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Section 508 and Maps: Breaking Down Barriers for People with Visual Impairments or Blindness

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ABSTRACT

Independent access to maps and geospatial data has always been a systemic barrier for people with visual impairments or blindness (VIB). That barrier inhibits our participation in the classroom, on the job, and within our communities. SAS® is working to solve that problem. This paper defines accessibility as it relates to maps and geospatial data, describes initial support for accessible maps in SAS® Graphics Accelerator, and explains how you can use SAS® 9.4 to create maps that are accessible for everyone, including people with VIB.

INTRODUCTION

The goal of accessibility is equal access for people with disabilities. The Section 508 amendment to the Rehabilitation Act, the Americans with Disabilities Act, and similar laws around the world were created to achieve that goal.

That goal has been largely realized for certain types of digital content. For example, simple static text web-based content is largely accessible for people with disabilities. However, the goal of accessibility has not been realized for content that is highly graphical and visual. As a result, people with blindness, including the authors of this paper, do not have equal access to the wealth of information that is communicated graphically.

Over the past few years, SAS has delivered technology that enables people with blindness to independently access many types of charts and graphs. We recently began to focus our accessibility R&D efforts on maps and delivered pre-production support for non-visual access to geo scatter maps, which are also known as coordinate maps. Coordinate maps represent a collection of individual geographic points.

The remainder of this paper will explain the pre-production support for non-visual access to coordinate maps in SAS Graphics Accelerator as of March 2020. It includes a description of how people with blindness can independently explore and perceive coordinate maps. It also includes a brief explanation of techniques that you can use to create and publish coordinate maps that are compatible with SAS Graphics Accelerator.

BACKGROUND

In 2010, SAS initiated a program to research and develop technologies that improve the accessibility of data visualization. The goals of that R&D program include:

1. Enable people with blindness to independently analyze data and perceive data visualizations using non-visual methods.
2. Incorporate those non-visual methods seamlessly into SAS products.
3. Enable researchers, statisticians, and analysts to easily create quantitative reports and data visualizations that can be independently accessed by people with blindness.

In 2016, the initial fruits of that investment were delivered as the new ACCESSIBLE_GRAPH option on the ODS HTML5 destination and a new product named SAS Graphics Accelerator.

The ACCESSIBLE_GRAPH option enables SAS programmers to easily create data visualizations that can be independently accessed by people with blindness. When enabled, this option automatically includes accessibility metadata within data visualizations created using the ODS Graphics procedures. The accessibility metadata is invisible for sighted users. However, it enables blind users to access alternative non-visual presentations of the data visualizations using SAS Graphics Accelerator.

SAS Graphics Accelerator is an extension for Google Chrome. It is free for all users. After it is installed from the Chrome Web Store, SAS Graphics Accelerator detects SAS Visual Analytics report objects and accessible ODS Graphics output within web pages, and enables users with blindness to access those graphs using multiple modalities. For example, users with blindness can interactively explore the bars in a bar chart with keyboard commands and hear a musical tone for each bar that indicates the height of the corresponding bar on the Y axis. They can perceive additional information about individual bars and the entire graph as text that is spoken aloud using text to speech technology or displayed as braille on a refreshable braille display. Those items might include exact values on the Y axis, categorical values on the X axis, axis labels, and so on.

Since 2016, we have worked closely with users with blindness to improve the utility of SAS Graphics Accelerator. For example, we added features that are required by students with blindness in middle school and high school. We also added a feature that enables users with blindness to extract data from tables in web pages and quickly graph that data. We added support for Exploratory Data Analysis so that users with blindness can quickly import data and explore it using descriptive statistics.

As we worked with users of SAS Graphics Accelerator, it became clear that there is a desperate need for tools that enable people with blindness to efficiently and effectively perceive geospatial data. In fact, we found compelling evidence to support the theory that the lack of awareness and understanding of maps among people with blindness is so pervasive that we, as a group, don’t know enough about maps to know what we’re missing.

MODELS OF INTERACTION

The user experience for coordinate maps within SAS Graphics Accelerator builds on two models that are widely used within the blind community. They include the screen reader interaction model and the long cane interaction model.

