Tangible Data, explorations in data physicalization

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Abstract

Humans have represented data in many forms for thousands of years, yet the main sensory channel we use to perceive these representations today still remains largely exclusive to sight. Recent developments, such as advances in digital fabrication, microcontrollers, actuated tangibles, and shape-changing interfaces offer new opportunities to encode data in physical forms and have stimulated the emergence of 'Data Physicalization' as a research area.

The aim of this workshop is (1) to create an awareness of the potential of Data Physicalization by providing an overview of state-of-the-art research, practice, and tools and (2) to build a community around this emerging field and start to discuss a shared research agenda. This workshop therefore addresses both experienced researchers and practitioners as well as those who are new to the field but interested in applying Data Physicalization to their own (research) practice. The workshop will provide opportunities for participants to explore Data Physicalization hands-on, by creating their own prototypes. These practical explorations will lead into reflective discussions on the role tangibles and embodiment play in Data Physicalization and the future research challenges for this area.

Keywords
Data Physicalization; Embodiment; Shape-changing Interfaces; Tangible User Interface;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Throughout the years there have been attempts to define and delineate the practice of encoding data in physical forms. In particular, Zhao and Vande Moere explored the concept of *data sculpture* as the physical "embodiment" of data in a tangible presence, shape or form [12]. More recently 'Data Physicalization' (or simply Physicalization) has been defined as a "physical artefact whose geometry or material properties encode data" [3]. Alongside these attempts to explore the theoretical foundations of physical data representation, a body of work has emerged that seeks to exploit the material, aesthetic and natural qualities of three-dimensional structures when representing data. Current examples range from physical bar charts (see Fig. 1a) used to compare physical and virtual visualizations [2], to physical tokens generated from personal data to encourage physical activity (see Fig. 1b) and rearrangeable wooden disks that represent social and economic data from Ireland (see Fig. 1c).

While work in this area has mainly been conducted within the field of HCI and InfoVis, other research has taken a more artistic and cultural view of non-typical data representations. Alongside the numerous articles by new media theorist Lev Manovich, where he discusses the cultural impact of data representations (cf. [5]), Viégas and Wattenberg have reviewed the field of

artistic information visualization to investigate how artists appropriate and repurpose "scientific" techniques to create data representations [11]. A large body of work consists of artistic and often provocative explorations of data that have recently received increased attention. Examples include wooden sculptures that represent the world's distribution of wealth (see Fig 2a) and intricate woven objects that represent weather data (see Fig. 2b). Research on data physicalization is distributed across a number of domains. Today we continue to see related work in fields such as Tangible Computing (e.g. [7]), Data Art (e.g. [4]) and Design (e.g. [9]). The primary goal of this workshop is to build a community around this emerging field by bringing together a group of researchers spanning across multiple disciplines to explore the practice data physicalization, and discuss the key future research challenges for the field.

Workshop Proposal
The aim of this workshop is to cover a range of theoretical topics while also allowing the participants to design their own physicalization during a hands-on session. Although we expect that some participants will have some previous experience with physical data representation, the workshop is open to all as there will be tools and equipment available to suit a wide range of experience and ability. The workshop will be divided into three parts each focusing on a different aspect of physical data representation. Part 1 and 2 will be held over the course of day one while part three will take place over a half-day session on Tuesday.

Phase 1: Introductory talks + Get-to-know others
We will commence the workshop with a brief overview of data physicalization. We will discuss the history and

Figure 1 A: Laser-cut bar chart showing annual unemployment rates in Europe [2]. B: Physical tokens representing activity data [10]. C: Vessels of Irelands Past [8]

Figure 2 A: Fundament (close-up) by Andreas Nicolas Fischer [1]. B: Changing Weather (close-up) by Nathalie Miebach [6].

origins of the research area. This will be followed by short presentations that highlight topics such as: state-of-the-art in physicalization, multisensory data representations, shape-changing data representations, data physicalization in education, evaluation of physical data representations and a summary of previous workshops held. Following this, in the format of madness presentations, each participant will introduce themselves and their interest in the topic. We will conclude by introducing the activities planned for the following session, thus allowing participants an opportunity to think about possible designs over the break.

Phase 2: Ideation, Design & Prototyping
In this session we will introduce a range of equipment, tools and materials that will be available to participants for creating their own physicalizations. These include micro-controllers and actuators, 3D printer, Lego™, paper and card etc. We also encourage the participants to bring their own materials with them if they wish. The group will be divided into teams of 4; each team will be given a selection of datasets and use-case scenarios to choose from. We will also provide a facility on our website to submit datasets prior to the workshop. We will hold an open design session to discuss possible design strategies and the possibilities and limitations of the technology. At the end of this session each group will have created a unique physicalization that will be exhibited in the conference venue for those who didn't attend the workshop to view and interact with.

Phase 3: Reflection and Discussion
The final part of the workshop will involve a round-table discussion on the role of tangibles and embodiment in the future design of data physicalizations. By drawing from the participants' practical explorations (in phase

2), and possibly also from feedback collected from the exhibition of their creations, each group will present their physicalization and discuss their design process to capture what problems they encountered, which tools (software/technology) were missing, and what limitations they encountered. Practicing researchers in the area will then contribute to a discussion on the key research challenges in this area and open research topics such as design issues, technical issues, underexplored areas, open questions, as well as evaluation criteria and methodologies.

Workshop Topics
In the process of exploring the role of tangibles and embodiment in the physical representation of data, participants will be introduced to a number of different topics, including:
Data physicalization: A brief introduction to the research area, its origins, key attributes and state-of-the-art in research and practice.
Prototyping: Introduction to tools and techniques that can be used to quickly prototype data physicalizations.
Design session: An overview of various design strategies for the creation physicalizations. A hands-on session where participants can use the prototyping tools to create their own data physicalizations.
Resources: A review of resources available to support participants in the future, such as software tools, books, and websites etc.
Reflection sessions: A half-day session that focuses on current and future research goals and challenges within Data Physicalization.

Learning Goals and Discussion Objectives
This workshop aims at (1) introducing new researchers and designers to the emerging area of physicalization

and (2) discussing future research challenges in this new research area and starting to form a research community that can tackle these challenges through different approaches. As such, the workshop combines practical and research-oriented approaches. From a practical perspective, participants will be introduced to the theoretical and practical considerations when studying or creating data physicalizations. They will gain an awareness of the area and will be provided with the skills to get started in this new, exciting and emerging area, such as how to use tools for rapid prototyping of data physicalizations. Completing a design task providing hands-on experiences with these tools will provide them with the resources to continue developing data physicalizations. From a research perspective, the re-

flection on challenges in developing physicalizations, methodological issues, and application scenarios will stimulate further research in the area. Here, the experts in the area may learn from the newcomers' perspective. Due to the interdisciplinary nature of TEI, we especially hope for novel insights and approaches as well as increased collaboration to emerge from this studio-workshop.

Preparation & Supporting Web Documents

During Phase 1, in the form of a one-minute madness presentation, participants will introduce themselves along with their interest and experience in the area of Data Physicalization. Further information can be found at http://dataphys.org/workshops/tei16/.

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