Security Urban Perception Tracking

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***Abstract*—This project introduces a visual prototype centered on Urban Security Perception: a profound exploration into the results of an experiment on how participants of diverse nationalities perceive safety based on various urban images from the city of Rio de Janeiro. This application leverages visualization techniques, utilizing a range of intuitive interactive graphical objects, thereby enabling users to explore all possible characteristics derived from this experiment.**

***Index Terms*—Security, Urban Perception, Tracking, Data Science, Visualization**

I. Introduction

Public perception is increasingly crucial in urban research, with subjective evaluations of safety playing a fundamental role in urban planning and design. Foundational theories in urban sociology contend that damaged infrastructure, such as broken windows [1], can erode the sense of security and foster increased crime and decay.

The advent of street view imagery platforms has revolutionized how researchers gather data on urban perception. While traditional approaches like surveys and crowdsourced ratings are labor-intensive, newer methodologies leverage technology such as Virtual Reality (VR) and eye-tracking techniques [2]. These innovations enable the simulation of urban environments and the evaluation of human perception in controlled, scalable settings.

A powerful approach to engaging with the topic of urban perception is through the use of visualization techniques. These techniques facilitate the understanding of complex concepts, thereby simplifying learning and improving comprehension.

II. Related Works

Numerous previous research efforts related to urban perception have offered valuable insights that served the Safety Urban Perception Tracking project.

A novel visualization technique for multi-participant eye-tracking data, termed “gaze stripes”, displays spatiotemporal information of gaze points directly on the visual stimulus. This approach effectively prevents occlusion and obviates the need for explicit area-of-interest definitions. This method significantly facilitates the analysis and comparison of viewing behavior over time, particularly for dynamic stimuli [3].

A prototype is presented, comprising an automated method for processing and filtering open-source Street View (SV) imagery for the preparation of visual data in human perception surveys. This software facilitates the efficient collection of visual perception ratings, thereby providing crucial insights into how individuals perceive urban environments [4].

III. Methods

For this study, we utilized images from the Place Pulse 2.0 dataset, a large-scale crowdsourcing initiative by MIT Media Lab focused on mapping global urban perception. Our research specifically investigated safety perception in Rio de Janeiro, Brazil.

From the extensive Place Pulse 2.0 dataset, a subset of 150 out of 3,659 images depicting various locations within Rio de Janeiro was selected. These images served as the visual stimuli presented to participants during data collection, which was conducted using the HoloLens 2 device.

Data collection involved an experiment with a cohort of 30 participants from the Fundação Getulio Vargas. The sample comprised individuals at different academic levels: 16 undergraduate, 9 master’s, and 5 doctoral students. Participants represented diverse nationalities, including 20 Brazilians from various states, 7 Peruvians, and 3 Paraguayans. The gender distribution was 21 males and 9 females.

The main experimental task involved sequentially presenting participants with 50 urban street view images. Each image was displayed for 15 seconds, followed by a 5-second inter-stimulus interval. During the 15-second viewing period, participants were asked to rate the perceived safety of each image on a Likert scale from 1 (very unsafe) to 10 (very safe). Crucially, real-time gaze data was not visible to participants during this core experimental phase to prevent potential observational bias.

Additionally, auxiliary geodatasets were utilized for the city of Rio de Janeiro, along with a representation of the South American continent map. These were crucial for facilitating comprehensive spatial visualization within the application.

This project is an interactive web application developed with SvelteKit, utilizing JavaScript as its primary language and Vite for compilation and development. It integrates D3.js library for advanced data visualization and manipulation. The application processes and handles various information formats, including CSV, JSON, and GeoJSON files. Also, is complemented by the use of HTML, CSS, Node.js/npm for dependency management, and Git for version control.

IV. Results

A. First Tab: Overview of Security Urban Perception Tracking (SUPT)

In this initial visualization, as depicted in Figure 1, the Security Urban Perception Tracking (SUPT) interface is presented. On the left, various tabs are displayed, commencing with the "Overview" tab. This section provides a comprehensive description of the project's explanation, objectives, detailed data generation process, and the project's working methodology.

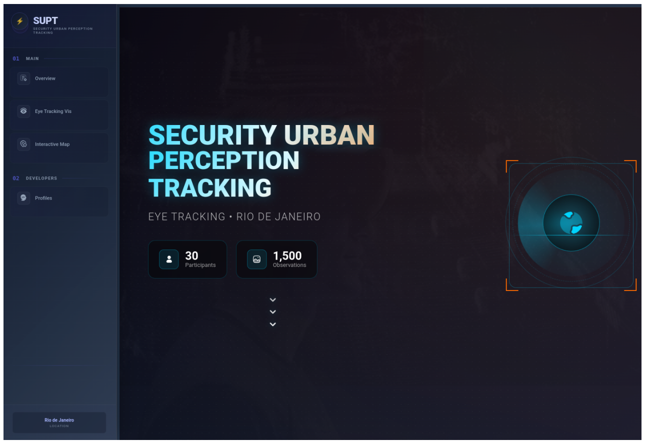

Fig. 1. Visualization of SUPT Overview Tab

B. Second Tab: Eye Tracking Vis

The second tab, "Eye-Tracking Vis", as shown in Figure 2, allows users to select one of 150 distinct images. This selection then enables the utilization of two key functionalities: "Eye Tracking" and "Fixation Points."

