Keeping in Touch with Data: Tangible Interaction Through DIY Capacitive Sensing

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Abstract*— *As data becomes embedded in daily life, traditional visualisations often distance users from the real-world events they represent. This paper explores data physicalisation as a more embodied and accessible alternative, focusing on touch-based interaction. While capacitive sensing is common in flat interfaces, integrating it into complex 3D forms remains a challenge. We present low-cost, modular prototypes using conductive materials and wireless sensing to enable tangible data interaction. This approach aims to lower barriers for artists and educators, fostering more meaningful, situated engagement with data.

I. Introduction / Background

The innate human senses such as touch, sight, and smell have evolved over thousands of years, enabling us to understand our environments. Humans have also developed digital methods for sensing, collecting this data to form insights usually represented by data visualisations. While data visualisations remain widely used, a more meaningful and promising approach is to physicalise the data, thus integrating it into everyday experiences beyond digital interfaces. Physical interaction with data has significant potential to enhance understanding, accessibility, and engagement [1] particularly compared to traditional screen-based visualisations. Although digital screens remain the dominant medium for exploring personal and environmental data, they inherently introduce a layer of abstraction that distances users from tangible meaning and situated context [2]. Moving data interaction from screens into the physical world fosters richer, embodied experiences, enabling intuitive exploration through familiar human senses such as touch [3].

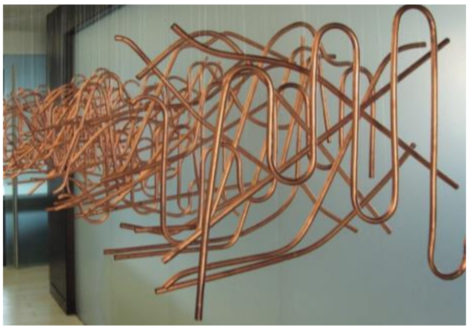

Fig. 1. *Endings* – an artistic data visualisation by L. Marsden, illustrating the expressive potential of physical form to represent complex human data [5]

Touch, as a natural and intuitive interaction mode, has become ubiquitous due to the widespread use of capacitive touchscreen technology [4]. Capacitive sensing, which detects changes in electric fields, allows for responsive and intuitive interactions. Despite its extensive application in flat, two-dimensional surfaces, integrating capacitive sensing into complex, three-dimensional objects remains challenging [4]. Additionally, physical data artefacts are often artistic [5]—as seen in Endings by L. Madsen (Figure 1)—or digitally fabricated, such as *Wage Islands* by Ekene Ijeoma, and intentionally arbitrary in form [6]. Yet the potential for embedding capacitive touch interactions into these non-planar, complex shapes remains underutilised due to technical barriers.

Recent advances in materials, such as conductive 3D printing filaments and capacitive paints, present promising new opportunities for integrating electronics, including capacitive sensing, into bespoke physical artefacts [7]. However, significant technical barriers persist, especially for individuals with less technical backgrounds such as artists. Enhancing accessibility to sensing technology will enable more people to seamlessly incorporate digital interactions into their work, fostering engagement and embodied interaction.

Our approach explores how physicalisations can serve as interactive interfaces to digital data. Beginning with interfacing through capacitive touchscreens, we investigated how 3D-printed conductive forms could be used to recognise artefact placement and geometry. Building on this, we developed a custom capacitive touch surface using conductive paint and modular sensing components. These experiments aim to democratise tangible data interaction by making wired and wireless capacitive modules accessible and easy to integrate through 3D printing or painting. In this paper, we outline our preliminary experiments (Figures 3–5) and highlight recent developments in capacitive sensing technology.

II. Related Work

Recent research has explored how capacitive touch sensing can extend digital interaction into physical artefacts. Touch, as a familiar and intuitive human sense, offers a compelling modality for engaging with data in tangible ways. Capacitive sensing techniques are particularly attractive for enabling lightweight, low-latency interaction without the need for complex mechanical systems.

Different technical approaches demonstrate this potential. Some, such as CAPath by Kato et al. [8], extend existing touchscreens through passive 3D-printed objects, allowing gesture recognition without additional electronics. Others embed touch sensing into three-dimensional surfaces; Palma et al. [4] proposed computational fabrication techniques for mapping multi-touch interactions onto complex forms. Götzelmann et al. [9] embedded capacitive sensor grids inside 3D prints to enable precise touch tracking across surfaces, as illustrated in Figure 2. Schmitz et al. [10] introduced Flexibles, 3D-printed tangibles that detect pressing, squeezing, and bending through deformation-aware sensing.

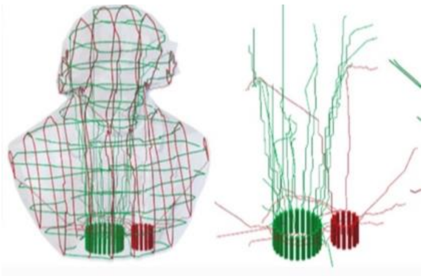

Fig. 2. Example of mapped conductive paths in complex 3D forms. These mappings highlight the technical challenges non-experts face in implementing capacitive interaction [9]

While these methods show the promise of capacitive interaction, they often require advanced fabrication techniques, custom hardware, or access to proprietary touch data, limiting their accessibility. Dual-material 3D printing, intricate sensor routing, and system-level modifications remain barriers to broader use, especially for low-fidelity prototyping and creative exploration.

