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Collaborative Data Exploration Interfaces

From Participatory Sensing to Participatory Sensemaking

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Abstract—As technological capabilities for capturing, aggregating, and processing large quantities of data continue to improve, the question becomes how to effectively utilise these resources. Whenever automatic methods fail, it is necessary to rely on human background knowledge, intuition, and deliberation. This creates demand for data exploration interfaces that support the analytical process, allowing users to absorb and derive knowledge from data. Such interfaces have historically been designed for experts. However, existing research has shown promise in involving a broader range of users that act as citizen scientists, placing high demands in terms of usability. Visualisation is one of the most effective analytical tools for humans to process abstract information. Our research focuses on the development of interfaces to support collaborative, community-led inquiry into data, which we refer to as Participatory Data Analytics. The development of data exploration interfaces to support independent investigations by local communities around topics of their interest presents a unique set of challenges, which we discuss in this paper. We present our preliminary work towards suitable high-level abstractions and interaction concepts to allow users to construct and tailor visualisations to their own needs.

I. INTRODUCTION

Andrejevic [1] pointed out, there is often an asymmetric relationship between data collectors and data collection targets. The author introduces the notion of a ‘big data divide’, which is characterised by users lacking access to their own data, as well as capabilities to analyse and make sense of it. Consequently, users are often frustrated and concerned by data collection. Nonetheless, they commonly relinquish control over their data when prompted by terms of use – accompanied by a sense of powerlessness and resignation. This stands in contrast to the empowering effect of other technologies, such as the Internet [1]. These shortcomings can only be addressed by democratising data with accessible tools that change the relations of ownership and control.

Recent approaches in *Personal Visualisation* and *Citizen Science* represent a user-centred turn in data visualisation and analysis. They draw on a number of developments that have been enabled by the increasing availability of ubiquitous and mobile technologies. First, people are increasingly becoming producers as well as consumers of data. For instance, trends like the *Quantified Self* [2] – enabled by wearable technologies that can extract health and activity data – show that people have a strong interest in gathering and analysing data on a personal level. Second, there is an increasing availability of tools that allow untrained users to generate visualisations [3,4], a process that previously would have required expert knowledge.

And third, shared sensemaking platforms support not just the individual analysis of data, but also allow users to share their interpretations of data with others [5,6].

One field that has pioneered a user-centred approach is *Participatory Sensing*, which specifically aims to equip users with sensing capabilities, for example by utilising everyday mobile devices. Building on widely available technology, researchers envision large-scale sensor networks which are directly embedded with the subjects of study: humans and their built environment. Nevertheless, such work is often primarily concerned with data collection, aiming to deliver anonymised and trustworthy data. However, early proponents in the field have already argued that participation does not stop at data collection. In order to complete their vision, there is a need for tools that allow citizens to take part in the data analysis to perform bottom-up, grassroots examinations [7].

II. CURRENT PROGRESS

Throughout our studies, we have explored the prospect of *Personal Visualisation* from multiple perspectives. A unifying characteristic is that the individuals engage in activities out of personal rather than professional interests. This includes the visualisation of personal data, as well as the analysis of external data for personal decision-support. As our focus lies on the sensemaking process, we emphasise the intended use, rather than the origin of the data, which can be crowd-sourced or made available by private enterprises and public institutions.

Initially, we conducted targeted deployments of interventions with tailored visualisations of personal data, such as a mobile application for delivering comparative feedback with the goal of domestic energy conservation (*EnergyWiz*). While the study corroborated evidence for the value of sharing data and conducting social comparisons, several shortcomings were highlighted. In particular, one of the identified problems was a lack of communication channels between the parties comparing data. This led to the conclusion that facilitating communication between users would be a key prerequisite for better learning outcomes [8].

Subsequently, our key point of departure from prior work was the emphasis of end-user customisation and social sharing. The *Dashboard* system allowed users to compose and visualise personally relevant data streams side-by-side [9]. The purpose of the *Dashboard* was to give the users a comprehensive and intuitively accessible overview of data that relates to their household. At the core of this study was the question of

how to build frameworks for working with heterogeneous and dynamic data streams. As a follow-up study to *EnergyWiz*, an evaluation of the system was conducted with a focus on data streams related to a users environmental performance. Post-study group interviews related to the *Dashboard* system provided initial indication for the benefits of close collaboration in co-located, synchronous settings. When participants were brought together, giving them a chance to share and show off their personal configurations, it often prompted further inquiry. The participants were able to draw inspiration from each other, experimenting with configurations that they had not thought of by themselves.

III. DISCUSSION

We observed a diverse set of individuals with various levels of expertise engage with personally relevant data. Overall, our experience led us to believe that there is promise for applying a participatory approach to make sense of the numerous data sets available today. However, this will require the design of novel interfaces to meet the expectations of users:

Dynamic: Several of our participants felt that the mere retrieval of information was not gratifying, expressing their wish to actively engage with the data by interacting with the visual representations on the screen and manipulating them to suit their current line of inquiry. Enabling playful interactions would also be beneficial according to psychological studies, which show that merely displaying information is less effective than actively engaging and experiencing it.

Flexible: While systems offering predefined components are commonly easy to use, they are not suitable for exploratory analysis, which requires the ability to manipulate and tailor representations based on emerging questions and insights. To generate personally relevant insights from the plethora of available data, we have moved from providing specialised visualisations with restricted analytical capabilities towards more flexible compositional models.

Educational: Providing guidance is especially important with regard to the aforementioned generic tools, since undirected exploration incurs overhead in terms of learning and requires initial dedication from the user. It is tempting to focus on the ability to generate appealing visuals with minimal effort, but it is counterproductive to the diligent and thorough analysis that is required. An interface that hides all the complexity of the underlying process is likely to impede understanding.

Collaborative: The feedback from study participants indicates that collaborating and exchanging ideas with others can result in highly engaging, productive, and memorable interactions around data. Therefore, our recent designs incorporate large-scale, interactive surfaces to provide shared workspaces for collaboration. A key goal is to develop design considerations for interaction environments that enrich data analysis activities, allowing groups of users to surpass the outcomes they could achieve as separate individuals.

Ultimately, we believe that participation is one of the keys to unlocking the potential of big data to address concrete problems in various social contexts and communities. Members of these communities are not just essential for generating and collecting data, but also valuable resources for making

sense of this data and implementing solutions. In such cases, participatory and collaborative research approaches promise advantages over traditional methods. The collaborative analysis performed by participants on their own data sets – as well as those made available by others – has the potential to stimulate discourse and generate diverse and unexpected insights. Therefore, our recent work focuses on placing participants in a shared interaction environment, aiming to utilise implicit and explicit communication channels to stimulate creativity and critical discussion in the analytical process.

IV. FUTURE WORK

Rather than limiting our users to specific visualisation techniques, we are working towards novel interfaces to allow the creation of custom visualisations in collaborative settings. Through focus groups and early experimentation with low-fidelity prototypes, we are gaining insights into the mental models and workflows of users, as well as the acceptance and usage of different interaction concepts for visualisation specification. Nevertheless, especially when working on flexible tools, we have found it invaluable to deploy and evaluate in specific scenarios. It is challenging to manage the increased complexity of general-purpose solutions. Concrete use cases provide grounding and focus, ensuring that the resulting tools can be applied by users in the real-world. Therefore, the observational strand of our research aims to assess the potential impact of participatory data analytics. By evaluating the developed software prototypes in specific scenarios (urban mobility, academia, and entrepreneurship) with members from local communities, we continue to explore the opportunities and challenges for a participatory approach towards making sense of data through visual analytics.

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