Embedding Robotics in Civic Monuments for an Information World

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Abstract
The monument is our first computer: a complex, physical entity that stores and brings to consciousness facts, ideas and aspirations – information. In this paper, we introduce transdisciplinary research aiming to overcome, in the Information World, the static, petrified character of monuments which has long-presented collective memories about human events in immutable spatial forms. Our concept is, instead, the *monument-as-robot*. Embedded with sensing and actuating technologies, our concept affords multi-configurations representing the multivalent character of "collective" memory more so than the single conventional monuments. We reflect on the crisis of the monument today, describe our three novel prototypes responding to this crisis, and discuss the import for HCI.

Keywords
Monuments, robotics, architecture, memory, interactive environments, architectural-robotics.

ACM Classification Keywords
H.1.2 User/Machine Systems, J.5 Arts and Humanities

General Terms
Design

Introduction
Historically, monuments are spatial representations of our collective past memories as elaborated in

architectural treatises for centuries [3,5,6,12,21]. Monuments are the signs and landmarks of our cities and the collective mnemonic devices for societies to recall past memories.

Architecturally, monuments have tended to be concrete, static vessels for transmitting collective memories [2,21] whereby the human-monument interaction is defined by a singular, static, petrified form of architecture. While recalling the past through monuments is a topic intensively investigated, the idea of embodying memories in dynamic spatial representations has largely been neglected by researchers [2, 15].

Human-Architecture interaction is among our first human-machine interactions [9, 10]. In this light, the monument is our first computer, storing and bringing to consciousness facts, ideas and aspirations. In an IT-embedded architecture, Malcolm McCullough recognizes the potential to augment architecture's capacity to serve as a vessel of collective memory, opening the petrified state of built form to reform and renew itself by way of human-architecture interactions [9]. Our research aims to overcome the crisis of the monument by offering a built form of multi-formal representations that embody the richness and density of our collective memory.

Motivations

In the 1990s, Weiser envisioned a world of ubiquitous computing that recedes into the background of our lives. "In such a world, we must dwell with computers, not just interact with them" [18,19]. Bill Gates has more recently envisioned "a future in which robotic devices will become a nearly ubiquitous part of our everyday lives" [7]. Our research in monuments is motivated by these visions, and specifically the growing research in architectural-robotics [17] in which the built environment is embedded with robotics and other information technologies to overcome certain limits endemic to architecture and computing. Technically, the gap between the technology of making things and the science of understanding them is one of the main challenges for interactive, intelligent architecture [10]. Consequently, we are also motivated by Negroponte's vision "that [give] machines access to the physical aspects of the world" [10]. More specifically, we are motivated by diverse, recent exemplars of interactivity in and of public spaces, such as the Anne Frank Tree [1], the Make History Project [20], the Muscle Projects of TU Delft [11], Ito's Tower of Winds [4], the Community Chalkboard [14], and the Ice Fern of Ramsgard and Mossé [13].

Monuments for a Digital Society

As "collective" memory is not singular, constant and stable over time [16], our vision for a monument in the information world is a robotic monument reconfigured by the dynamism and richness of collective memories. We envision the experience of interacting with monuments as responsive, dynamic and accommodating the richness of human memory. Our team of investigators from Architecture and Robotics has consequently designed and prototyped three early examples to demonstrate our vision. We describe our design concepts, scenarios, and the hardware used for these prototypes, named *re:Birth*, *We.bot* and *Flotus*.

Hardware Overview for All Prototypes

- We employed Arduino, an open-source electronics prototyping platform based on an 8-bit

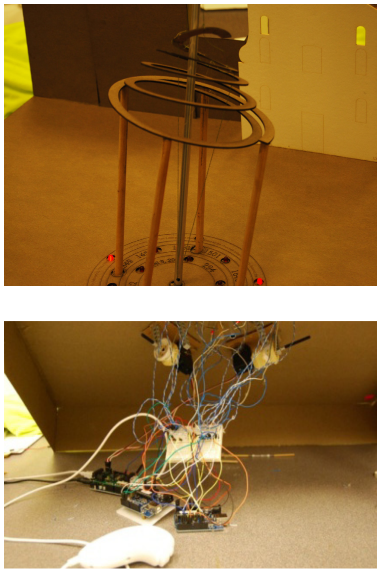

Figure 1. The re.Birth hardware: (top) shaft and strings;(bottom) two servos, Wii, and microcontroller.

microcontroller which is popular in the field of physical computing. Arduino uses a simplified version of C/C++ programming language.

