Reviewing "Tracking exposure to natural scenes"

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Executive Summary

Exposure to natural scenes can have positive effects on an individual, such as decreasing stress and improving attention deficit. Currently, environmental psychology studies that wish to investigate these effects face limitations when determining an individual's exposure to natural scenes. They must rely on fabricated laboratory settings, subjective participant surveys, or post-study GPS-analyses in order to complete their investigations. This project creates a prototype Android application that allows real-time, objective tracking of natural exposure persistently in a real-world environment. The application accomplishes this by using GPS and network location tracking alongside Geographic Information System (GIS) map tiles to log when an individual is in a green, natural environment. The prototype uses the GIS OpenStreetMap to evaluate natural exposure once every two minutes. This application can also notify participants to complete stress and attention deficit data daily through push notifications.

The low-level objectives of the project were as follows:

- Design and develop a prototype Android application to track user exposure to green space
- Test application in a controlled environment with automated script testing
- Test application against an external GPS device in a live testing scenario
- Perform an experiment that measures natural exposure, stress, and attention deficit
- Perform feedback survey for participants following the experiment
- Perform data analysis on results collected during the experiment

The experiment was performed to test the functionality of the prototype. Stress and attention deficit information was recorded from each participant once per day. Exposure, stress, and attention data were stored from the mobile device to an online cloud server. User feedback from the experiment supported the prototype's ability to successfully identify when a user is in green space according to OpenStreetMap. The experiment did not show a correlation between natural exposure and stress levels or natural exposure and attention deficit. However, participant completion of surveys shows the tool has the ability to gather psychological data during similar experiments. The in-the-wild approach of the experiment also provided insights into prototype use. Due to the prototype's success in tracking natural exposure and recording psychological outcomes, this project serves as a step towards creating an environmental psychology application that can be used in future research.

The main contributions of this project were as follows:

- Developed a mobile application prototype that tracks natural exposure in real time
- Created a tool that collects psychological data daily from participants

Strengths, Weaknesses, and Extensions

This project covered a wide array of subjects and topics, some of which included location tracking, activity tracking, testing methodologies, and issuing psychological surveys.

This project had several strengths which highlighted the author's proactive judgment. These strengths included use of in-the-wild testing to establish ecological validity and making the ethical decision to not store GPS data. Another strength involved the persistent activity tracking behaviour of the prototype. The author addressed high battery consumption by allowing an Android device's default Doze mode to remain enabled. High phone battery usage in activity tracking applications can lead to less use [1] and could have possibly impeded study participation. Another example of the author's proactivity involved the decision to convert OpenStreetMap tiles to bitmaps. OpenStreetMap contains colourings based on assigned land use [2], and certain APIs may not return these terrain colours correctly [3]. Using bitmaps instead of APIs to retrieve OpenStreetMap's layering circumvented this issue.

The main weaknesses in the project came from certain design decisions. A potential weakness was that only two GIS appear to be considered, only comparing Google Maps and OpenStreeMap. Analysis of other

systems would have further strengthened the decision to use OpenStreetMap. Additionally, for the design of the psychological evaluation, a healthcare professional was not reported to be involved. Incorporating such a professional would have strengthened the psychological aspects of this project [4]. A more impactful weakness was due to survey schedules. The timings of survey completion potentially attributed to the missing correlation between natural exposure and both stress and attention deficit. A similar study used a user's arrival and departure to send a survey upon travel completion [5]. Because this project also tracked such starts and stops, a similar targeted survey could have been used to firmly connect the natural exposure event to survey completion upon arrival and departure.

The software of this project can be expanded by enhancing data collection. One simple extension is to include additional environments from OpenStreetMap when tracking natural exposure. Introducing wearables to include real-time stress tracking through physiological responses could also extend this prototype. Previous research has incorporated wearables into their psychological studies in order to track health [6] and stress [7]. The Garmin Companion SDK allows real-time stress data retrieval for compatible wearables [8]. Stress-tracking wearables will help discern how stress is affected during natural exposure. Finally, supplemental systems for green space identification could extend the base prototype. Although NDVI can have inaccuracies, it can identify land a human considers green [9]. Incorporating NDVI could better align green space identification with a participant's idea of green space, such as private gardens or tree-strewn cities.

