Location, Aim, and Audience of Data Physicalisations: Design Approaches instead of Frameworks

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While the data physicalisation community tends to focus on analysing data physicalisations and establishing frameworks for classification as well as for design, the activity of designing data physicalisations is less investigated. There is a demand to establish more practical guidelines and develop design approaches for data physicalisation. Regarding this we see two main challenges i) how to map abstract data to physical properties, and ii) how to foster informed design decisions considering content and context of a data physicalisation, including the presented data, the intended aim, the location, and the addressed audience. To establish the influence of a data physicalisation's context, we think it is fundamental to distinguish i) thematic context and ii) physical context as well as to consider both in the design process. Further we discuss sustainability challenges of data physicalisation in this position paper.

CCS CONCEPTS • Human-centered computing • Visualisation Application domains

Additional Keywords and Phrases: Data Physicalisation, Design, Domain application, Sustainability

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1 BACKGROUND

For a long time, the working definition introduced by Jansen [14] stated data physicalisation as "a physical artifact whose geometry or material properties encode data". While this definition was recently extended by Sauvé [24] regarding interaction, audience and environment, research showed that the design of most data physicalisations do not consider location or audience [4], instead many data physicalisations are driven by technology [25]. In theoretical work the data physicalisation community tends to focus on analysing physicalisations, sorting them in categories and establishing classification frameworks [19, 20, 31] or frameworks for design in general [7, 8, 15, 24] or with special foci, e.g., on dynamic data physicalisations [27], on multimodal physicalisations [9, 10], regarding semiotics [30], or to foster

interdisciplinarity [4]. This approach generated many important insights, but was also criticized to focus only on single perspectives or properties, while neglecting the big picture of data physicalisation [3]. Often these frameworks give recommendations for design [7, 8, 10, 27], or are intended to work as inspiration [30]. Only few frameworks are suggested to be used in the design process [4, 24], but they do not provide concrete instructions or exemplary use cases. There is little research which investigates the design process of data physicalisation [28, 29], but recently the data physicalisations design process of professionals [26] and lay people [16] have been investigated. This is a promising shift in the research landscape of data physicalisation and a first step to overcome the ontological dualism of theoretical frameworks and practical fabrication. A possible reason for this gap could be that actual frameworks and guidelines are too abstract and difficult to incorporate in the anyway complex design process of data physicalisation [30]. To bridge this gap and foster the connection of theoretical and practical work a less analytic and more practice-oriented approach is required. We need to not only discover the design space through different lenses but to find a format for frameworks and design guidelines appropriate to utilize them in the design process. We need to consider data physicalisation not only as research object, but to take into account content and context of the physicalisations, as well as designer's aim and audience as fundamental reasoning for design decisions. So, we take data physicalisation out of the ivory tower of science and bring it to the real world, supporting real people engaging with data and enhancing their everyday lives. This reveals two main challenges i) how to map abstract data to physical properties, and ii) how to consider content, location, audience and aim of the data physicalisation in the design process.

2 OVERREACHING CHALLENGES

To address the overreaching questions, this workshop raises "Which data is valuable to represent?" and "For which context and location do we design?" [25], we suggest to find an approach how to incorporate these questions into the design process of data physicalisations. Since it is unique for each data physicalisation, these questions cannot be answered universally. This lack of generalisability could be seen as weakness, but the resulting high level of customization and the uniqueness of each data physicalisation is a particular strength of the medium. Data physicalisation bears the potential to create artefacts tailored to perfectly fit the requirements, presenting the data in the best way, and creating meaning, e.g., by choosing a location and material which stays in direct or metaphorical connection to the represented data. This is a huge advantage compared to data visualisation, which allows to present a wide range of data sets through various visualisation techniques. To find an appropriate answer to the questions stated above, the presented data, the aim or intention of the designer, the audience, the planned location and probably many more factors need to be considered in the design process. For this we need more practical oriented tools. Like the high level of individuality and diversity among data physicalisations, also presented data and the message conveyed by the physicalisation, can vary by introducing physicalisations in a specific context: in a specific place, addressing a specific audience. Here the main challenge is to collect these implications and find a way to relate and evaluate them. Easily accessible utilized in the design process, this knowledge can inform future design decisions in the next step.

