The Context as Material for Physical Data Representation

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Abstract
In this position paper, we discuss contextual physical data representation, i.e., the physical representation of the data is materialized in relation to the context of the data. Therefore, we present an example of a interactive installation targeting a factory by describing the characteristics of the context, the resulting design and the initial prototype. Finally, we discuss potentials of deciding for specific (contextual) materials to use for the physical representation of data.

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Contextual Data Representation; Physical Data Representation

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

Introduction
With this position paper we aim to draw attention to the role of the material in physical data representations. Physical data representations are effective means to display and visualize various parameters in order to make them not only visible, but also tangible. However, how do we decide on the kind of visualization, of physicality, of tangibility, of materiality? Many examples of physical data

Figure 1: A worker in a cleanroom, carrying a wafer box to a machine to start a process (picture staged in our cleanroom lab, but with an actual wafer box).

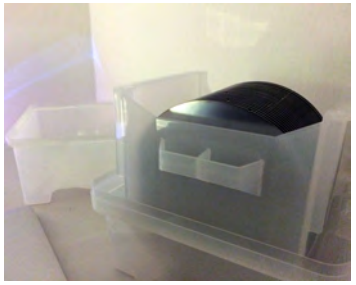

Figure 2: Wafers inside a wafer box.

representations are available, e.g., physical charts that have been provided by Microsoft research [7]. In order to make data accessible and "a joy to view", they created bar charts (i.e., actuated bars that extend according to the size of the item they represent), and pie charts (i.e., visualizing up to 5 categories). Another physical data representation has been designed by Adrien Segal, the "Tidal Datum Tables", representing analytic information through the medium of furniture [6]. Paul May, an Irish designer, created "From Over Here", where he created a physical, tangible data visualization by means of laser-cut cardboards that indicate the number of newspaper articles about or related to Ireland for every month between 1992 and 2010 [4]. Those examples physically represent data, but the materials they use to create the forms of visualization are detached from the context. A link between the form of visualization and the context has been obtained by John Oquist in an example of transit data of a bike-sharing service in Boston. He modeled a miniature, stylized version of Boston, where high-traffic areas and frequently visited stations were on display [5]. However, the materials used are still detached from the context; they do not carry any specific contextual meaning in respect to the data represented.

In the work presented here, we follow the question on how we can make use of *materials from the context* that the data refers to. Based on the very specific context of a semi-conductor factory, we will, subsequently, provide an example of contextual physical data visualization. We describe the respective design and an initial prototype. Afterwards, we discuss different design for data materialization which have been informed and inspired by the context to varying extents.

An Example of a Contextual Data Representation

In this section, we provide a brief overview of the context that our example stems from. We have cooperated with the very semi-conductor factory for several years and researched the specifics of the context and the requirements for interactions and interfaces intensively (see e.g., [2]). Our overarching theme in this cooperation has the idea that all interactions and interfaces are contextual, i.e., they are situated and influenced by specific demands; thus, they require an in-depth understanding of the context, but they also allow to create interactions and interfaces that match the situated challenges and opportunities. This contextual view has also implications when it comes to physical data representation, as it constantly draws our attention to contextual sensitivities, e.g., in terms of the data, as well as in terms of the materials that provide the physicality of the data representation. In the following, we describe the design in detail, which is essentially linked to this context, and illustrate the resulting prototype.

The Context

The semi-conductor factory is mainly characterized by a cleanroom, in which wafers are produced. Wafers are very sensitive goods that require a multitude of processing steps in various departments until they are completed, a process that lasts up to several weeks. Workers in the cleanroom do not handle single wafers, but process them in bundles, i.e., wafer lots (see figures 1 and 2). Among others, the workers load and unload machines with the correct lots (see picture 1), operate the machines that process the wafers, or transport wafers between places and departments. The cleanroom, furthermore, has specific requirements in terms of clothing, lighting and movements (e.g., no fast movements being allowed).

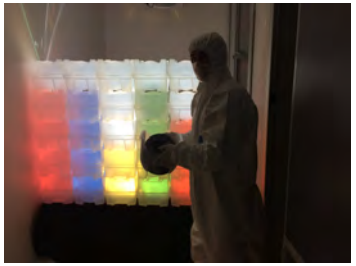

Figure 3: The Prototype (its front; a worker carrying a wafer box next to it).

