Augmented Reality for Situated Outdoor Geospatial Data Visualization PhD Proposal

Supervisors: Vanessa Peña-Araya and Emmanuel Pietriga
{vanessa.pena-araya@inria.fr, emmanuel.pietriga@inria.fr}

Location: ILDA, INRIA, Université Paris-Saclay, Building 660, Gif-sur-Yvette.
Website: `https://ilda.saclay.inria.fr/`

Context

Augmented Reality (AR) superimposes information in the user's field of view and is particularly relevant to outdoor contexts of use, where users can access digital data and seamlessly relate those data to their physical surroundings. This can be useful for leisure activities (outdoor games, tourism), but in a variety of work contexts as well such as urban planning, construction work, and a variety of scientific activities. To take one particular example, geologists often need to access data about the location they are currently visiting: terrain models, soil sample data analyses, databases and documents about the area, including maps.

To further illustrate this scientific case, let's consider Tephrochronology, a discipline of Earth Sciences that analyzes samples of volcanic eruptions in order to reconstruct the volcanic history of a place. When going to the field, Tephrochronologists extract soil samples in places close to certain volcanoes. They later analyze these samples to extract information such as their geo-chemical composition and age with specialized machines. To associate the sample to a volcanic eruption, they correlate the extracted information of a new sample with previously analyzed samples. An important problem in this process is that information is disconnected between steps, making the overall process difficult to manage for the scientists. Geologists in the field usually do not have access to the analyses they conducted before going to the field (planning phase). And even if they have tablets to access the data, it is hard to make interactive queries adapted to new hypotheses formulated in situ, in the field at the location itself, and to visualize and relate those data to what they see around them.

Augmented Reality can provide effective support to such users, by enabling them to display data in their field of view, directly integrating digital information with the physical environment. Users can then interact with the virtual content using freehand gestures, combining them with pen-based input on a handheld tablet when relevant. However, designing visualization techniques for such outdoor contexts raises multiple challenges that stem from:

- the scale of the physical environment considered – expressed here in kilometers rather than in meters as is typically the case for indoor environments – that makes spatial registration of virtual content with the physical referents much more difficult and sensitive to measurement inaccuracies, but also raises issues with virtual content depth perception and estimation;
- varying outdoor conditions (weather, natural light) that can adversely impact the perception of the virtual content as the "background" on top of which the virtual content is superimposed is much less controlled than in indoor environments;
- the need for geologists to effectively switch between different situations: sometimes keeping their hands free to manipulate samples or make their way through a difficult path; sometimes inputting data into the system using form fields; sometimes using a pen to sketch terrain configurations;
- the need for geologists to orient themselves and plan the next steps of their terrain explorations, based not only on their first-person view of the terrain but on an overview of their geographical surroundings as well.

Objectives

The goal of this PhD is to design, prototype and evaluate interaction techniques and visualization techniques to effectively support geologists in the field, addressing the above challenges using combinations of interactive devices: augmented reality eyewear; handheld tablets and digital pens; and a combination thereof.

Example research questions to address include:

- Designing visual representations that enable geologists to effectively relate elements from the physical world with digital data relevant to their task, by displaying this information in their field of view or on a handheld device such as a tablet.
- Streamlining the input of novel data, which can take many shapes: textual/numerical data typically captured through forms; annotations made on maps or photos captured on the spot; 2D/3D sketches about terrain configurations and features.
- Exploring the design space of transition techniques between first-person augmented reality view and a third-person virtual reality view to support orientation and wayfinding [5, 6].

Work Plan

The PhD work will involve observing geologists working in the field, interviewing them – adopting a user-centered design methodology that can also include participatory design workshops. Activities to be performed by the student are typical of HCI research projects:

1. Literature review about relevant work from different communities including Augmented Reality [1]; Situated Visualizations [2, 4]; Mobile HCI [3].
2. Participate to the observation and interview campaigns with geologists, and analyze the results.
3. Design novel interaction and visualization techniques informed by the above.
4. Implement those techniques using AR headsets and mobile devices.
5. Evaluate those techniques using relevant means, including but not limited to controlled user studies.

Requirements for Applicants: Training in Human-Computer Interaction. Design and software development skills, in addition to user evaluation and prototyping methods. Knowledge of Unity, WebXR or other Augmented Reality/Virtual Reality development frameworks is a big plus.

References

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[3] Kjeldskov, J., and Graham, C. A review of mobile hci research methods. In *Human-Computer Interaction with Mobile Devices and Services* (Berlin, Heidelberg, 2003), L. Chittaro, Ed., Springer Berlin Heidelberg, pp. 317–335.

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