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Interactive exploration of the vulnerability of the human infrastructure: an approach using simultaneous display of similar locations

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Currently, three quarters of the Swiss population is living in urban areas. The total population is still increasing, and urbanized space is increasing event faster. Consequently, the intensity of use has decreased but the exposure of the urban space to natural events has grown along with the cost related to the impact of hazards. In line with this fact, during the 20th century there has been a noticeable increase of natural disasters accompanied by the rapid increase of the world population, leading to higher costs. Additionally to the fact that more people are exposed to natural hazards, the value of goods globally has increased more than proportionally. Consequently, the vulnerability of urban space is, more than ever before, a major issue for socio-economic development. Here, vulnerability is defined as the potential human loss or loss of infrastructure caused by a hazardous event. It encompasses factors of urban infrastructure, population and the environment, which increase the susceptibility of a location to the impact of hazards.

This paper describes a novel method for improving the interactive use of exploratory data analysis in the context of minimizing vulnerability and disaster risk by prevention or mitigation. This method is used to assess the similarity between different locations with respect to several characteristics relevant to vulnerability at different scales, allowing for automatic display of multiple locations similar to the one under investigation by an expert. Visualizing vulnerability simultaneously for several locations allows for analyzing and comparing of metric characteristics between multiple places and at different scales. The interactivity aspect is also useful for understanding vulnerability patterns and it facilitates disaster risk management and decisions on global preventive measures in urban spaces.

Metrics for vulnerability assessment can be extracted from extensive geospatial datasets such as high-resolution digital elevation models (DEM) or individual building vector layers. Morphological properties can be calculated for different scales using different moving window sizes. Multi-scale measures such as fractal or lacunarity can be integrated into the analysis. Other properties such as different densities and ratios are also easy to calculate and include. Based on a rather extensive set of properties or features, a feature selection or extraction method such as Principal Component Analysis can be used to obtain a subset of relevant properties. In a second step, an unsupervised classification algorithm such as Self-Organizing Maps can be used to group similar locations together, and criteria such as the intra-group distance and geographic distribution can be used for selecting relevant locations to be displayed in an interactive data exploration interface along with a given main location.

A case study for a part of Switzerland illustrates the presented approach within a working interactive tool, showing the feasibility and allowing for an investigation of the usefulness of our method.