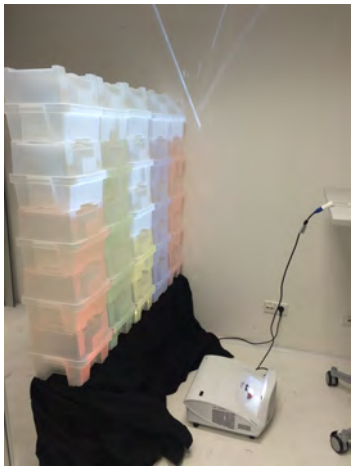

Figure 4: The Prototype (its back).

The Design
The objective of the design was to visualize production parameters to the workers in order to create awareness for changes or stability of overall production figures. Thereby, the aim was to strongly link the data to the physical representation, i.e., the materials used for the data representation being related to the data. In the context of a factory, production parameters are relevant data (e.g., throughput), which can be visualized by means of wafer boxes (as the material for the data representation). The more wafer boxes the workers literally hold in the hands (to carry them around for processing), the more throughput their is. Thus, the wafer boxes create a strong link to the data.

In order to explore the aesthetic and material qualities of the wafer boxes, a group of three undergraduate students was prompted to develop design concepts that repurpose a single wafer box each as a visually expressive artefact. This design exercise was guided by the expressiveness of the properties of the wafer boxes (consisting of semi-transparent plastics, being cubicals with side lengths of approx. 30 cm, allowing to put electronics in the boxes, etc.).

Based on those inspirations an interdisciplinary design team (a group of researchers from different disciplines) then developed a design concept that combines multiple wafer boxes to display data. Due to the fact that they are stackable, they provide a possibility to easily create a matrix, which is perfectly appropriate for displaying bar charts. Production parameters (e.g., throughput) can thereby be visualized in respect to further parameters, e.g., throughput in different departments, on different days, etc. In order to enable further exploration of the wafer boxes, especially focusing on the respective interaction possibilities, we built an initial prototype (which is described subsequently) that dynamically displays data.

The Prototype
The prototype consists of a 5 x 5 matrix of wafer boxes, with a short-throw projector projecting at the back side of the matrix (see figure 4). Thereby, the quality of the boxes being manufactured from semi-transparent plastics together with their almost cubicle shape allows to create the impression that each box is illuminated from within the box, although the projection only directly covers one of the boxes' face (see figure 4). Each box can thus be illuminated in an individual color, which can be perceived from all directions (see figure 3).

The prototype, which we presented, is an initial version of what we envision for this contextual physical data representation. The next version will explore interaction possibilities that allow to dynamically change the parameters by rearranging the boxes in the matrix as well as by further interaction possibilities (e.g., orientation of an individual box). Finally, we aim to deploy the prototype at the factory's site to find out how individuals will interact with it in situ. We envision that familiarity with the tangible artefacts, their cultural situatedness together with the material qualities and aesthetics of the boxes fosters accessibility and inclusiveness. Having designed this particular system based on very specific contextual artefacts (i.e., the wafer boxes), we hope that our design supports the engagement of spectators (i.e., factory employees) with the visualised data.

Considerations for Contextual Data Materialization

Having provided the very specific example of contextual data visualization in a factory environment, we are aware

that this example is limited due to its very specific context of use. However, with this example, we aimed to create awareness for carefully considering and choosing the materials that create the physicality and interactivity, as they may result in very different materialities of the experienced interaction. One way to decide on the materials is aesthetics (as e.g., done by Paul May in "From Over Here" [4]). Another way would be to consider the context carefully in order to design a situated, social or physically embedded artifact as physical data representation. An example of such a contextual physical data representation is the keyboard frequency sculpture, which indicates the frequency of each letter in the alphabet on an actual keyboard in form of a 3D bar chart [3]. Thus, the possibilities are almost endless (see an extensive collection of physical visualization in [1]).

The decision on how to materialize the data (contextually or abstracted from the original context) highly depends on the aim of the data representation, some of those may benefit from being contextual, e.g., to create attention and familiarity, some of them may benefit from an abstracted representation in order to be appropriate for different data of different contexts. However, a context and its contextual materials, artefacts, metaphors, practices, can be a valuable source of inspiration for designing a specific form of tangible interactions with physical data representations.

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