University of Illinois CS416 Narrative Visualization Essay

Messaging.

What is the message you are trying to communicate with the narrative visualization?

The message I am trying to communicate with the narrative visualization is the substantial increase in annual carbon emissions since 1980 and the correlated increase in global surface temperature and storms globally each year. A conclusion can be drawn by these trends that there is a strong link, and correlation, between increased carbon emissions and global temperature and storm frequency. There are costs that come from increased annual storm frequency including financial costs, homelessness, injuries, and lives lost, and therefore it is important as individuals to make mindful decisions that can help promote the health of the planet and strive to limit carbon emissions.

Narrative Structure.

Which structure was your narrative visualization designed to follow (martini glass, interactive slide show or drop-down story)? How does your narrative visualization follow that structure? (All of these structures can include the opportunity to "drill-down" and explore. The difference is where that opportunity happens in the structure.)

The structure of my narrative visualization follows the martini glass narrative structure. This structure is followed by beginning the visualization by having the user navigate down an author driven path across scenes 1 and 2, and it isn't until the user transitions to scene 3 is there the opportunity for the user to "drill-down" and explore data further by their own accord. When the narrative visualization first begins, the user is met with scene 1 and there are no tooltips nor data filtering options. There is only a bar chart displaying the annual global CO2 emissions with data annotations and simply a "next" button to navigate to the next scene. Upon selecting "next" the visualization transitions to scene 2 where there is also only a bar chart displaying the annual global surface temperature deviations with annotations, but no tooltips nor filtering capability maintaining the author-driven structure at this point in the "martini glass stem" part of the martini glass narrative structure. Once the user selects the "next" button on scene 2, the user transitions to scene 3. Now, at scene 3 user exploration and "drill-down" is possible via tooltips and dropdown components to filter the data and reveal additional information. At this point, in scene 3, the user is no longer in the martini glass stem and is able to explore.

Visual Structure.

What visual structure is used for each scene? How does it ensure the viewer can understand the data and navigate the scene? How does it highlight to urge the viewer to focus on the important parts of the data in each scene? How does it help the viewer transition to other scenes, to understand how the data connects to the data in other scenes?

Each scene follows the same visual structure to ensure smooth navigation between each scene throughout the narrative visualization and avoids unintentional distractions or disorienting the viewer. Each scene features a bar chart with year along the chart x-axis, and the same range of years (1980-2024) is intentionally chosen for each dataset used in the different scene bar charts to provide consistency among the different scenes and allow the user to understand concurrent observed trends between co2 emissions, global temperature, and storm frequency within the same period of time. In addition to the same range of years included for observation between the scenes, each scene is a simple bar chart in the same visual position and structure to further provide consistency and avoid confusion and disorientation as scene are transitioned to and from. In terms of same graph structure, chart label annotations are included for each scene again to provide consistency and seamless scene transition.

Scene 1 and 2, which are a part of the author-driven martini glass stem, include brief data annotations within the bar chart display to urge the viewer to focus on the upward trend of CO2 and global land-surface, air, and sea-surface temperatures respectively so that these trends are highlighted and known by the user which is important for the message to be communicated. These annotations are brief, data-driven, and are useful for highlighting the important trend in the data that I have looking for the viewer to take notice of.

All scenes, 1, 2, and 3, all additionally have an annotation below the bar chart display in order to provide additional information such as the source of data, questions that can drive the curiosity of the viewer and urge them to explore the narrative visualization further (a question is specifically in scene 1 since scene 1 is part of the author driven martini glass stem within the martini glass narrative visualization structure), as well as affordances (affordances such as information about using the “next” and “prev” buttons for scene navigation, as well as the user exploration options such as the mouse hover tooltip and dropdown filters available in scene 3). Simple “next” and “prev” buttons were chosen to help the user understand how to By including a more detailed annotation below the chart, I can further ensure the message is communicated in support of the data, as well as highlight the affordances so that the viewer can understand the interactive options available and use the visualization to the highest potential — especially important when it comes to the tooltip since this is an option that is not visible by default until a mouse hovers over a bar in scene 3.

Simple navigation buttons with text reading “prev” and “next” at the bottom of the page to the left and to the right respectively are included to indicate that the user may progress further into the narrative visualization or return back to a previous scene. Although this is clear to help the user transition between scenes, the annotation below the chart includes an affordance that further explains how the user can use the next and previous buttons to help them more.

Scenes.