SCREEN READER INTERACTION MODEL

People with blindness access computers using keyboard commands and a special type of assistive technology software program called a screen reader. We use keyboard commands that are part of the operating system and software applications. For example, in Microsoft Windows we press Alt + Tab to switch applications, we press Tab to move keyboard focus among the controls within an application, and we use arrow keys to navigate lists, trees, and so on. We also use special keyboard commands that are provided by screen readers. These commands allow us to quickly navigate content within an application in a way that is roughly equivalent to the process that a sighted person uses to visually scan the content of an application.

Screen readers present application content as text that is spoken aloud using computer-generated speech. The speech output from a screen reader might be identical to the text that is represented visually on the screen, or it might be special text that conveys essential information about graphical controls. For example, whereas a sighted user sees a checkbox visually on the screen, a blind user can perceive the same checkbox as text that states the fact that the role of the control is a checkbox, the state of the control is “checked”, and the label associated with the checkbox is “I agree”.

The pattern of interaction between an accomplished blind user and a screen reader typically includes very rapid keyboard input followed by speech output from the screen reader, ad infinitum. This interaction model is always top of mind as we design software for users with blindness because we want to create user experiences that feel native to that target audience.

LONG CANE INTERACTION MODEL

People with blindness learn how to navigate the physical world safely using a long cane. Long canes that are used by adults are typically somewhere between four and five feet long.

Conceptually, the long cane serves as an extension of the blind pedestrian's pointer finger. Blind pedestrians use the cane to feel the ground and potential obstacles. We are trained to systematically move the cane from side to side in approximately a 45-degree arc as we travel.

Figure 1. A Person with Blindness Using a Long Cane

SAS GRAPHICS ACCELERATOR MAP VIEW

As of March 2020, SAS Graphics Accelerator includes a new view called the Map View. Within the Map View, map data are represented on a spherical model of the Earth. A blind user explores this virtual Earth using a first-person interaction model that is conceptually identical to the model she uses to explore the physical Earth.

When exploring the physical Earth, the blind pedestrian occupies a location on the Earth. She perceives her surroundings in 360 degrees using her cane and her sense of hearing. She can move along the surface of the Earth in any direction to systematically explore her surroundings.

Similarly, when the blind user explores a map within map View, she occupies a virtual location on the virtual Earth. She can move to a new location on the virtual Earth. She can perceive her surroundings in 360 degrees. However, she uses a virtual cane instead of a physical cane. As she touches map objects with her virtual cane, Map View provides feedback about the objects using sonification and computer-generated speech.

One important difference between the physical Earth and the virtual Earth within Map View is the size of the area that can be perceived from a specific location. Realistically, a blind user can perceive only four or five feet of the physical Earth in 360 degrees with her physical cane and perhaps a few hundred yards with her sense of hearing. However, when exploring the virtual Earth in Map View she can increase the length of her virtual cane up to 6,225 miles. That allows her to explore an entire hemisphere with one 360-degree sweep of her virtual cane.

When exploring the virtual Earth in Map View, blind users can control their virtual cane using a joystick on a standard gamepad controller. Gamepad controllers are designed for use with video games. They connect to a computer using a USB cable. They have several joysticks that permit 360-degree motion, a D-pad, and many other controls that can be utilized by video game designers. Gamepad controllers can be purchased for as little as $20.

