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Introduction: The USGS Astrogeology Science Center is developing the Planetary Image Editor (PIE), an I/O Web Service that can be used by researchers to create publication ready figures from images found using the Planetary Image LOcator Tool (PILOT) [1] and processed by the Map Projection On the Web (POW) service [2]. PIE accomplishes this by utilizing the Integrated Software for Imagers and Spectrometers (ISIS) [3] to read labels and convert raw binary data to graphical image formats.

This application removes the tedious parts of preparing publication-ready figures by limiting the amount of effort required to create scale bars and other annotations as well as extract metadata for image captions. For example, researchers looking to add a scale bar to an image product typically need to extract the pixel scale from the metadata and then calculate the mathematical ratio to make a scale bar the correct length for the image using an image editor like Adobe Photoshop. PIE does this automatically, not just for scale bars but also for figure annotations with standard icons for a north arrow, sun direction and observer position. PIE also extracts information from the metadata to fill in an image caption template at the push of a button. PIE greatly reduces the steps that researchers must complete every time they want to create a figure for publications. Automating these procedures following established standards will also enhance the completeness of captions and interpretability of figure annotations.

Background: The original goal for PIE was to assist researchers in creating publication ready figures from ISIS .cub files. However, it was decided that the utility would be greatly enhanced by integrating PIE into an online tool. We chose PILOT since it is an inhouse tool that already works with ISIS on the back end. Working with PILOT simplified some aspects of the problem because the input files to PIE are the products of a well-defined processing pipeline. The problem with using any generic ISIS file, is that the level of processing and available metadata can be extremely variable.

PIE takes advantage of the design of POW to retrieve the user's products while on the USGS servers without needing to download a file before editing an image. POW gives the user a job key when they submit a new job, and with this key we can use the known file system design of POW to query for folders with the specified job.

The user interface had to be redesigned in the shift away from accessing local files on a user's computer.

The new design is focused on giving users additional customizable options. PILOT simplifies the process of preparing the files by connecting the use of POW. PIE then simplifies the last steps in the process, making a publication figure.

Implementation: Users of PIE will be able to 1) upload map projected images (.cub or .tif), 2) input a POW job key to retrieve images processed by POW, 3) add icons to the images, 4) add annotation to the image 5) drag and drop any of the elements in the figure, 6) create inlayed caption boxes, 7) manipulate the size and colors of any figure element, 8) customize text sizes and color of caption 9) change the layers of the objects in the figure, 10) export the caption text as an ASCII file (.txt) separately from the figure, 11) export figure with icons and annotation objects as PNG, JPG, SVG, or GeoTIFF and 12) accomplish all these tasks on any browser.

To allow users to upload a map projected image, PIE uses a simple upload button with a validation script that checks the file type of the image uploaded before uploading and again on the server after upload. Accepted file types are ISIS .cub and GeoTIFF.

If users have processed images with POW and received the job key, they can access the output using the key given to them from the POW service. PIE uses the key to return a copy of the folder to the user. This gives PIE users the ability to edit their map projected images and download them in one step as opposed to downloading the images, calculating scale and editing them, then downloading the finished image.

PIE users can add icons to the screen by dragging and dropping the icons from the button toolbox on to the figure area. Icons were made using SVG 1.0 and added to the image using JavaScript. Annotation elements for PIE include SVG line and rectangle objects. For both annotation elements and icons, SVG gives PIE the freedom to manipulate the photo all on the browser instead of requiring a strong internet connection to a server and it can be used on any browser. Using Sharp.js gives the PIE server the ability to convert SVG metadata into JPG or PNG files then the Geospatial Data Abstraction Library (GDAL) [4] can be used to reattach the geospatial data labels to make GeoTIFF files.

PIE allows users to drag and drop objects all within the figure area by simply clicking and dragging the objects. This was done by writing an object class for tracking objects using class names to distinguish from different important objects in the figure. In order to add multiple draggable objects to the figure, the user

will only need to drag and drop them into the figure; PIE assigns unique object IDs and uses a generic drag and drop module in JavaScript to handle the rest.

PIE allows users to write custom captions as well as providing recommended captions based on the metadata within the image itself. The caption can then be exported as an ASCII file (.txt) so the user can copy and paste it into their document editor of choice. PIE uses JavaScript to download the text file of the caption. In order to give users an interface for writing the captions, PIE created a custom formatter that uses SVG 1.0 text objects as well as SVG tspan elements to format the caption within the editor box, something that SVG text elements alone does not support. The key parameters in this module are the text size, the width of the caption box and the total non-whitespace character count. With these measures, PIE is able to force a paragraph format on SVG text elements which are designed for single lines of text at a time and does not render new line characters.

