Identifying Geographic Features through Map Interpretation: A Case Study of Craters Using Controlling Variables

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With the development of three-dimensional geovisualization techniques, people realize the increasing need on their sensory experiences on maps. A map usually depicts the location, the topography and thematic information. The identification of geographic features on the map can facilitate the process of understanding the geographical background of a study area. However, identifying geographic features on the map at the first sight is not trial. In this work, we present a comprehensive analysis aiming to answer the research question: which variables would affect the interpretation of the geographic features on the map. We use craters on a Hawaii Island (i.e., The Big Island) as an example to study which geovisualization/cartography variables have more influences on helping people distinguish the geographic features more easily and efficiently. We apply the method of controlling variables in scientific experiment design to make our research more convincing. The variables used in our case study are *transparency*, *spatial resolution*, *layer order*, *discrete or continuous data model for visualization*, *classification methods,* and *the numbers of classes*. In each study, we only change one variable and keep all other variables unchanged.

We downloaded the digital elevation model (DEM) at the spatial resolution of 90m*90m of the Hawaii Island from the Consortium for Spatial Information of the Consultative Group for International Agricultural Research (CGIAR). Then we derived the hillshade from each input DEM layer to facilitate the visualization of the terrain surface. As shown in Figure 1, the following studies are all based on changing different variables' property settings of the hillshade layer and the DEM layer. In our first group of experiments, hillshade is the top layer and DEM is the layer below. The first variable we changed is the *transparency* of the hillshade, since the transparency helps people simultaneously visualize different layers especially in the terrain feature identification process. We evenly divided the percentage of transparency into 20%, 40%, 60%, 80%. We excluded 0% and 100% since 0% means we cannot see the layer below and 100% means we cannot see the top layer. The results demonstrated that 40% and 60% of transparency settings can have a good combined visualization of the two layers, which were neither too abrupt nor too hazy for identifying craters. The difference between them is that 60% transparency setting is brighter than the 40% transparency at the craters' area.

In addition to transparency, we studied whether increasing spatial resolution will amplify the difficulty of visualizing craters. We kept the hillshade as our top layer and used both 40% and 60% transparency to compare the results. Our original cell size is 90m and we used the "resampling" tool to reset the cell size. With spatial resolution of 300m, we can still clearly visualize 4 craters under both 40% and 60% transparency settings, while the "Kohala" craters become too vague to be identified on the map at the spatial resolution of 800m. With the cell size of 1000m, except the largest crater chains in Mauna Loa, the craters in Hualalai and Mauna Kea are all too vague to be identified. And no crater features could be identified at the spatial resolution of 2000m. Therefore, we concluded that *the spatial resolution* is an important factor in visualizing and identifying different sizes of craters on the map.

Whether the layer order can affect the visualization of craters becomes our second group of study. We moved the hillshade layer to the bottom and then changed the transparency into 0%. Then we changed the transparency of the top DEM layer in both 40% and 60% settings to see the alternatives. We found that no matter at which spatial resolutions, the resulting maps based on the DEM layer with 60% transparency at the top were similar to the corresponding maps based on the 40% transparency hillshade layer at the top. Therefore, we concluded that *the layer order* is not an important variable for the visualization of craters.

We also examined whether the GIS data type – continuous or discrete – will influence the visualization of craters. We only changed the settings -- *classification methods* and *the numbers of classes* – of the discrete layers at the top. Since we already figured out that both 40% and 60% transparency and high spatial resolutions can better visualize craters, we used these settings in the following discussions to minimize the impacts of other factors. Using hillshade as the top layer and changing the numbers of classes, it showed that larger classification numbers could display maps more smoothly and include more details. However, it was hard to identify too many color ramps because of the limitation of human cognition. We found that 5 or 7 classes could have better visual interpretations. In addition, we found that the classification methods will only slightly change the brightness of grayscale area, but no matter which classification methods were used we can still clearly identify craters under these combination settings. Therefore, we concluded that the data types – whether the map layer is continuous or discrete – would influence the recognition of the craters; nevertheless the classification methods and the numbers of classes of discrete data are not determining factors.

In conclusion, after conducting about 100 times of six controlling-variable experiments on visualizing craters on the map, we found that primary determining factors should be *the transparency* and *the spatial resolution*. Both 40% and 60% transparency layer settings are good in visualizing craters. The higher the spatial resolution is, the clearer the craters are represented. The choice of spatial resolution would be determined by the size of the crater. Other than these two variables, changing the data type of the map layer of which should be visualized, the layer order of DEM & hillshade, the visual classification methods, and the number of classes are not determining factors according to our study. Our future plan is to apply this study design into more craters in other areas and other geographic features as well. This research could offer insights on how to better visualize and identify craters with the DEM and the hillshade information on the map.