What are the scenes of your narrative visualization? How are the scenes ordered, and why

The ordering of scenes have been chosen carefully based on the data that they visualize in order to best convey the overall message to the viewer. As previously described, the message this narrative visualization communicates is the substantial increase in annual carbon emissions since 1980 and from which the correlated increase in global surface temperature and storms globally each year. Therefore to best communicate the message the increase in CO2 emissions is first presented, and as the narrative progresses the global surface temperature trend is presented so the user can make the connection between co2 emissions and global climate change, and which is finally followed by the visualization to display the increase in global storms. To drive home the message, and provide user exploration following the martini glass structure, the final scene allows filtering and the ability to hover over bars and reveal a tooltip to further communicate the final cost of such storms including number of lives lost, the number of people injured, affected, made homeless, and reconstructive and insured costs.

Scene 1:
Scene 1 is comprised of a bar chart, an annotation that appears within the bar chart visualization, text that appears underneath the bar chart visualization serving as another annotation, and a "next" button at the bottom right of the visualization. The "prev" button is not visible for scene 1 since this is the first scene of this narrative visualization - and by hiding the "prev" button this communicates such information to the viewer and does not allow them to navigate to a previous scene since there is none.

The bar chart in scene 1 plots the annual global CO2 emissions caused from fossil fuels and industries from 1980 to 2024 from data sourced from the publicly available Global Carbon Budget (2024). The annotation that appears within the bar chart visualization highlights to the viewer that there has been a dramatic increase in global annual CO2 emissions since 1980. The "next" button at the bottom right of the visualization enables the user to proceed further into the narrative visualization and transition into scene 2 to follow. Following the martini glass structure, scene 1 is still within the martini glass stem and is author-driven not proving the capability for the viewer to conduct exploration.

Scene 2:
Scene 2 is comprised of a bar chart, an annotation that appears within the bar chart visualization, text that appears underneath the bar chart visualization serving as another annotation, a "prev" button that appears at the bottom left of the visualization, and a "next" button at the bottom right of the visualization.

The bar chart in scene 2 plots the annual global land-surface, air, and sea-surface temperature deviations from 1980 to 2024 from data sourced from the publicly available NASA's Goddard Institute for Space Studies (GISS) dataset. The annotation that appears within the bar chart visualization highlights to the viewer that global temperatures are increasing as the dataset reveals that since 1980 there has been higher mean temperature deviations from the previously recorded means. The "prev" button at the bottom left of the visualization enables the user to navigate backward within the narrative visualization and return to scene 1. The "next" button at

the bottom right of the visualization enables the user to proceed further into the narrative visualization and transition into scene 3 to follow. Following the martini glass structure, scene 2 is still within the martini glass stem and is author-driven not proving the capability for the viewer to conduct exploration.

Scene 3:
Scene 3 is comprised of a bar char, text that appears underneath the bar chart visualization serving as another annotation (and included affordance), a tooltip on mouse hover, two dropdown components, and a "prev" button that appears at the bottom left of the visualization. The "next" button is not visible for scene 3 since this is the final scene of this narrative visualization - and by hiding the "next" button this communicates such information to the viewer and does not allow them to navigate to a next scene since there is none.

The bar chart in scene 3 plots the annual global number of storms from 1980 to 2024 from data sourced from the publicly available EM-DAT dataset by y the Centre for Research on the Epidemiology of Disasters. The block of text that appears below the visualization highlights to the viewer where the data was sourced, what the data plots, and also provides affordances that the user may now explore by choosing a country and/or a storm subtype classification from the dropdown component for filtering, or hover over a bar to reveal a tooltip comprised of additional information. The tooltip includes the following information: year, number of lives lost, the number of people injured, affected, made homeless, and reconstructive and insured costs. The user can select a country from the first dropdown and/or a storm subtype from the second dropdown in order to reveal new insights into more drilled down, filtered, perspectives of the dataset. The "prev" button at the bottom left of the visualization enables the user to navigate backward within the narrative visualization and return to scene 2. Following the martini glass structure, scene 3 has moved out of the martini glass stem and now is in the mouth of the glass offering viewer exploration of the data to "drill down".

Annotations.
What template was followed for the annotations, and why that template? How are the annotations used to support the messaging? Do the annotations change within a single scene, and if so, how and why

The narrative data visualization is comprised of three scenes following the martini glass structure and each scene is comprised of its own annotations based on the data being displayed and affordances needed.