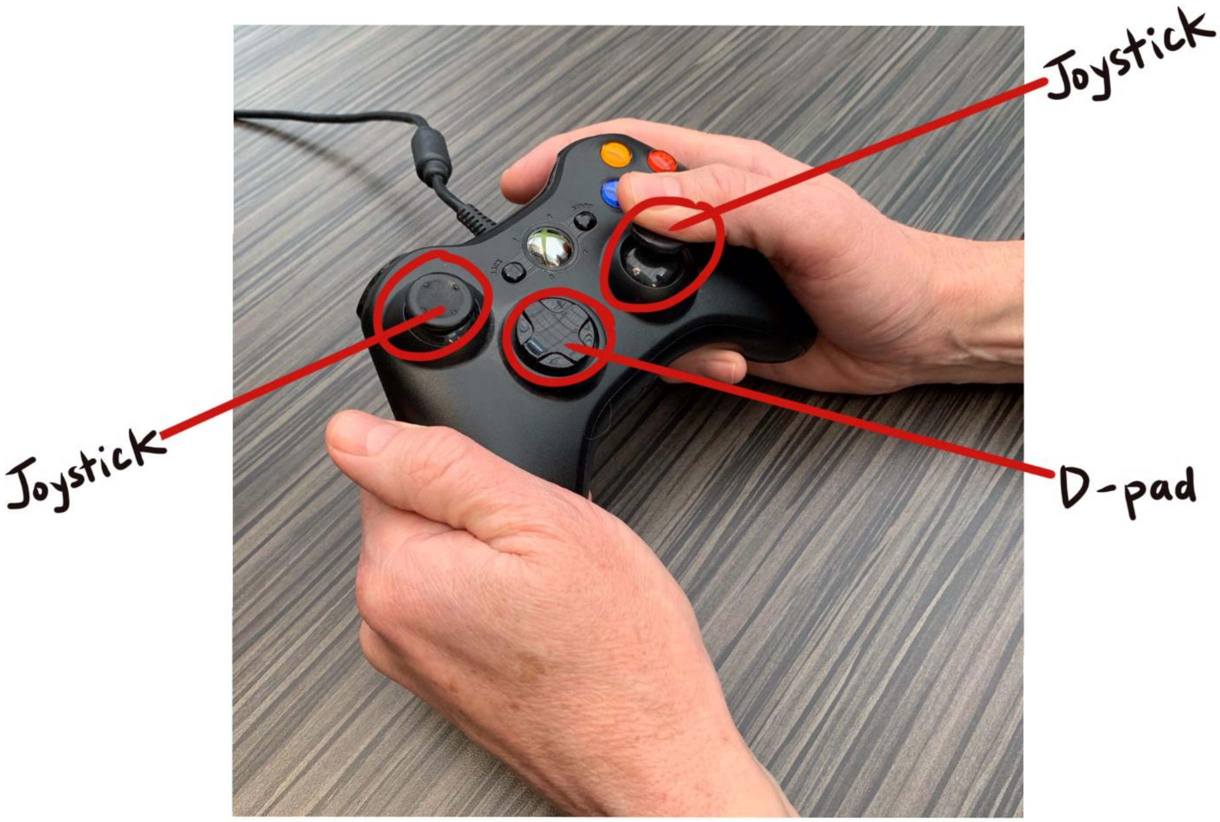

Figure 2. A Gamepad Controller

Map View accepts input from standard computer keyboards and gamepad controllers. However, the gamepad controller provides a much more intuitive user experience for blind users because the joystick on a gamepad controller is a powerful metaphor for a long cane. This metaphor leverages knowledge and experience that is possessed by many people with blindness.

When exploring a map using Map View, the user is always facing due North. So, when she pushes the joystick directly away from her body, she encounters map objects that are in front of her and north of her virtual location. When she pulls the joystick directly towards her body, she encounters objects that are behind her and south of her virtual location. When she pushes the joystick to her right, she encounters objects that are to her right and east of her virtual location. When she pushes the joystick to her left, she encounters objects that are to her left and west of her virtual location.

As the user physically moves a joystick to control the position of her virtual cane within 360 degrees, she hears instant auditory feedback for each object she encounters within the map. The primary auditory feedback is a short musical tone. The tone is generated using spatial audio. However, a surround-sound speaker configuration is required to hear spatial audio. So, the tones were designed to include redundant audio characteristics that support standard stereo speakers or headphones.

For example, the relative distance of an object from the user's virtual location to the end of her virtual cane is indicated using pitch. Nearby objects are indicated using high pitch whereas objects that are near the end of her virtual cane are indicated using a low pitch. Recall that the user can effectively zoom in and out by changing the length of her virtual cane.

The tone for each object is panned between the left and right speakers based on the object's bearing off due north. Objects that are due north and south from the user's virtual location are perfectly balanced between the left and right speakers. Objects that are due east are played in the right speaker. Objects that are due west are played in the left speaker.

The front or back position of an object is indicated using synthesized sound. Objects to the north are not synthesized, whereas objects to the south have a slightly metallic sound.