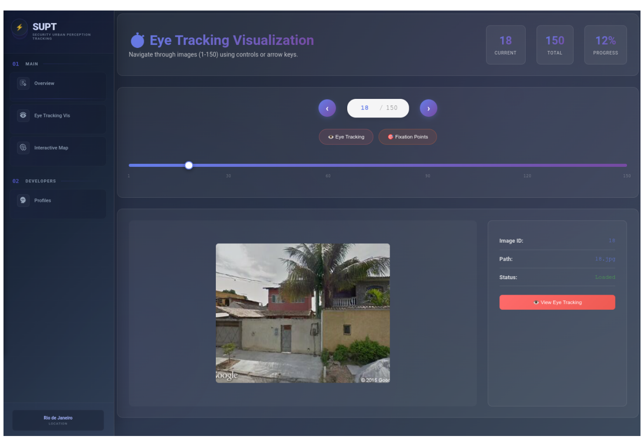

Fig. 2. Visualization of Eye Tracking Vis Tab

Upon pressing the "Eye Tracking" button and selecting image number 18, as depicted in Figure 3, a new container will be displayed. On the left side of this container, the user can observe the 10 participants (randomly selected according to the methodology detailed in Section III) and choose one of them (e.g., Participant 19). Below this selection, an "Active Tracking" container provides additional information, such as the tracking points (890 points for the selected participant). On the right side, the image is overlaid with various circular elements representing the participant's visual tracking path. The initial gaze point is marked by a green circle, while the final gaze point is indicated by a red circle. From this visualization, it can be precisely interpreted that the participant's initial perception focused on the second floor (red color indicating the gaze) of the first house on the right.

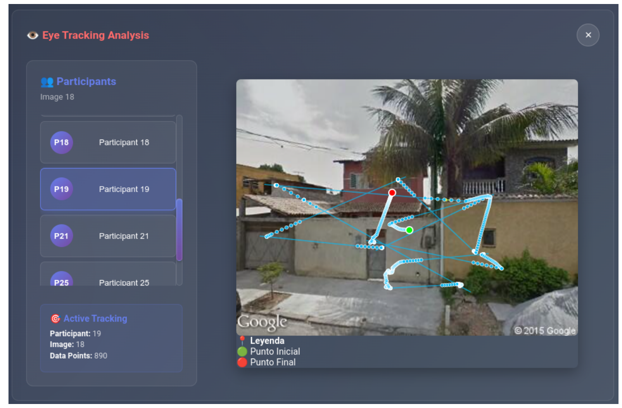

Fig. 3. Visualization of Eye Tracking Analysis

Upon pressing the "Fixation Points" button, as depicted in Figure 4, a new container will be displayed. The objective of this section is to illustrate the specific points within the image where each participant fixated their gaze. This functionality aims to ascertain whether the image of a particular area in the city of Rio de Janeiro evokes a sense of security or insecurity. On the left side, a summary for this image is presented, detailing the total number of fixations, the number of participants, and "gaze points". On the right side, all participant tracking paths are visible, with orange circles highlighting the corresponding fixation points.

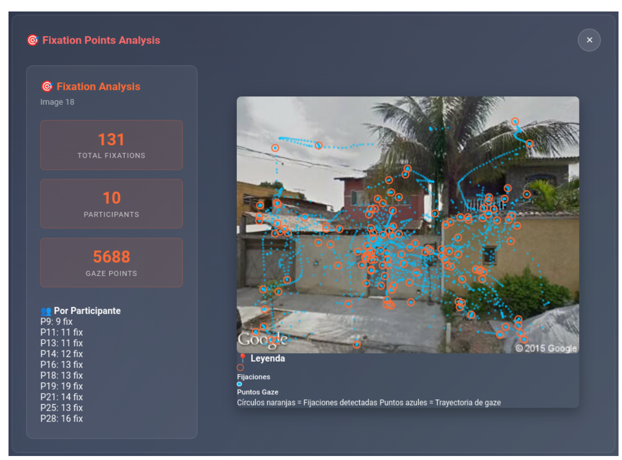

Fig. 4. Visualization of Fixation Points Analysis

C. Third Tab: Interactive Map

The final tab, "Interactive Map", as depicted in Figure 5, is structured with three distinct visualizations. The central quadrant, “Perception Analytics-GeoSpatial Analysis”, features a map of Rio de Janeiro, displaying the 150 image locations (itemized as circles). Each circle’s color is determined by the “Safety Levels” legend: red (0-5) indicates that users, on average, perceived the image’s location as unsafe; yellow (5-7) represents an average perception of a moderately safe area; and green (7-10) signifies an average perception of a safe area. Subsequently, on the right side, two visualization objects are presented: the upper-right object represents the “Safety Correlation Analysis”, and the lower-right object illustrates the “Similarity between Participants”, both of which will be elaborated upon in the subsequent paragraph.