Scene 1 is comprised of two annotations: one which appears within the bar chart display that highlights to the viewer that there has been a significant increase in the levels of co2 emissions caused by industry and fossil fuels since 1980. There are no annotations that change within a single scene and remain simple and static to draw the user focus to the trend of data. Since the overall message of the narrative visualization is to explore the rise of global co2 emissions and the correlated consequences, the annotation highlights this rise to the user to ensure the message

is conveyed. There is also an annotation underneath the chart that informs the viewer of the meaning and source of the dataset, further highlights the trend that can be seen from the bar chart, prompts the user of a question that engages the viewer to seek more information and continue the narrative visualization, and finally offers an affordance by letting the viewer know that the “next” button can be used to navigate to the next scene of the narrative visualization. The annotations in these scene are specific to the co2 emissions dataset being used, and the annotations will change as the user transitions to scene 2 and scene 3 since different datasets are used in each scene and different information is highlighted, and additional affordances required for the viewer experience.

Scene 2 is comprised of two annotations, similar to scene 1 and in the same positions for consistency and familiar structure for the viewer, but differ in their content since a new piece of the message is communicated using this scene and an entirely different dataset is used. There is also an annotation that appears within the bar chart display, like scene 1, that highlights to the viewer that since 1980 the mean global land-surface, air, and sea-surface temperatures have increased (have positive deviations since previously recorded means). This continues to communicate and build upon the message being conveyed by the narrative visualization and ensure that the user is drawn to make the conclusions and observations that temperatures have increased - and make a link between such increases particularly after just seeing the dramatic increase in global co2 emissions which are known to negatively impact the Earth’s climate and environment. There is another block of text included underneath the bar chart, like scene 1, but the content differs as scene two uses data sourced from NASA's Goddard Institute for Space Studies (GISS) dataset and this is relayed to the viewer. To further highlight the trend that can be seen from the bar chart and build upon a conclusion that can be drawn after having seen the rise of CO2 emissions in scene 1, the annotation includes the following language “This link is alerted by the user in the annotation by saying “Global temperature increases have scientifically been linked with human activities such as fossil fuel burning, and greenhouse gases which cause the increase in global CO2 emissions shown by the previous scene.”. This is important to ensure the user is drawn to make such conclusions and further take home the message being communicated by the visualization. Finally, affordances are also included here to inform the user that the “next” button can be used to navigate to the next scene (so the user is drawn to the next button to understand the narrative is not over yet). However, differing from scene 1 this annotation includes the affordance that the now visible “prev” button can be used to return to the previous scene, scene 1.

Scene 3 is comprised of 1 annotation, which does not appear within the bar chart display but as text underneath the bar chart display, which is data-driven still informing the viewer of important information such as trends that can been seen and connections made to drive home the overall message. Scene 3 is the final scene and is at the end of the martini glass structure where user exploration is granted. Here, the user has the ability to filter the dataset by country and/or storm subtype to view trends of annual storm frequency since 1980 according to these selected parameters. Since the data within the bar chart display is able to change based on these parameters, there is no annotation within the chart display which is different than the earlier

scenes that fall within the author-driven martini stem part of the martini glass narrative visualization structure. However, since scene 3 introduces drop-down elements for data filtering the scene 3 annotation does provide affordances to highlight these options the viewer has. Also, scene 3 provides the user capability to hover the mouse over a bar in the bar chart display and an affordance within the annotation informs the viewer of this option since this option is not easily known by simple inspection of the scene.

Parameters.

What are the parameters of the narrative visualization? What are the states of the narrative visualization? How are the parameters used to define the state and each scene?

There are several parameters a part of the narrative visualization, as well as states, and how the parameters are used to define the state and each scene is detailed below for each:

1. *sceneIndex*: the sceneIndex is a parameter a part of the narrative visualization that is used to track the state of the visualization. Namely, this is an index that ranges from 0 to 2 inclusive that corresponds to each of the three scenes of the visualization (therefore there are **three states** of the narrative visualization: scene 1 (index 0), scene 2 (index 1), and scene 3 (index 2). The "next" and "prev" buttons used to navigate across scenes within the visualization increment and decrement the sceneIndex respectively (conditions keep the index within expected bounds) and this dictates the state of the visualization and which scene should be displayed so that then the expected information attached with each scene is rendered. When the sceneIndex is updated, the SVG data is cleared, and the sceneIndex is inspected during my renderScene() function to reference the necessary parameters and draw the correct visualization with the scene's loaded data, and other page aspects are updated based on the sceneIndex such as the visibility of dropdown and the content of the scene annotations. In summary, sceneIndex tracks with state (which scene) is active and based on this value the page is rendered accordingly and parameters associated with the active scene are referenced in order to yield the expected scene within the narrative visualization.
2. *co2_emissions*, *year_global_means*, and *em_dat*, are three array parameters that store the loaded CSV datasets for each scene. Based on the current state of the data visualization, which is tracked by the sceneIndex, the correct data source parameters are used when drawing the SVG elements using D3. Namely, when the sceneIndex is 0 and therefore the state of the narrative visualization is at scene 1, the co2_emissions parameter is used when drawing the bar chart display. When the sceneIndex is 1 and therefore the state of the narrative visualization is at scene 2, the year_global_means parameter is used when drawing the bar chart display. When the sceneIndex is 2 and therefore the state of the narrative visualization is at the final scene 3, the em_dat parameter is used when drawing the bar chart display.
3. *unique_countries*, and *disaster_subtypes* are two additional parameters in my narrative visualization that contain the sorted list of countries and storm subtype classifications that were created by inspection of the loaded em_dat CSV dataset which populate the country and storm subtype dropdown respectively. These dropdowns are made visible when the