PIE provides a high level of customizability of the output. Any object in the figure area has customizable locations, primary and secondary color schemes, and in the case of icons, scale. PIE created a custom layer system for the SVG figure where the level of the toolbox inside of the toolbar is directly correlated with the location of the icon in the SVG layer. Users drag the toolboxes up or down and the object associated with it is moved as well. This helped customizability by giving users the freedom to order layers and icons inside the figure.

The last and most important feature of PIE is the ability to take the figure that was created and export that image into a format that meets the requirements of major journals as well as support meeting posters and presentations. PIE does this using Sharp.js to convert SVG image data to JPG for posters, presentation slides and web pages as well as PNG or TIFF files for journals. GDAL is used to combine a geospatial label, called a virtual file, and a JPG or PNG file created by Sharp.js to export GeoTIFF files.

To maximize accessibility, PIE uses raw CSS and JavaScript features that are supported by all the major browsers. For example, foreignObjects in SVG 1.0 are not supported in some browsers and thus we could not use them to format the text for the caption. Raw JavaScript was used extensively to guarantee compatibility between the various web engines and many design choices on the front end were made to guarantee compatibility with browsers.

Conclusion: The main functionality of PIE has been implemented. Soon this service will replace the PIP Server as the new online publication figure editor at the Astrogeology Science Center. The link to this service is not active yet but it will be hosted on the ASC servers in Flagstaff.

References:

[1] https://pilot.wr.usgs.gov/.
[2] https://astrocloud.wr.usgs.gov/.
[3] https://isis.astrogeology.usgs.gov/.
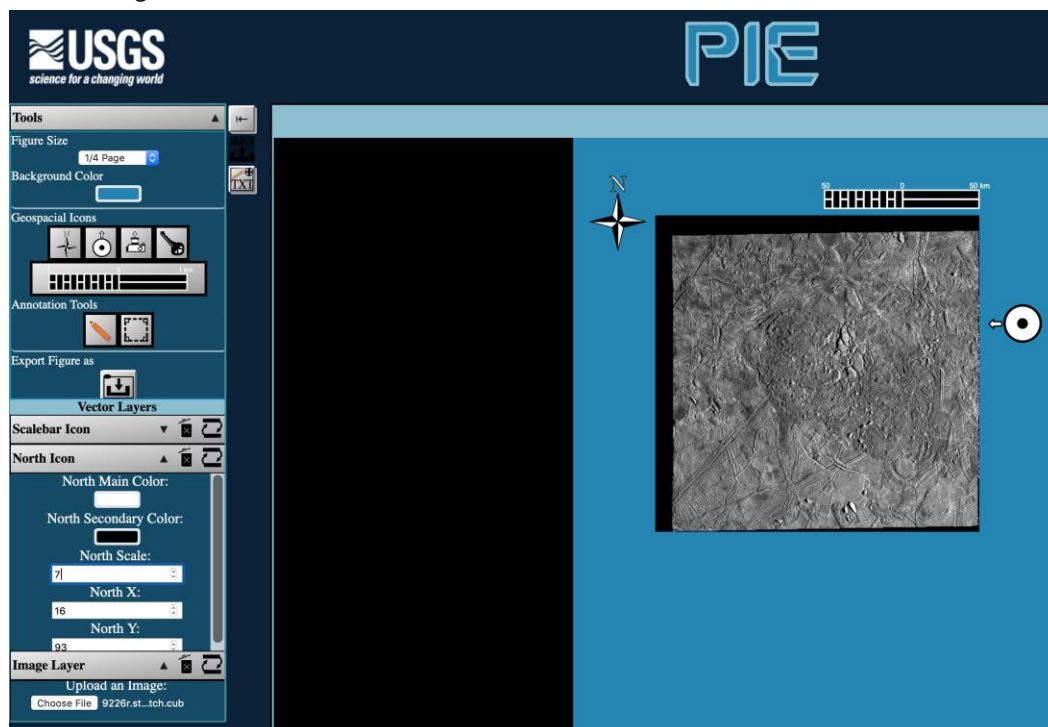[4] https://gdal.org/.

Figure 1. The graphical interface for PIE. A *Galileo* image of Europa is shown on the right with a north arrow, scalebar, and indicator of the sun direction. Working down the left side are controls for (a) sizing the figure to fit journal formats, (b) icons and text annotations, (c) exporting results and (d) adjusting layers