Real-Time Visualization of the Electric Grid Disruptions: Cartographic and Computational Challenges

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US electric grid is a sophisticated network system that consists of thousands transformers, generators, and loads interconnected through high-voltage transmission lines and local distribution systems. To make the electric grid running and prevent major outages, the balance must be kept between energy generation and energy consumption. This goal is achieved by equipping electric grid with a large number of sensors and other data collections devices. These monitoring data has to be analyzed and presented to grid operators and other decision makers in a timely and concise manner so that they can receive a clear and up-to-date picture of what happens on the grid and at the same time have a good grasp of the geographic context of the events. Presenting such operational picture to the decision makers brings about a number of computational and cartographic challenges. The real-time data stream of 1-2 TB per hour has to be ingested and processed by a number of modeling and analytical algorithms and then converted into a form that can be comprehended by a human eye and displayed or replayed using advanced visualization hardware like display walls. Typically the data (e.g., synchrophasor measurements) are updated at 60 Hz.

In this paper we propose several cartographic techniques for real-time visualization of the electric grid frequency data at the subcontinental scale and substation-level resolution. Jenks natural breaks classification method is extended to support dynamic data and series of frequency maps by applying the algorithm both to spatial and temporal domains. We also use multiple sets of natural breaks and diverging color ramps on the same map to emphasize those frequency ranges that are most indicative of the disruptions. A prototype system was developed and tested using historical and simulated data for known and hypothetical failures and outages.

Keywords: electric grid visualization, dynamic maps, Jenks natural breaks, diverging colormaps