In response, this work investigates a simpler, more accessible approach. By using conductive 3D-printing filaments and conductive inks to create custom sensing areas, connected via low-cost I²C modules such as Stemma QT or wireless commuication, we aim to support easy integration with microcontrollers like the Raspberry Pi, Pico, and BBC micro:bit. This approach seeks to democratise interactive, tangible artefact creation by lowering technical barriers.

III. Imagined or existing prototype sketches/drawings/photos

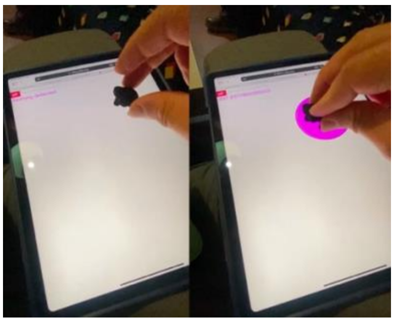

Fig. 3. Identifying unique 3D-printed artefacts using conductive filament and capacitive touch on a tablet. Each artefact is recognised by its distinct footprint geometry.

A. Conductive 3D-Printed Artefact with Capacitive Touchscreen

During the TEI’23 studios, we explored 3D printing artefacts using conductive filament and discovered their compatibility with capacitive touchscreens. These materials responded to pressure through deformation, enabling potential for expressive interaction. A prototype artefact with three conductive “feet” was printed and tested on an iPad using p5.js, which detected simultaneous touchpoints and calculated their spacing. This allowed basic artefact recognition, where different objects could be identified by the geometry of their footprint.

Fig. 4. A DIY touchboard built with conductive paint, wirelessly sending capacitive touch data to a laptop running a particle-based data visualisation.

B. Bespoke touch board: feat wireless communication

To further explore tangible interaction, we developed a 3×3 capacitive touch board using conductive paint. Each of the nine zones was connected to a Bare Conductive Touch Board, which handled capacitive sensing. I paired this with a simple Bluetooth module to wirelessly transmit touch data to a p5.js sketch running on a nearby computer. The sketch used a particle system to visualise the interaction: each touch point created a flowing stream of words, representing UK rivers affected by sewage outflows. These river names flowed across the screen as interactive data particles. The system was designed for projection at larger scale, enabling public interaction through a tangible interface that shaped the movement and density of the visualised data streams.

These prototypes demonstrate two different yet complementary strategies for enabling tangible data interaction—one leveraging passive conductive 3D-printed forms directly on touchscreens, and the other using wireless sensing to expand interaction beyond the screen surface. Both approaches highlight the potential of data physicalisation to foster more embodied, situated engagement with digital information. By focusing on low-cost, modular materials and methods, these prototypes also support greater accessibility, enabling a wider range of people—including artists, educators, and non-experts—to meaningfully interact with data in creative and personal ways.

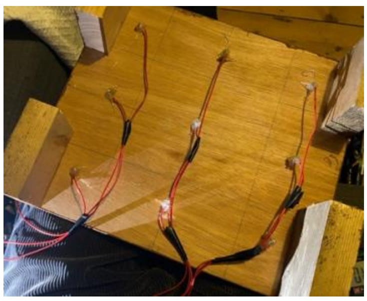

Fig. 5. Underside wiring of the 3×3 capacitive touchboard showing how each zone connects to the capacitive sensor via wires and hot glue for support.

IV. Responsible innovation

At the core of our work is fostering broader societal engagement with environmental and personal data through intuitive, tangible interactions. By using 3D printing and capacitive painting to create interactive sensing areas, we can develop responsive technologies precisely when and where they are needed. Additionally, adopting modular and reusable electronic components for touch sensing and wireless communication ensures versatility and sustainability, enabling components to be easily repurposed for different applications.

Furthermore, our research seeks to empower non-technical communities—particularly artists, educators, and citizen scientists—by significantly reducing barriers to creating interactive data representations. This approach facilitates inclusive and meaningful participation in data-driven discussions, thereby enhancing societal engagement and promoting informed decision-making around data.

V. Author bio(s) / experiences

Chris is a PhD student exploring how creative computing and DIY electronics can help people engage with complex data. With a background in Computational Arts, his research is shaped by a personal commitment to environmental issues, particularly ocean health—something he has experienced directly as a surfer confronting sewage pollution.

His work involves computationally sculpting physical artefacts based on sewage outflow data, using them to investigate how metaphor and interaction can foster emotional and intellectual connections to environmental challenges. His expertise includes physical computing, tangible interaction design, and data-driven art, with exhibited work that combines artistic practice and critical environmental storytelling.

VI. Refernces

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