- We employed two types of IR sensors, IR switches and a combination of IR transmitters and receivers. The IR switch output is low if no object is in front of it and high if an object is near to it; its range is approximately 25 cm.
- We employed standard and continuous servo motors that use a supply of 5V, as well as a number of super bright LEDs.
- For *re.Birth* we used a *Wii* Nunchuk controller; for *We.bot*, a photo resistor sensor is used to detect the amount of light in the environment; and for *Flotus*, a custom-fabricated sensor of 4 resistors is used to detect sea level.

re:Birth: The Earthquake Monument

re.Birth, is a monument in La'Aquila, Italy motivated by the tenacity of the its residents who have repeatedly rebuilt their city in the wake of earthquakes. The design of this prototype aims: (1) to realize a monument that senses and displays seismic activity and restructures itself into a protective configuration when dangerous seismic activity is detected; and (2), to realize a monument that celebrates the "rebirth" of the city and its people.

re.Birth Components

re.Birth consists of three main components: the *dome*, the *shaft* and the *base*. The *dome* is a spiral supported by 4 columns. The *shaft* is the main mechanical piece with strings that help to elevate the spiral and changes its form. The *base* is engraved with rings and dates of past earthquakes that ravaged the area and celebrate these dates by using LEDs to mark them.

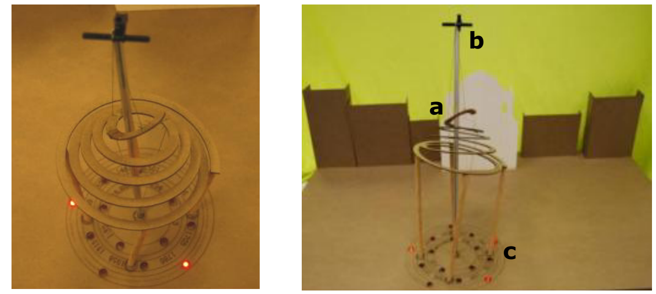

Figure 2. The re.Birth with its three main components: (a) spiral dome, (b) shaft, (c) base.

re.Birth Scenario and Operations

Tony and Vidya decided to visit *re.Birth* in La'Aquila. When they first encounter it, they find its spiral dome, suggestive of the dome of the Santa Maria church it faces, is changing. Actually, the spiral component raises and falls as the monument senses seismic vibrations (simulated by using the Wii Nunchuck). Lights also help to display seismic intensity: when there is no seismic activity, the lights dimly illuminate; when seismic activity is detected, the same lights glow from inner ring to outer ring depending on seismic strength; and on a day of commemoration, the lights start off dimly illuminated and glow in intensity. During levels of high seismic activity the monument's spiral descends to the ground.

We.bot: The Interactive Weather Monument

We.bot is a responsive weather monument motivated by extreme daily climate changes in Melbourne, Australia. We propose a monument to bring awareness to the collective memory of weather that has long been tumultuous in this city. *We.bot* is designed with the goal of having a monument for recalling past weather

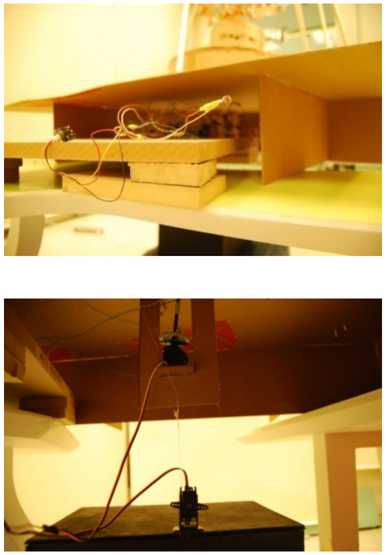

Figure 3. The *We.bot* hardware: (top) IR sensor and Photo resistor sensor; (bottom) two servo motors.

changes at the given calendar day in Melbourne's history.

We.bot Components

We.bot consists of three main components: *heart*, *leaves* and *rotating wheel*. The *heart* is a ring-shaped ceiling supported on 4 main compression members and 7 zero columns. The *37 leaves* are connected with cables in complex relations that bring to life the different changes of weather in Melbourne when actuated by servo motors attached to the base of *We.bot*. The *rotating wheel* is the information screen that presents to visitors the year in which the *We.bot* is tuned, and is based on a rotating disk actuated by a servo motor at the base of the monument.

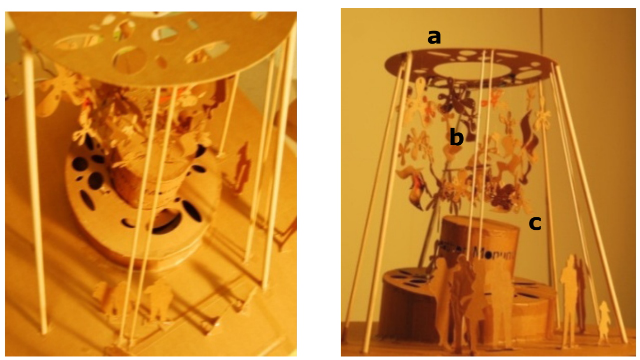

Figure 4. The We.bot with its three main components: (a)We.bot heart, (b) We.bot leaves, (c) We.bot rotating wheel.

