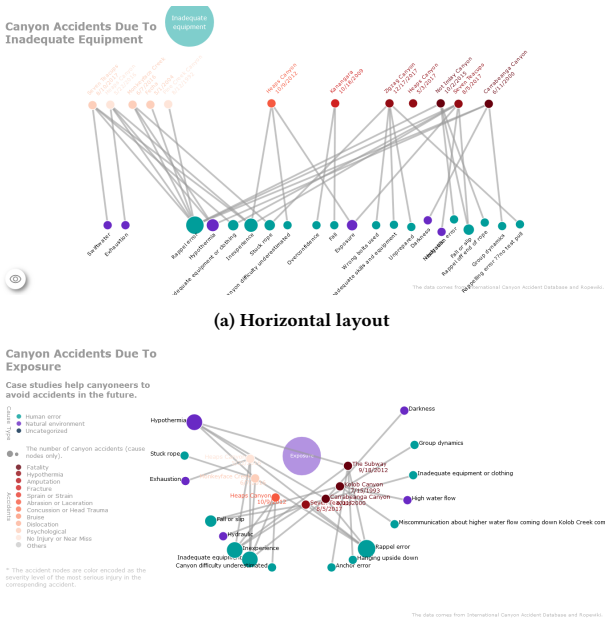
The stacked bar above shows the percentage of the most severe injury type from the accidents related to the focused cause. The



(a) The tooltip provides more details of the focused cause.

(b) The legend of injury type

Figure 3. The Tooltip in main chart



(a) Horizontal layout

(b) Radial Layout

Figure 4. Two layouts of secondary chart

injury type is not the most important factor in accident case study because one of the professional canyoneers told me in the interview that every small mistake can lead to serious result, and the only reason why they were survive is luck. Yet, I still position the injury bar at the top because it is a new information, compared with the horizontal bar chart. Moreover, although the injury is less important than cause, users will have great sympathy for the victims, making them more immersive and serious while analyzing the accidents.

The single sequential hue is encoded as the severity of injury type (See Figure 3b). I use red to represent injury, so users can easily identify the severity level by different level of lightness. Red is also in general a complementary color of cause type color, so users will not be confused about the color encoding. The percentage can be represented as pie chart as well, but since human are more sensitive to length and the bar chart can save more space, I decide to use single stacked bar chart.

The horizontal bar chart provide accurate numbers and comparison of the associated causes. The purpose is to emphasize the correlation of causes again.

2.2 Secondary Chart

The secondary chart shows more information after clicking on one of the node in the main chart. In this screen, users are able to focus on the accidents related to the selected cause.

The force-directed graph is applied as well, but I manipulate the parameters of the simulation function to set up two different layouts based on the number of nodes (See Figure 4). The radial layout is more immersive but less suitable for many nodes, so it is applied only on a small number of nodes. The horizontal layout shows a more transparent relationship. Since it occupies more space, I hide the legend. Users can find the legend by clicking on the show and hide icon (See Figure 5b).

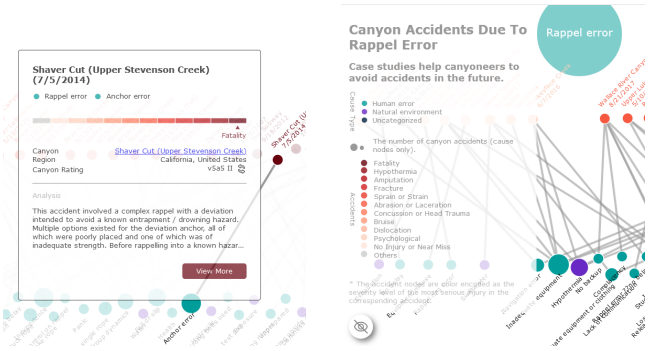
There are two kinds of nodes: accident nodes and cause nodes. Each accident node represents one accident and is color encoded and ordered by injury severity. The accident nodes link to other causes that identified in the accident. The order helps users to explore the relationship between cause and result. The number of links and the size of the cause nodes help user identify which cause is more important. The cause nodes have an implicit order, which is the average injury severity value.

The causes in the secondary chart are slightly different from the main chart. The causes in the main chart are categorized and lost details, while the causes in the secondary chart are not. Since the cause analysis is the primary purpose of this visualization, I decided to keep the detailed information in the secondary chart for users. Another reason is that the canyoneer I interviewed also mentioned that knowing the cause category is not enough for him since everyone knows that water or rappel error can cause fatal accidents. What is more important is the details.