In addition to the sonification describe above, the user can choose to hear a verbal description of each object. The verbal description can include the label of the object, the distance to the object, and the bearing of the object. For example, the user might hear "New York City, 230 miles at three o'clock".

The user can quickly move around the map by panning due north, south, east, or west. She may also jump to any object she encounters with her virtual cane or search the entire map for an object and then jump directly to it.

People with blindness can use these interactions to efficiently perform the following tasks:

- Scan an area of a map to quickly perceive the location and distribution of points within the map.
- Quickly perceive the density of points within a map.
- Jump to a cluster of points, zoom in, and perceive the distribution of points within that smaller area.
- Locate a specific point within a map by name and jump to that point.
- Understand the name of nearby points as well as the bearing and distance of each point from the current virtual location.

- Systematically explore a map by panning and scanning each area with a 360-degree sweep of the virtual cane.

CREATING ACCESSIBLE COORDINATE MAPS

When creating SAS output, we recommend that you follow the best practices defined in [Creating Accessible SAS 9.4 Output Using ODS and ODS Graphics](). Some of the most important best practices include using the ODS HTML5 destination, using the ACCESSIBLE_GRAPH option, and using ODS Graphics to create data visualizations. We also recommend that you use the SGMAP procedure to create maps.

In the future, we hope to enable the SGMAP procedure to support the ACCESSIBLE_GRAPH option on the ODS HTML5 destination. That will enable you to easily create maps that are compatible with SAS Graphics Accelerator by simply enabling the ACCESSIBLE_GRAPH option.

For the time being, we recommend that you include your PLOTDATA in your SAS output so that people with blindness can manually create accessible maps within SAS Graphics Accelerator using that data. Be sure to include the variables you used for longitude and latitude as well as variables that were used for options such as COLORRESPONSE, DATALABEL, GROUP, and so on. Including all relevant variables enables blind users to create a map that they can perceive in a way that is functionally equivalent to the way sighted users perceive the visual map.

There are two ways to include your PLOTDATA in your SAS output. For small data sets, use the PRINT procedure to create a table inline within the same HTML5 output file that contains the corresponding map. That enables people with blindness to use SAS Graphics Accelerator to quickly extract your PLOTDATA from the table and create an accessible map from it.

The following code produces output that includes PLOTDATA as an inline table

```
ods html5 accessible_graph file="output.html";

proc sgmap plotdata=work.dams description="High hazard dams in Wake
County";
   openstreetmap;
   scatter x=longitude y=latitude / datalabel=name;
run;

proc print data=work.dams label contents="High hazard dams in Wake County";
   id name;
   var longitude latitude;
run;

ods _all_ close;
```

For larger data sets, you might create a side file that contains your PLOTDATA and provide a link to that file inline near the corresponding map. In that case, people with blindness can download the side file, import the file into SAS Graphics Accelerator, and create an accessible map from it. SAS Graphics Accelerator can import comma-separated values (CSV) files, tab-delimited files, and XLSX files. To create CSV or tab-delimited files in your SAS output, use the EXPORT procedure. To create XLSX files, use the ODS EXCEL destination.

The following code creates a side file and output that includes a link to the side file:

```
proc export data=work.dams dbms=csv outfile="dams.csv" dbms=csv replace;
run;

ods html5 accessible_graph file="output.html";
```

```
proc sgmap plotdata=work.dams description="High hazard dams in Wake
County";
   openstreetmap;
   scatter x=longitude y=latitude / datalabel=name;
run;

ODS ESCAPECHAR="^";
proc odstext;
   p "^{style [url='./dams.csv'] Download map data in CSV format}";
run;
```

ods _all_ close;

CONCLUSION

People with blindness currently do not have equal access to maps and geospatial data. We believe the root cause of this problem is not a lack of standards, legislation, or enforcement. Rather, we believe that the root cause is a lack of imagination and innovation.

This paper describes a powerful, intuitive interaction model that enables people with blindness to independently explore and perceive coordinate maps. The interaction model was designed by blind people for blind people. It leverages existing concepts and models that are widely used in the blind community. However, it is just a start. There are more complex types of maps that are still inaccessible. In the future, we hope to create accessible solutions for all types of maps and seamlessly incorporate those solutions across the SAS product line.

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