We.bot Scenario and Operations

In July 8,2009, as Tarek and Akshay approach *We.bot,* the monument begins to change its shape, its color, and its transmitted sounds capturing the nature of different climatic conditions(stimulated by using photo resistor sensor, and IR transmitter and receiver). Suddenly Tarek notices that the *rotating wheel* begins to move, resting at "1922". While the visitors observe this change, the audio changes in character and the monument's *leaves* begin moving and changing in color from red to cold-blue. Tarek starts to understand why this occurs: on this given day of the year 1922, the weather was record-breaking cold. The monument reflects the historical record of weather of the given calendar day to bring greater awareness to the particular character of this place.

Flotus: The Floating Monument

Flotus is a floating monument for the remembrance of the great Khmer empire that ruled the land of Cambodia in the 9th century. *Flotus* is motivated by the 14th century disastrous flood that caused the Tonle Sap Lake to flood, resulting in the destruction of the Khmer Empire. In form, *Flotus* is inspired by the design of the Angkor Wat temple with its five towers inspired by the form of a lotus-bud. Spatially, *Flotus* has multiple locations: on the Mekong River that is reversing its course, on the Tonle Sap River, and on the West Baray Pond. *Fotus* is designed with the goal of alerting residents of the flood in its different locations, and as a guide for fishermen to the location of fish in the Tonle Sap river, recognized as the world's largest fishbowl.

Flotus Components

Flotus consists of two main elements: the five lotus-shaped *petals* which open and close according to the water level; and the *base*, with its shaft that collects the cables used to activate the monument.

Flotus Scenario and Operations

In June 2009, Raghu and Sumod are in front of one of

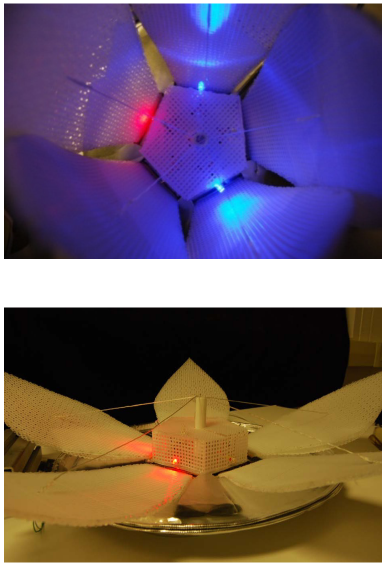

Figure 5. The *Flotus* hardware: (top) opened petals and strings; (bottom) shaft and base with LEDs.

several, identical, floating manifestations of *Flotus*. Its petals are closed and the Mekong River is still. While watching this, Raghu notices the resemblance the monument has to the temples of Angkor Wat. Raghu recalls the stories his grandmother used to tell him about the temple towers built like the lotus buds found in the lakes and ponds around it. But suddenly, the monument's various satellites start to communicate with each other and send information regarding the rise in water level – the flood is starting. Depending upon the intensity of the flooding, the monument's petals start opening and changing color to reflect this intensity as an alert system for local residents. After two days, our visitors are now encountering another manifestation of *Flotus*, this one floating in the Tonle Sap River. The visitors note fishermen tracking the monument's light that marks the presence and direction of the maximum concentration of fish in the lake by way of the glowing petal pointing towards the fish - another interactive feature of *Flotus*.

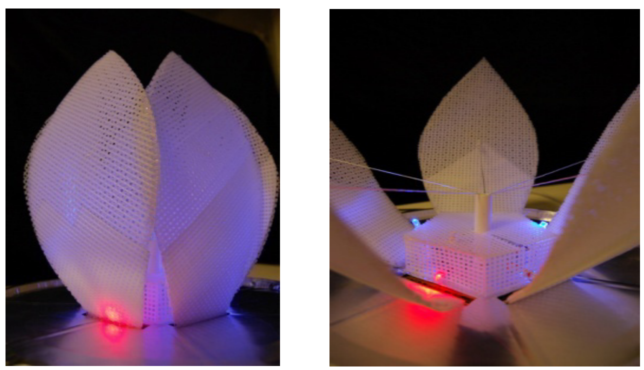

Figure 6. *Flotus* with its five lotus petals in two configurations: (left) static state, (right) flood state.

Significance for Future HCI Research

It was long assumed that monuments serve as the static and concrete signs of collective memory; but our vision of the monument as an early expression of "architectural robotics" opens this long-standing architectural typology to real-time reconfigurability by way of human-computer interaction.

In three projects, *re.Birth*, *WE.bot* and *Flotus*, we describe the hardware employed, the projects' motivations, their components, likely scenarios, and corresponding operation, that follow from our design and prototyping activities as well as our previous work in architectural robotics [8]. These investigations suggest a novel, promising path for future HCI research: namely, the prospect of integrating ubiquitous, *physical* computing into our built, civic environment, rich with collective memory and information. The three prototypes also represent promising works that have the potential to be realized at full-scale and evaluated with respect to the metrics of human factors, architecture and robotics. Finally, our conceptual leap from static to interactive monuments forwards the broader conceptualization of collective-memory environments that invite participation from a wide representation of society which increasingly lives with digital information and technologies.

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