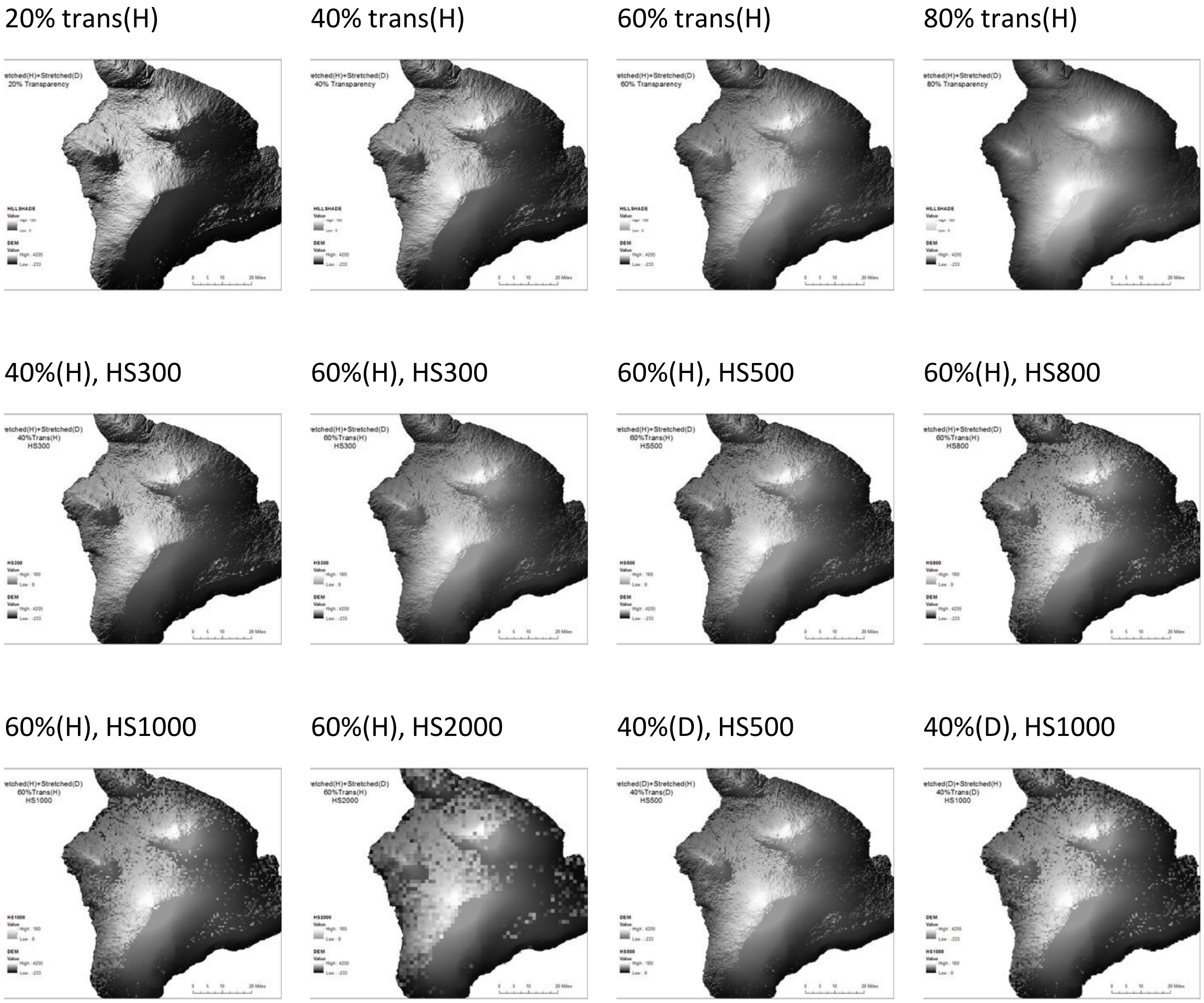

Figure 1. Selected resulting maps from our controlling variable experments

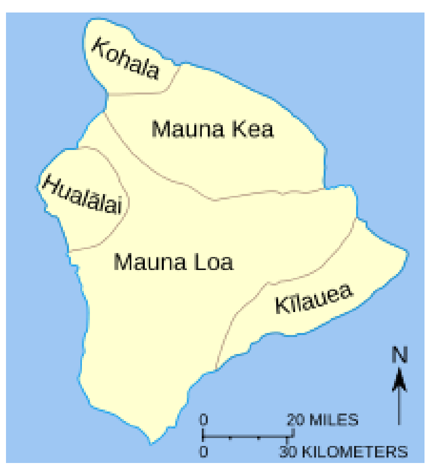

Figure 2. The study area