# Connect-S: A Physical Visualization Through Tangible Interaction

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## ABSTRACT

In our current society, open data streams are more and more available through the Internet. This data can have an increasing impact on everyday life. Its full potential can, however, only reached through better integration and new interfaces. The goal of this project is to explore the possibilities of repurposing public information in a developing area of a large city in the Netherlands. Can we create a tangible interaction with use of physical visualization of these data streams? A series of prototypes have been made to develop a physical visualization through the method of research through design. Users were involved in expert panels and interviews to fine-tune and create a final prototype, Connect-S. The concept shows the opportunities of using physical visualization in connection with physical interaction for browsing and navigation.

## Keywords

Physical visualization, tangible interaction, interactive systems, gesture control

## 1. INTRODUCTION

Every day of our lives, data is gathered about our activities and interactions with people, objects and systems. Technology is advancing at a rate where user generated data can be implemented in systems to make life more efficient and more connected. A lot of data sets are now publicly available through systems and services such as Xively (formerly known as Cosm)[Xiv13], but also through more mediated interfaces embedded in social networks and mobile apps (e.g., location-based weather forecast, media recommendations etc.).

Can sources of raw data be turned into meaningful information, which could fit our daily life better? [LW01] This research project focuses on a future scenario for a former industrial, but now developing area of the municipality of a large city in the Netherlands. Within this area, different types of sensors will be placed and open data streams are available in the near future. In addition, other external data sources will be linked. These open data streams can be used to improve information distributed about the area to inhabitants, visitors and professionals in the area.



Adopting the methodology of research through design [ZFE07], different concepts have been developed to create both a physical visualization of open data streams as well as means to interact with the data.

The purpose of this paper is to address the potential of open data streams and the application in everyday life through accessible and easy-to-use tangible interfaces. In the following, after outlining related work, a series of prototypes leading to a final concept are presented, explored and evaluated with involvement of stakeholders, experts and potential users. The paper concludes with a summary and an outlook on future opportunities.

## 2. RELATED WORK

Inspired by the earlier drawings and concept sketches of the architects envisioning the city area in 2020 [FPW09], a benchmark performed on existing work related to either public installations [BD08, RKM10] or systems connected to the web [BT10, KBM02].

While these projects were mainly public installations or visions of future city areas [SKP11], installations or visualizations of open data streams in the context of the Internet of Things [FPC09] at the time did not implement system elements in them with the

intended interactivity and appropriate use of information.

**Fig 1. Existing project involving projection mapping on a scale model as visualization** [**BS11**].

Aside from the concept of using data visualization in public, many projects embed techniques such as projection mapping, augmented reality and the use of microcontrollers and sensors to enhance the experience [BKP01].

## 3. Connect-S

The system that is developed to address the challenge of fitting data to everyday use is called Connect-S. It is a publicly accessible visualization in form of table with a scale model of the city area, showing open data streams and public information through layered animations projected from the bottom of the table onto the scale model. Passersby could interact with this data related to the surrounding by gesture recognition, and based on the distance between the hand and the table, navigation through layers of information was made possible. These layers of information were categorized into social media feeds, traffic and public transportation, event and planned activities in the area, and local activity of citizens.

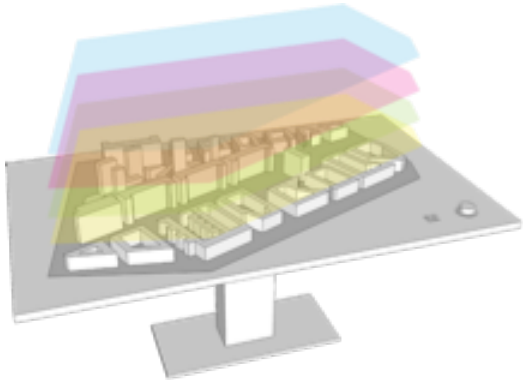

**Fig 2. Sketch of the Connect-S table, including visual representations of categorized data layers.**

## Research through design

Based on the research through design approach, an iterative process was adopted to create this physical visualization. Starting with a scale model of the city area and the use of projection mapping as a method to animate and visualize the data projected directly onto the scale model, several explorations were made and discussed with focus groups, experts and inhabitants of the area in order to fine-tune the animation and the interaction with the proposed concept.

