How do people perceive the disclosure risk of maps? Examining the perceived disclosure risk of maps and its implications for geoprivacy protection

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Introduction

Mapping is an effective way to visualize various geospatial data, but people's geoprivacy can be violated through the process of spatial reverse engineering when people's private locations like GPS trajectories are displayed on maps (Curtis et al., 2006; Kounadi & Leitner, 2014; VanWey et al., 2005). To avoid privacy violations, it is important to evaluate the disclosure risk of maps when mapping people's confidential geospatial data. In this light, assessing how people subjectively perceive the disclosure risk of maps is important. Perceived disclosure risk considers the cultural and social influences on people's risk assessment that may not be properly handled by existing studies (Armstrong & Ruggles, 2005; McLafferty, 2004). Despite the importance of evaluating the perceived disclosure risk of maps, very few studies to date have investigated it. To fill this gap, this research examines how people subjectively perceive the disclosure risk of maps utilizing original data collected in an online survey. Specifically, we ask the following questions: How do different components of a map affect an individual's perceived disclosure risk of a map? How do different geomasking methods affect an individual's perceived disclosure risk of a map? How does an individual perceive the disclosure risk of a map when the private locations of socially vulnerable people are visualized?

Data and Method

856 participants were recruited to participate in the online survey by distributing a solicitation message to 12,000 randomly selected members of a university (Kim et al., 2020). ***Part 1*** of the survey examines how different attributes of a map affects an individual's perceived disclosure risk of the map (Figure 1). ***Part 2*** investigates how different geomasking methods (aggregation and random perturbation) and parameters affect an individual's perceived disclosure risk of a map. ***Part 3*** examines how an

individual perceives the disclosure risk of a map when private locations of socially vulnerable people are visualized. ***Part 4*** collects participants' basic sociodemographic information. Note that the perceived disclosure risk of a map is defined by the extent to which a person subjectively feels (un)comfortable with the map that displays the person's private locations (Benisch et al., 2011; Kounadi et al., 2015). It is measured on a 7-point scale, where 1 indicates "the most comfortable" and 7 indicates "the most uncomfortable."

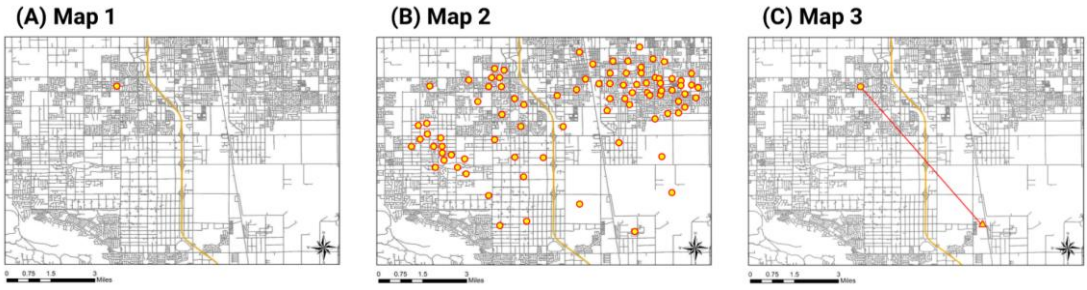

Figure 1: Example maps used in Part 1 of the survey (Kim et al., 2020).

Results

First, the results indicate that specific map attributes influence the perceived disclosure risk: (1) The perceived disclosure risk of a map increases when the map visualizes more locational information. (2) With regard to map type, perceived disclosure risk is significantly lower for kernel density maps, convex hull maps, and standard deviational ellipse maps, compared to point-based maps. (3) Perceived disclosure risk is affected by map scale and the presence of information of other people on a map. Second, the study reveals that the geomasking method used influences the perceived disclosure risk: as the aggregation level and the relocation distance increases, perceived disclosure risk decreases. Third, participants are most uncomfortable with a map that shows the location of elementary school students, followed by maps that show the location of HIV/AIDS patients, people who engage in sex with people of the same sex, people who are under alcohol or substance abuse treatment, pregnant women, elderly people, cancer patients, people in poverty, and high-income earners.

Conclusion

This research examined how people subjectively perceive the disclosure risk of maps by conducting an online survey (Kim et al., 2020). This study significantly contributes to the literature by systematically investigating perceived disclosure risk and providing solid scientific evidence that confirms some of our common expectations. For instance, one can easily expect that the perceived disclosure risk of a map would be reduced when the proper geomasking method is applied. However, systematic investigations of how and to what extent people perceive disclosure risk have not been conducted to date.

Furthermore, the significant results can be used for proposing guidelines for geoprivacy protection while considering people's perceived disclosure risk. Moreover, the results also provide important insights into mapping infectious diseases like the COVID-19 pandemic in 2020. During the pandemic, it may be important to balance between the

needs for releasing disease-relevant information (e.g., a list of public places where patients had visited) to promote public health and protecting the geoprivacy of patients by properly applying geomasking methods (Harari, 2020). In this regard, surveying the perceived disclosure risk of the general public can give invaluable insights about how governments can prudently balance between privacy protection and public health during the pandemic.

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