Field and Context

This project has one major facet: identifying green space through mobile location tracking. The goal of this functionality is to monitor and track psychological data and create a tool that can be used for environmental psychology studies.

Psychological studies that rely on an individual's data and actions may use mobile applications [5], [10]. For example, a mobile application called Daynamica is a software tool that tracks activities and transportation throughout the day [11]. This application can gather psychological data by delivering questionnaires or surveys based on a user's physical activity [5]. Others applications may focus on other data, such as ambient sound or phone usage [10].

The main contribution of this project to computer science falls into its activity and location tracking capabilities. Numerous mobile applications utilise location information to aid in activity tracking. Some applications, like Google Fit [12] and Daynamica [11], track and identify actions passively throughout a user's day, such as walking and cycling. Health trackers and mobile exercise applications can log activities more actively. Using these tools, a user can choose when to track activities. While running, these applications gather pertinent exercise information, but also gather information on the user's environment, such as elevation [13], [14], [15]. Other activity tracking applications, like tour planning software, may gather environmental data by displaying information, such as weather forecasts and nearby landmarks [16].

Reviewing these applications, they do not possess the ability to log if a user is in natural scenery nor the amount of time spent in these areas. A more comprehensive inability to accomplish this task is highlighted by environmental psychology research. Studies often rely on surveys and separate analysis to determine surrounding green spaces [17], [5], [18]. Even when studies focusing on green space rely on mobile activity tracking by using applications such as Daynamica, identifying green space required external data analysis of the collected GPS data in combination with a GIS [5]. In general, GIS are often used in analyses to identify green spaces [9].

This project successfully creates new functionality within a single mobile application by using location and activity tracking combined with GIS analysis. Like other passive activity tracking applications, the prototype logs the pertinent information, natural exposure, in the phone's background by using GPS and mobile networks to identify a user's location. The software achieves green space identification by analysing the current GPS coordinates against corresponding map tiles from the GIS OpenStreetMap. When a user's location is determined to be in a green space, natural exposure data is logged.

Ethical Discussion

In order to discuss the full view of ethical considerations in this project, the potential uses of this software must be evaluated in addition to its intended use. Overall, the project is ethical in its current use, but applications of the software might face ethical dilemmas.

The first ethical consideration of this project is one of data privacy. One purpose of this project was to determine natural exposure using location tracking. Choosing not to store GPS coordinates was an ethical decision in this project from a consequential and virtue ethics perspective. GPS tracking can allow discovery of a user's location habits, which could breach a person's privacy and security, potentially leading to detrimental outcomes [19]. Another purpose of the prototype was to collect and store psychological data. Based on consequential ethics, storing these psychological data is ethical because the data can be used to improve the

overall population's mental well-being. The project's storage methods, however, raise some ethical concerns because cloud storage is inherently subject to the opportunity for malicious attacks [20]. A risk that prototype users' sensitive information could be accessed and used in an unethical way is therefore not impossible. By attaining consent for participation, however, deontic ethics can conclude data storage is still ethical because proper procedures have been completed prior to data collection. Overall, the prototype's data storage is ethical because the prototype gains user consent, only stores pertinent data, and can benefit people overall.

In future implementation's of this prototype or similar software, certain ethical considerations should be taken into account. First, the user's right to data deletion must be considered. From a virtue ethics perspective it would be unethical to continue to retain information against a user's wishes. Being refused deletion may cause a user trauma or distress, which causes unnecessary harm, especially considering the sensitive nature of these data. In general, because storing data long term could cause distress for users, expiring data after periods of use, such as following an experiment, prevents these data from being stored unnecessarily [21]. Lastly, this prototype logs psychological and health data in a way that allow users to track aspects of their well-being. While well-being apps are often well intended, they often raise ethical questions due to a lack of guidance from healthcare professionals during development. Consequentially, successful applications that involve monitoring behaviour can lead to personal improvements, but they can also lead to negative effects involving anxiety [4]. Based on virtue and consequential ethics, healthcare professionals should be involved during further development of similar software to stay more ethically sound.

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