The method allowed for a process of refining the interaction and the implementation of technology throughout several phases, and through a set of prototypes, several possibilities of information representation and visualization were built and tested. Another prototype focused on the user interaction with the table and explored options to navigate and interact with different, overlapping layers of information by using a combination of ultrasonic sensors and direct controls such as rotary controllers and buttons.

These explorations resulted in the final prototype, which was optimized by user involvement and designed to show the possibility of a public interactive system based on physical visualization of data, as shown in the following section.

## Experience Prototype

The final prototype is a moderately scaled down version of the drawing shown in Fig. 1. This high fidelity prototype serves as an experience prototype to show the potential of combining physical visualization and tangible interaction.

The prototype consists of a laser-cut wooden scale model of the city area map (including buildings and roads, cf. Fig. 5) with an integrated LCD display underneath the surface to visualize different information layers.

Users could navigate through the connected data by either changing the layers of information through hovering their hand on different heights above the scale model (cf. Fig. 3).

**Fig 3. User testing the experience prototype**

Another interaction possibility was the use of a dedicated rotary controller to skim through time. This implementation was needed to show for example planned activities in the area over a period of time, but also to look at a range of public transportation options.

The layers of information consisted of the following categories:

- *Social Media layer*, consisting of messages, photographs and videos taken in the area and displayed on the corresponding location. Information that is made public on the web is repurposed as informative data to visitors and inhabitants of the area.

- *Traffic Information layer*, sets of information related public transportation and related information to traffic such as the available parking places and traffic jams. The public transportation would be displayed as a dynamic logo to inform users of the transportation schedule.

- *Events layer,* a more scripted layer of information. Organizations and companies could use this layer to promote and announce activities and events. By introducing a separate layer for summarizing events and activities users can easily foresee (future) events. This information would also be mapped out on the scale model.

- *Intensity layer*, information created by users and showing hotspots of areas based on sensors and information that is made public over the Internet. The use of these data streams and information the concept can be considered as a physical visualization of a 5-dimensional model of values: *(x, y, z, time, intensity)*

With use of these five dimensions, the concept would be able to use various in- and outputs to function. The X and Y dimensions are the dimensions that are used for to display location; the values are translated to a pixel grid on a LCD display. The Z dimension is controllable and mapped to the ultrasonic sensor, measuring the distance of the hand and showing one of the layered animations. The Time dimension would be mapped to a different controller; a rotary dial fulfilled the purpose of scanning in the past, present and future by browsing through different animations per layer. Intensity is only shown on the display itself. By creating points and a surface surrounding these points on the scale model, specific locations and sensors could be visualized representing dynamic content.

Based on the 5-dimensional model and the use of these four layers of information the interaction was fine-tuned appropriately with through the use of an LCD display, ultrasonic sensor and a rotary dial (cf. Fig. 4). The action possibilities of the experience prototype were influenced considerably by the practicalities of a public system and efficiency in mind.

**Fig 4. Experience prototype with scale model and integrated LCD display, controllers (ultrasonic sensor and rotary dial) on the left.**

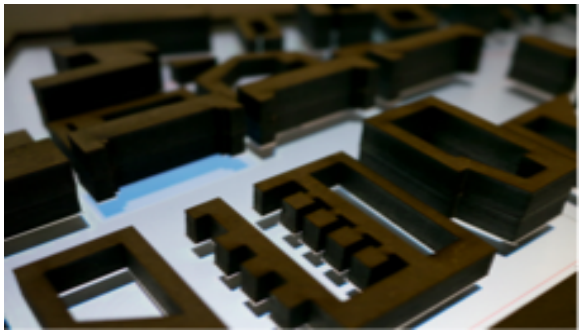

**Fig 5. Close up view of the scale model and animation on the integrated LCD display**

## 4. USER EXPLORATION

Within the design process of the Connect-S table, several methods were applied to validate the final concept and to receive feedback from users:

### Expert panel

An expert panel was used to evaluate the current concepts and at the same to map out the design implications for the context. Through a series of informal interviews with experts in the field of architecture, organizations in the area and inhabitants, information was gathered about their vision and opinion of this plan for the future.

