transFORM - A Cyber-Physical Artefact Augmenting Social Interaction in Residual Public Spaces

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ABSTRACT
The emergence of social networks and apps has reduced the importance of physical space as a locus for social interaction. In response, we introduce transFORM, a cyber-physical environment installed in under-used, outdoor, public spaces. transFORM embodies our understanding of how a responsive, cyber-physical architecture can augment social relationship and increase place attachment. In this paper we critically examine the social interaction problem in the context of our increasingly digital society, present our ambition, and introduce our prototype, which we will iteratively design, and test. Cyber-physical interventions at large scale in public spaces are an inevitable future, and this paper serves to establish the fundamental terms of this frontier.

Author Keywords
HCI; co-design at scale; cyber-physical artefact; place attachment; social interaction.

ACM Classification Keywords
• Human-centered computing~Interactive systems and tools • Human-centered computing~Interaction design process and methods • Human-centered computing~User centered design

INTRODUCTION
The subject of place attachment in public and semi-public urban spaces is an important contemporary issue that calls for careful examination and further comprehension in a technologically changing world. "Place attachment" is the cognitive and emotional bond that individuals develop towards a place [[13]]. Place attachment helps to explain and predict other outcomes, such as behaviors, perceptions and emotions [[15], [12]]. As a setting for all sorts of social engagement, public outdoor places like plazas have been a remarkable example of beloved and attached places [[24]].

TEI '19, March 17–20, 2019, Tempe, AZ, USA

ACM ISBN 978-1-4503-6196-5/19/03…$15.00
https://doi.org/10.1145/3294109.3302959

Traditionally, these positively-viewed outdoor spaces have been the capacious settings for people's interaction in many cultures and societies, such as the Agora (Figure 1) in ancient Greece. However, digital and networked technologies have drastically changed the way people interact with each other, and the way people interact with the built environment [[11], [21], [9], [16], [20], [14]]. Such change has shown significant impact on the levels of place attachment to such spaces.

In response to public outdoor spaces being supplanted by social networks and apps, our team from design, computing, digital humanities, and library science, partnering with a library and local government, proposes *transFORM*, a cyber-physical environment at room scale, installed in underused outdoor, public squares. Our objective: to enhance information access, use, and archiv1ng outside the walls of public libraries and to foster social interaction and place attachment in public, urban spaces. Our main goal is to rethink the relationship between people, space and technology, and ultimately, to redesign urban, outdoor spaces as a vehicle for human interaction embedded with today's digital technologies. The key is not to negate technology, but to reintegrate it into the built environment [[8]] in order to, in William J. Mitchell words, "create fresh urban relationships, processes, and patterns that have the social and cultural qualities we seek for the twenty-first century." [[23]]

Figure 1. Agora, by Edward Dodwell. Photo on Wikipedia.

RESEARCH QUESTIONS
Based on these concerns, this research posits two major research questions:

1. What are the key design features that lead to enhanced social interaction?

2. How does a responsive cyber-physical environment affect social interaction and place attachment in a public outdoor space?

Figures 2, 3 and 4. Three different configurations – two "open" and one "closed".

transFORM: GOAL AND DESIGN PROCESS

transFORM will serve as the physical manifestation of our understanding of how an intelligent, cyber-physical environment can augment social interaction and place attachment in urban, outdoor space. transFORM is an architectural-robotic origami that creates various meaningful scenarios, setting premises for people's appropriation in urban space.

Practically, transFORM is a collection of folding, hinged origami that aims to support several activities for urban dwellers. By physically changing its shape, color and sound, transFORM offers different activities, varying from one to another according to user's needs (Figures 2-4).

Origami is mostly recognized as a three-dimensional sculpture formed by folding a sheet of paper. A variation of origami called kirigrami, also known as "pop-up" origami, introduces a single, internal cut into the folded sheet of paper to expand the formal possibilities of the resulting form. Using numerical computing program (MATLAB), we analyzed the gravitational forces actuating in the geometry of our first prototype in order to find the reaction force necessary to accomplish static equilibrium (Figure 5).

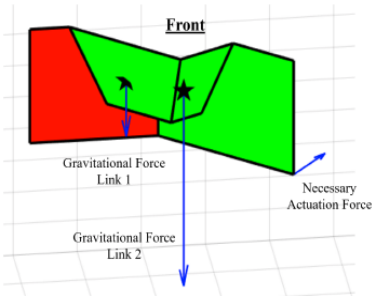

Figure 5. Geometrical Analysis of transFORM using MATLAB

CO-DESIGN AT SCALE: INITIAL STUDY TO GENERATE DESIGN REQUIREMENTS

Our main goal is to design for an under-used public space a responsive environment with imbedded information technologies matched to what people do with them. Therefore, the objective of this first (out of two) co-design study is to understand "*Who* does *what* with *whom* using *what* physical and digital resources?" To seek responses, we conducted a survey asking 41 participants (ages 16-68) to select three activities they would like to do in the under-used place under three different conditions: (a) being alone, (b) being with family/friends, and (c) being with strangers.