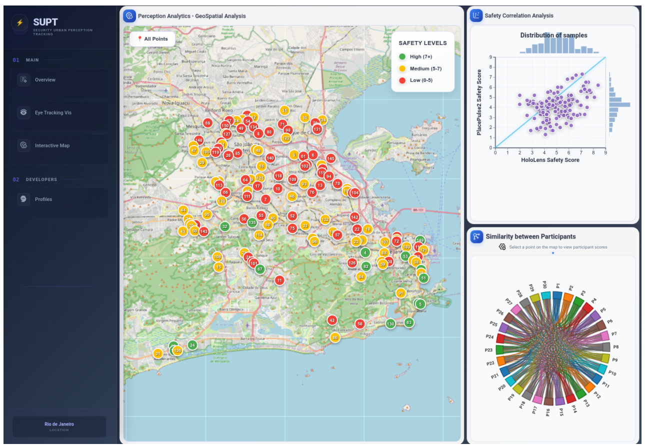

Fig. 5. Visualization of Interactive Map Tab

To elaborate on the functionalities of the right-hand section, we first select a location within the “GeoSpatial Analysis” container. For instance, choosing the location of Image 91, situated in the Humaitá area of southern Rio de Janeiro, as depicted in Figure 6, generates a tooltip. This tooltip displays comprehensive image information, geographical coordinates, and comparative safety scores between the PlacePulse1 dataset and the Hololens (SUPT) dataset. Subsequently, the upper “Safety Correlation Analysis” container illustrates the correlation between these two scores, indicating its presence in the lower region. Finally, the lower container, “Similarity between Participants”, features a chord diagram to visualize the perceptual similarity among participants. For example, upon selecting Participant 15, the view filters to reveal their perceptual commonalities with users aligned with the participant’s designated color.

V. Discussions

Through the SUPT prototype, users are afforded the opportunity to explore valuable information concerning the landscape of urban perception, specifically as it relates to safety. By examining its diverse features, users can develop a deeper comprehension of how participants in the SUPT experiment perceived whether a given image represents a safe or unsafe area, identifying new trends and patterns through visualization techniques.

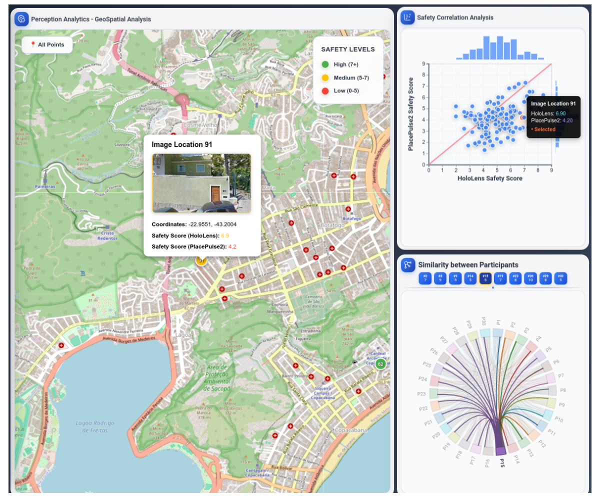

Fig. 6. Visualization of GeoSpatial Analysis of an Image Location & Safety Correlation Analysis & Similarity between Participants

VI. Conclusion

The project aimed to elucidate for a diverse user base how an urban image can influence individuals’ perceptions of safety. By leveraging an appropriate set of images and the resulting data from each participant, the proposed visualization prototype offers essential information to interested users. A key distinguishing feature of the project is its compelling focus on identifying what participants initially perceive in an image when evaluating its safety, as well as enabling comparisons of perceptual similarities among participants, all elucidated through intuitive visual objects.

VII. Future Works

For future work, it is necessary to expand the number of participants and also increase the quantity of images from the city of Rio de Janeiro to provide a more precise summary, closer to the PlacePulse dataset. Furthermore, it will be interesting to incorporate additional features related to urban perception, such as beauty (aesthetics) and liveliness (vitality), to gain a richer and more nuanced understanding of the public’s subjective evaluations of the urban environment.

References

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