The findings from these interviews were used to generate concepts in the explorative phase of this research. Furthermore, requirements and practicalities for public installations and useful systems could be mapped based on this expertise and user involvement.

### User confrontation

Different users and experts were asked for an informal feedback session about the final Connect-S prototype, in which they could experience local data in a spatial visualization by interacting with the table.

Findings from these sessions proved to be useful to confirm and fine-tune the general impression of the concept. While the prototype was tested using a few scenarios of using public data, the involvement of users proved itself to be useful even on this scale of testing the concept with an experience prototype.

## 5. DISCUSSION

Connect-S showed that the use of (moderate levels of) tangible interaction in a physicalized visualization can be useful as a medium to display and interact with intangible data that is collected and publicly available via the Internet, but not accessible for everyday use by inexperienced stakeholders. Through the design process and the inclusion of users during development, a physical visualization based on the information about the city area was developed, which would enable users to use information more actively and efficient in their everyday life similar to other physical visualizations [JDF13].

In comparison with earlier studies and projects involving public installations and implementation of technology in city areas [Sta11], this project did not only address the aesthetics and implementation of a public system, but also emphasizes opportunities of using tangible interaction as a means to include open data in a meaningful way.

One of the main reasons for choosing deliberately for a solution, which makes the interaction tangible, was due to the target user group. The Connect-S concept is focused on different users such as inhabitants of the area, visitors and working professionals. By placing multiple tables in the most populated and frequently visited areas users can interact and use this public installation both as a visualization of the area as well as a functional system strengthening the unique identity of the area with modern technology.

This project was developed and evaluated with the involvement of an expert panel and informal interviews. The concept was received positively by all parties, but needs to be tested on a larger scale in the future to make stronger conclusions to strengthen the use of open data for tangible interfaces. Also, given the quite generic implementation and mapping of data to visualization and interaction, the concept could be easily scaled up to different parts of the same or different cities. As a starting point, however, designing for a specific context, such as the future city area proved to give the research a more practical point of view, thus affecting the outcomes such as the experience prototype that users and stakeholders could directly and actively test and give feedback on. A strong and realistic context certainly accelerates the process of designing and developing physical visualizations with animated data layers and tangible interaction. Through this approach, the table goes beyond the boundaries of a (physical) data visualization that only shows the aesthetics of data, but highly constrains the amount of information presented.

## 6. FUTURE WORK

Some pointers for the future have been mentioned in the previous sections: The Connect-S concept inspires different projects related to tangible interaction through the use of visualization of data.

Developing a prototype with layered animations and gesture control is one of the possibilities to create a tangible interaction. While this seemed the appropriate mapping for the context in this paper, other methods of mapping would be possible depending on the design requirements. This new challenge of system development arises with the freedom of mapping the data to an appropriate visualization and interaction without the boundaries of the physical form. An example is AMP (cf. Fig 6), a lamp that uses an original method of projection to display the activity around the city by means of social media streams. The concept shows different interaction possibilities in both the use of visualizations and the method of interaction by its user in comparison with this research project [ET13].

**Fig 6. AMP concept projecting a city map and displaying current activity based on data sourced from social media.**

This paper introduces an approach for developing concepts concerning visualization of data and the tangible interaction for a specific context and user group through the method of research through design [ZFE07]. For future work, one can consider developing an application of data visualization using the methodology to create real life applications of this field of research involving stakeholders and future users.

## 7. CONCLUSION

In this paper Connect-S is introduced, an interactive scale model of a city area with animated data layers.

A tangible interaction was presented as a means to give purpose to the open data streams and the physical visualization of information related to the city area. While the interaction with Connect-S has been not explored extensively over a period of time, this ongoing research shows potential of integrating more systems in daily life that inform and give back user generated data.

The visualization of data can be used as a medium to communicate information from open data streams. Embedding this information into systems in daily life can enrich the experience and the use of data on

manners that have not been explored in the past. Public systems as in the case of Connect-S show that technology can be integrated on a new level of interaction, a level that invites users to interact and inform on a daily basis and can grow over time depending on the use of the system.

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