Following from the results of the survey, we invited participants to engage in a co-design activity (Figure 6) where they designed a space that supported the top selected activities correspondent to each of the three conditions (i.e. treatments (a)-(c)). Participants were be given six fundamental components to design such a space – screen, light, bench, floor, canopy and table (Figure 6).

It'd be extensive to report the complete analysis in this paper given its level of complexity. As an example, however, in Figure 7 shows the most used components for each of the top 4 activities engaged by people when they are with family/friends. These matrixes enable us to create a collection of human behavior-environmental patterns and their associated fundamental components.

In addition to the co-design activity, we also asked participants to 'think out loud' as they imagined and described their behavior in the space.

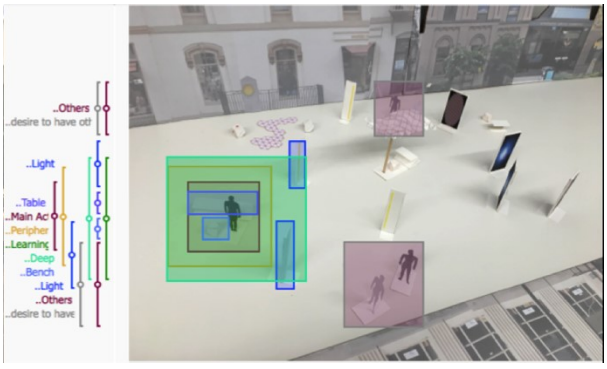

Figure 6. Coding of a Co-Design Activity

Figure 7. Actor-Activity-Component matrix

An interesting pattern we identified refers to the participants' behavior when they approach the space populated with strangers. Some of the participants said they would first observe from afar what others are doing, a behavior that we call "Observing Others"; then, if they became interested, they would approach the screen, canopy or lights to "…*see what others are doing*." In instances when they became interested, they reported that they would engage in a deeper interaction with the installation. We call this behavior "Exploring Surrounding" characterized by participants' exploration in terms of learning and discovering the spatial attributes and affordances. Finally, some participants said they would engage in either "Talking/Socializing" or "Playing Games" with strangers. This behavior suggests that the installation facilitate the interaction among strangers. Figure 8 shows the taxonomy of interaction just described.

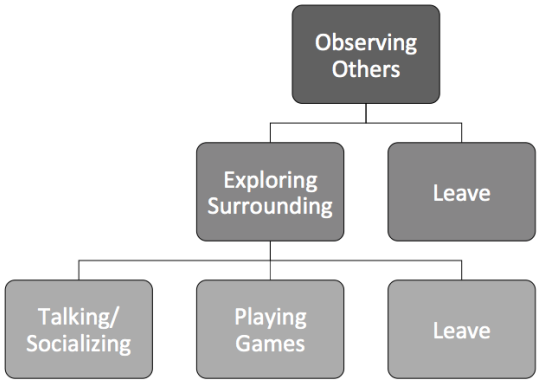

Figure 8. Taxonomy of Interaction when Interacting with Strangers

CURRENT AND FUTURE WORK

In current work, we are constructing a full-scale prototype of transFORM in our lab. We will then invite participants to engage in a second co-design activity, this time using a full-scale prototype. The aim of this second co-design study is to gain more detailed input regarding the attributes and affordances of transFORM artefact. Following this, we will iterate the design and test the full-scale prototype in-situ where we'll measure the effect of transFORM in social interaction and place attachment. For this quasi-experiment, we'll do five observations: two before the installation of *transFORM*; two after its installation; and one after its removal (Figure 9). We expect to see no major change in the levels of place attachment in the first two observations (O1 and O2) (see figures 9 and 10). However, we do expect to see a significant increase in place attachment levels after the installation of transFORM (O3 and O4). Lastly, we expect lower levels of place attachment after the removal of transFORM.

$$O_1 O_2 X O_3 O_4 \underline{X} O_5$$

Figure 9. Quasi-Experiment, Remove Treatment with Pre- and Post Test. The letters 'O' means observations. Letter 'X' means add intervention, in this case transFORM. Letter 'X' means remove intervention.

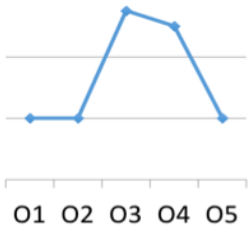

Figure 10. Expected levels of place attachment for each observation.

IMPLICATIONS FOR TEI COMMUNITY

transFORM will probe unexplored opportunities in public, outdoor places for Tangible, Embedded and Embodied Interaction (TEI) at large physical scale, and will provide a deeper understanding of how people perceive and interact with each other in such new places. Others have created larger-scale interactive installations [[17], [5], [3], [6], [18], [1], [2], [7], [10], [19], [4], [22]], but transFORM is distinct from these in its objective to foster place attachment and offer information services beyond the walls of the library. Servings as a design exemplar of large-scale outdoor HCI, transFORM offers a replicable installation and resources to underserved communities

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