3 HOW DOES CONTEXT INFLUENCE THE DESIGN OF PHYSICALISATION

Talking about the impact of context on the design of data physicalisation, it is important to distinguish between the i) thematic context and ii) the physical context. The thematic context includes questions like: What is the topic of the data physicalisation? What is the aim of (the designer of) the data physicalisation? Who is the target audience? The physical context deals with the spatial location of the data physicalisation: Where is the data physicalisation intended to be shown?

How long does the physicalisation stay? Has it a thematic or metaphorical connection to the location? Does the physicalisation impact the place or situation? Does the location impact the physicalisation in any way?

Like mentioned before, it is important to consider these questions during the conceptualization of data physicalisation. Recently we experienced the importance of these factors. In an iterative design process, we developed a toolkit for the design of data physicalisations. Primarily we focused on tools based on image schemas, which enable the designer to map abstract data to physical properties in a more intuitive way. Feedback sessions revealed that questions about the context, like the physical location, the target group, and the aim of the designer are essential in two ways: as inspiration and to further elaborate the concept of a data physicalisation. To address this needs we integrated these questions in the toolkit, in order to root them in different phases of the design process.

4 DOMAIN AREA SPECIFIC CHALLENGES: SUSTAINABILITY

In the data physicalisation course I teach at a German university, some student chose sustainability topics like production-, recycling- and disposal-rates of plastic waste or cloth. During the conceptualisation phase, they encountered the dilemma, how to create a data physicalisation representing these data sets (best with metaphorical material choice) without exploiting resources and creating even more (plastic) artifacts, which need to be disposed at some time. A possible solution could be to reuse real waste as material to display this data. This might work in some cases, like [21], but even if we give these materials a "second life" by using it for data representation, the physical data representation has a limited life span and the material needs to be disposed sooner or later.

In general environmental pollution and climate change are popular topics for data physicalisation (waste production [21], air pollution [1], water pollution [22], (CO_2) emissions [2, 6, 23], or climate change [17]). These projects aim at increasing the attention regarding environmental pollution, its reasons, and its consequences, as well as to foster behaviour change. However, sustainability is a special challenge for data physicalisation which requires by its physical nature the use of resources and materials. Here we need to weigh the benefits and disadvantages of highly customized data physicalisations tailored to a specific data set with the aim to present it in the best way vs. more universal physicalisations that offer re-arrangement or adaption to represent different datasets. But even a shape changing physicalisation which is able to be reshaped or rearranged requires material to build the physical components. An interactive physicalisation additionally requires an energy source as well as technical components like batteries which entail valuable soil resources and environmentally hazardous disposal. Further, even if data physicalisation is promising to enable a more emotional experience of data, there are no long-term studies considering if it worth to present physical data representations in long terms or if users lose interest. In this case the physicalisation needs to be deconstructed, decomposed, or recycled. So, the material choice need to investigate recyclable or easily disposable material. Focusing primarily on sustainability it could be an interesting approach to build temporal physicalisations which use only natural material: produced by nature and decomposed without leaving harmful residues. Another approach could be to use living material like plants or moss to create permanent, living data landscapes.

5 CONTRIBUTION

We can contribute to this workshop not only as researcher investigating the field of data physicalisation for years, we've been part of a research group which developed the highly interactive and dynamic data physicalisation "Move&Find" [13] and established with this the field of "kinaesthetic data physicalisations".

To investigate the repeatedly stated challenge, how to physically encode data [9, 14, 18, 30, 10], we purpose the approach to use image schemas – abstract representations of basic multisensory experiences [12], which promise a more innovative

and intuitive outcome, when incorporated in the design of graphical and tangible user interfaces [11]. In our current work we attempt to utilize this potential for the design process of data physicalisation and foster a more intuitive mapping of abstract data to physical properties by incorporating image schemas in the decision-making process. For this we created in an iterative design process physical representations [5] and evaluated their effect in a user study [paper submitted] and a workshop setting [paper submitted].

Beside a scientific perspective, we contribute to the workshop the perspective of a designer, initially educated in communication design and information design, who investigated the field of sensory design and used design as explorative research approach.

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