Robotic displays based on de-computation

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Abstract
We describe one approach to display as a de-centered, distributed experience combining the properties of tangible interactions with machine intelligence and decoherence. The design of environments, objects and systems concerned with representations of digital data is filtered through an orientation towards the heuristic of spatial mapping. Digital habitats and information ecosystems are described as having material properties separate from their metaphorical representations. Resolution, mapping and coherence are our guiding principles to the orientation and augmentation of everyday objects, towards interactional mediation and new meanings. This paper suggests a connection between physical and virtual artefacts, machine intelligence, and data manifestation along with an associated view of materiality, and some key principles for design and for the process of 'de-computing' problems, systems and meanings.

Author Keywords
Interfaces; display; materiality; data environments, digital objects; physical interactions.

ACM Classification Keywords
H.5.m. Information interfaces and presentation

Introduction

This paper takes display in its widest sense to mean the intended locus of interactions, not just the surface they unfold on top of. As everyday digital interactions have become portable, touch-based and connected, the ways data are experienced have moved away from desktops and tethered environments into ecospheres of everyday actions. This movement has allowed a reframing of how displays are defined and what they are for.

Material user interface (MUI) design refers to programmable matter; materials 'that are computationally transformable and reconfigurable' [1] and can include clay [2] and sand [3] based systems that respond to actuator control. Advances in nanotechnology [4] allow for increasingly precise control of matter at a molecular level, making MUI design an increasingly realistic proposition.

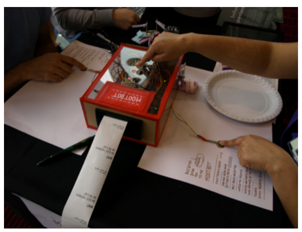

Fig. 1 'Mootbot' for influencing social interactions.

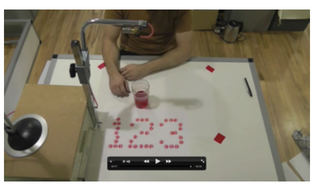

Fig. 2 Robotic display using liquid as medium.

If each grain of sand or molecule of clay can be individually programmed to frame a set of interactions that address a problem or task, what would be the nature of such a display? One response to the question of such a distributed surface is to think of the display as robotic. Robotic displays are characterised by how their *coherence* depends on a set of constraints mapped to underlying data models, and how the *resolution* of the display can be decoupled from information density.

Tangible Use Interfaces (TUI) endow physical objects with sensors responsive to human touch and gesture [5]. Common concerns for the design of tangible interactions include the position of displays relative to people and spaces, resolution (also taken here to mean data resolution), form factors, coherence, and mapping.

These concerns are explored further in a new approach we are exploring, which we call 'de-computation.'

De-computation

De-computation is a way of understanding the world that emphasises processes and systems. It approaches basic phenomena such as language, matter, physical spaces, and social systems through computational thinking principles of decomposition, pattern recognition, abstraction, and algorithmic design. As an example, we have de-computed language by taking an obscure, ancient language, breaking it down into a subset and abstracting it to form a new gestural language as a way of investigating gestural interfaces.

Decomputation has also informed a project called 'Mootbot' intended to structure social interactions. The system is based on de-composing particular social interactions at a networking event, identifying patterns in how people made serendipitous or random social connections, abstracting this to basic principles and computational elements, and designing a robotic, distributed display requiring two people to operate. The Mootbot structured social interaction by printing a thematic discussion topic, and outputting randomised printed posters to affect further social interactions in the space.

A robotic display created in our lab uses computer-controlled drops of liquid as a display medium. It works on a tabletop, but one can imagine taking a broader view of pattern recognition in larger landscapes, and enacting this with a similar approach informed by computational thinking. Key to such a display is resolution, which is discussed next.

Resolution

Resolution refers to the ability of a display to convey information at a level suitable for the efficient transfer of knowledge. The distribution of pixels across a display corresponds to the minimum level of detail necessary to convey data and influences power consumption, image making, and meaning. Images contain varying levels of information but the universal adoption of standard screen resolution and the bias towards photorealistic illusion flattens this difference.

Robotic display subverts this convention by operating at multiple levels simultaneously, and by abstracting the concept of pixels to spatial distribution. For example, when a digital experience is distributed across three-hundred cell phone screens [12], the overall resolution can grow, shrink or reconfigure at any time. In a live, spatially-distributed scenario this can be seen as *experience resolution*. The nature of the experience depends on how the information or knowledge imparted changes dynamically depending on the number of individual pixels present. In a current project called The Exploded Screen, the phones of a participating group of people are orchestrated over time and space.

The integration of social media (and their bias toward connection, sharing and storytelling) with the Internet of Things turns devices into active, connected pixels in a larger social composition. The operating resolution of displays that represent the global technium [13] can then be thought of as robotic. In the same way that a novel contains higher-resolution information than a till receipt, so the configuration of individually addressable bits (connected objects) creates *social* resolution.

In the context of future displays, de-computation implies thinking about surfaces and representational metaphors. Just as TUI transcends the flat surface of digital displays, so de-computed displays mean distributed and decohered screens. The next section describes decoherence in further detail.

Coherence

Coherence refers to the way in which displays are presented as integrated, bounded sites for interaction. A computer screen is framed literally and metaphorically by its casing and by the limits of its abilities. Cascading levels of display coherence in portable or deformable displays are represented by system design, applications, and interaction models. These often borrow from previous modes of information consumption, e.g. the digital photo album, the folder of documents. Projected displays, whether onto flat surfaces or mapped to buildings and objects are similarly complete systems: they are bounded by angles of view, light levels, and geometric composition.

Decoherence [14] is a term borrowed from quantum mechanics. It refers to the appearance of an interference factor in probability calculations for wave detection. In some cases this interference is not observed and is assumed to be an artefact of measurement or a result of wider system distribution. The way in which wave phase relations interact with their quantum environment is termed decoherence. The analogy we propose is with displays that exist in, or react to, wider environmental conditions.

Displays are considered to be decohered if they are unbounded by system architecture or if they interact dynamically with other systems. For example, a network of distributed displays such as bus shelter information screens react to transport data. Alternatively, programmable objects such as wearable pulse sensors react to environmental conditions individually, creating an aggregated picture or display. Robotic displays are characterised by their level of decoherence; how responsive to their environment they are and how they aggregate across time and distance.

Mapping

Our age is increasingly driven by database structure. Databases store, retrieve, structure and connect; they also represent the granular nature of digital data. One of the challenges we are looking at is how a display system can be designed and configured to reflect the nature of large, real-time datasets. If the display represents a large dataset in a one-to-one mapping, the level of detail would be overwhelming. On the other hand, if design constraints are too limiting, only a vague impression of the data will be communicated. Typically representational systems display a level of detail appropriate to task fulfillment, e.g. search results are filtered for relevance. Deformable displays offer the opportunity for the display medium itself to take on the shape of the data – a concept that can be interpreted in a number of ways. We have described how materials can be programmed to represent underlying data entities to varying degrees of fidelity. Robotic displays consisting of a distributed pattern of 'screens' provide the chance to be arranged in multiple configurations. A constrained set of these configurations could correspond to different levels of mapping fidelity.

In the context of TUI design 'dynamic changes of the physical form can be reflected in the digital states real time, and vice versa' [1]. We propose the concept of multi-directional coupling whereby the display system is free to make its own associations in a hierarchy of data networks. In the same way cells divide and mutate, displays combine, aggregate and divide to adapt to diverse mapping requirements.

For further information, see decomputation.rca.ac.uk

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