sceneIndex is 2 indicating the state of the narrative visualization is at scene three which is the final state of the visualization at the point of the martini glass structure where users have the capability to explore.

4. *country_selection*, and *disaster_subtype_selection* are two additional parameters in my narrative visualization which are stored as global parameters when the callback functions are invoked from the trigger of a viewer selecting a country or storm subtype classification respectively from the country and subtype dropdown elements respectively at scene 3. By default, scene 3 displays global annual storm frequency and defaults to displaying such information across all different storm types but these parameters are updated during a callback function when the trigger of dropdown selection occurs by the user and the scene is re-drawn now that these parameters have changed.

Triggers.

What are the triggers that connect user actions to changes of state in the narrative visualization? What affordances are provided to the user to communicate to them what options are available to them in the narrative visualization?

The narrative visualization includes several triggers, and affordances to communicate their existence, to connect user actions to invoke change in the state of the narrative visualization:

First, the user can click on the ‘Next’ or ‘Prev’ buttons featured in the narrative visualization which is an event that is listened for and when the click occurs this causes a callback (is a **trigger**) for the scene index state parameter to increment or decrement accordingly and for the scene to then update (is re-drawn and update with new information) based on the new scene index so the correct scene is rendered. The ‘Next’ button is only available (visible) when scene 1 or scene 2 is rendered since scene 3 is the final scene and therefore there would be no “next” scene and so no need for a ‘Next’ button. Similarly, the ‘Prev’ button is only available (visible) when scene 2 or scene 3 is rendered since scene 1 is the first scene and therefore there would be no previous scene to navigate back to and thus no need for a ‘Prev’ button. The affordance that is provided to allow the user to have knowledge of this option is the text (affordance) below the chart visualization that reads “Select 'Next' to navigate to the next scene.” and “Select 'Prev' to return to the previous scene” accordingly depending when the buttons are visible to further emphasis to the user the purpose and available option of the ‘Next’ and ‘Prev’ buttons.

Second, the user can select an option from one or both of the drop downs that are visible for scene 3. Scene 3 offers user exploration and there is a dropdown containing a list of countries. The event (action) for the user to select a country from the dropdown is listened for, and when this actions occurs this issues a callback (country selection is a trigger) to a function that will read the selected item, store the selection as a global parameter and re-invoke scene rendering which will reference the parameter and filter the data, and re-draw the scene based on the new filtered data the SVG elements can bind to. This enables the viewer to view storm frequency trends for a specific country, or by default, the “World”. There is a second dropdown that works

similarly and offers the user the ability to select a storm subtype (Hail, Cyclone, Tornado, etc.) and the user selection of a storm subtype is listened for (this is a trigger). When the selection occurs this causes a callback to a function that will store the selection and re-render the scene. Comprised within the block of text serving as an annotation underneath the chart, the following text which is an affordance, lets the user know the purpose of the drop-downs:

> "Explore! … and select from the drop-down to filter by country and storm subtype to reveal trends"

Third, another trigger is when the user hovers over a bar in the bar chart in scene 3 (the mouseover event), as well as when a viewer stops hovering over a bar in the bar chart in scene 3 (the mouseout event) after having been moused over. When the user hovers over a bar in the bar chart, this invokes a tooltip with additional data information associated with the bar (including the aggregated number of lives lost, the number of people injured, affected, made homeless, and reconstructive and insured costs across all the storms that year) to become visible by increasing its opacity. When the viewer moves the mouse such that they are no longer hovered over a bar, the tooltip opacity reverts back to 0 so that it is no longer visible. Comprised within the block of text underneath the chart on the page which may serve as an annotation underneath the chart, the following text which is an affordance, lets the user know about the existence of the ability to hover over a bar and reveal a tooltip since this is not obvious:

> "Explore! Hover over bars in the visualization to reveal additional information about impact of the storms that occurred in the corresponding year…"