The size of the cause nodes shares the same meaning that it represents the frequency of the cause, yet the size of the accident nodes does not have the same representation. The width of the links is no longer used in secondary chart as well.

The secondary chart has similar interaction to the main chart. The hover effect, drag and drop effect, and force simulation is similar.

While hovering on the accident nodes, another kind of tooltip will display to provide further information regarding the hovered accident (See Figure 5a). The tooltip lists the causes, injuries, the canyon data, and analysis. The canyon data contains the canyon name, the link to the canyon introduction page, the region, and the difficulty rating. The canyon information helps canyoneers to determine if this case is worth dig into it. They might be more interested in the canyons they plan to challenge, or they might be interested in a certain canyon level. The rating index can be switched to users' preferred system.



(a) The tooltip provides more details of the hovered accident.

(b) Users can click on the icon on the bottom left to display the legend.

Figure 5. More interactions in secondary chart

The analysis provides a glance or a digest of the accident. If users want to know the detail, they can click on the button to read the entire report.

In the secondary chart, users can explore more details. Besides exploring the relationship between accidents and causes, the further information in the accident tooltips helps users select the more attractive reports and, hence, start reading the narrative analysis and descriptions. It is a process to filter out the less essential accidents for each user.

Users can simply click on the inherited cause node from the main chart to go back, which is the same behavior to get into the secondary chart. While hovering on the significant cause node, users will see a custom back cursor, implying the path to go back.

3 INTERESTING FINDINGS

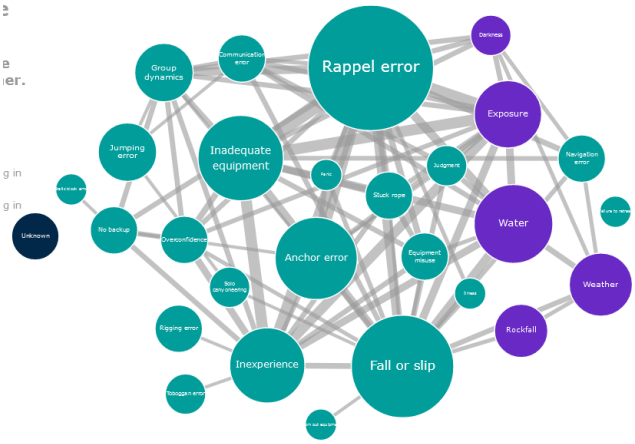
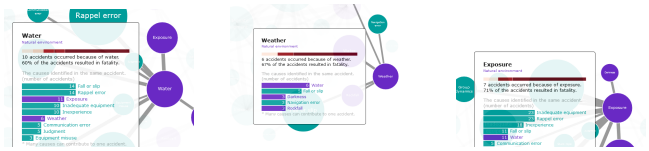


Figure 6. There are few single-cause accidents.

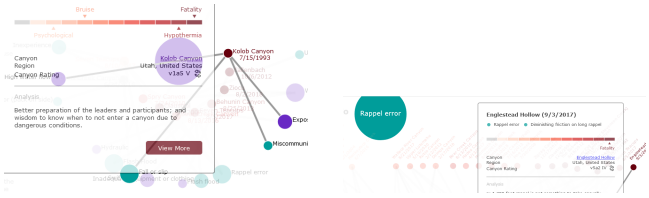
In Figure 6, we can see that most of the nodes are connected, and few nodes are isolated. This means that most of the time, an accident contains multiple causes. There is no single cause. The reason behind an accident is complex. Most of the time, the conditions or errors occurs successively. Canyonners need to be aware of series of mistakes.



(a) Water **(b) Weather** **(c) Exposure**

Figure 7. The causes related to natural environment usually resulted in serious accidents.

While exploring the natural environment cause type, the resulted accidents were usually serious (See Figure 7). We can observe this phenomenon at the single stacked bar. We can infer that there might be some human error occurred that made victims expose in cold water or rainy weather. Therefore, as a professional canyoneers, it is critical to judge which level of water flow is dangerous and should escape or stop travelling, or prevent yourselves to expose in fatal environment.



(a) The accidents related to water tend to occur in the canyons with more difficult challenges presented by water.

(b) The accidents related to rappel error tend to occur in the canyons requiring more advanced technical skills.

Figure 8. The relationship between cause and canyon rating

It is more likely that the water-related accidents occurred in canyons with more difficult water-related challenges, same as technical rating (See Figure 8). Nevertheless, the relationship is not strong. Other causes do not show the same patterns. That is, the canyon difficulty does not highly relate to injuries or causes. Canyoneers should be careful every time, no matter which level of canyon.