



Figure 1: Woodie as a facilitator for embodied hybrid placemaking: here a boy drawing a humanoid robot with chalk on the ground next to the robot's drawings.

Woodie. An Urban Robot For Embodied Hybrid Placemaking

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ABSTRACT

This paper presents the design of *Woodie*, a free-moving urban robot which draws on the ground with conventional chalk sticks, using the public space as a large art canvas. We outline the motivation and design considerations, which led the design process of the lightweight robotic device aiming to stage creative placemaking activities. Along this path, we relate to the various roles of 'embodiment' apparent in this placemaking investigation, such as the robot's physical appearance and coupling with the urban environment; the engagement of visitors into natural tangible interactions; and their involvement of physical activities around the precinct. We discuss our observation on how those embodied interactions emerged, and further elaborate on them as perspectives to inform future work.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI).**

KEYWORDS

Digital placemaking, urban robots, embodied interaction, urban media art, design.

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TEI '20, February 9–12, 2020, Sydney, NSW, Australia

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ACM ISBN 978-1-4503-6107-1/20/02.

<https://doi.org/10.1145/3374920.3375282>



Figure 2: Woodie exhibited during a public art festival: while the robot was drawing various designs, such as flowers and love hearts on the ground (middle), visitors were encouraged to add their own drawings. The area was illuminated with ultra-violet (UV) lamps to light-up the luminescent chalk drawings.

INTRODUCTION

Robots are increasingly entering urban spaces whether to automate public services, logistics or transportation, aiming to make urban life more efficient. Often these robots have a highly specialised utilitarian purpose, for example providing assistive services to customers at airports [18], and thereby relying on existing user interface design paradigms, for example by carrying a touchscreen display as an input and output device [20]. However, additionally to the aspect of mobility, urban robots enable a much richer, albeit little explored design space, through their ability to manipulate the immediate physical environment that they share with humans [8]. A recent example how to make use of robots in a creative way, comes from the design office CRA-Carlo Ratti Associati who deployed a swarm of drones to spray-paint a collaborative artwork on a large-scale canvas [5]. Building on such endeavours in art and design, and the increasing interest within the research community to apply exploratory design approaches to the design of robots [15], we present Woodie: the free-moving urban robot which draws on the ground with chalk sticks is meant to facilitate what we refer to as “hybrid placemaking” activities. Using the public space as a large canvas, Woodie invites people to become active co-creators by directly manipulating the drawings and tell their own stories in public space. In this paper, we explain the design rationale of Woodie, aiming to transform existing urban situations, however at the same time being unobtrusive and physically integrated within the environment. We report on our preliminary observations how Woodie lured passers-by to stop by and contemplate, thereby engaging them in embodied and social interactions. Overall, Woodie aims to reconsider the definition of a robot, explore new contexts for designing them and question how urban robots can be designed for peaceful cohabitation between humans and machines, one that brings joy, respect and collaboration.

RELATED WORK

Under the umbrella term ‘digital placemaking’, researchers and practitioners from various disciplines, including architecture, urban planning, design and arts, began to investigate the augmentation of physical spaces with location-based digital technologies to deepen the connection between people and places, and encourage public participation [6]. Due to their increasing availability, public digital displays have emerged as a platform of choice, for example as information gateways between local authorities and citizen [13], urban polling interfaces [7], or to broadcast urban media art [16]. Others also explored the use of non-digital approaches for displaying digitally collected information in public space, for example in the form of chalk infographics [12]. These enable barrier-free and tangible manipulation, and provide aesthetic appeal through their transient nature and materiality. In human-robot interaction (HRI), researchers have investigated the design of social robots in various contexts, such as home and working environments. Interacting with embodied robots has been reported to lead to higher engagement compared to digital screen-based technologies or virtual agents

[14]. This has been attributed to the physical body of the robot itself [19], the communication using expressive gestures and movement, and the robot's ability to manipulate objects shared with humans in the physical world. In our investigation, we draw on these abilities and present the design of an embodied urban robot to replicate the qualities of non-digital public displays, such as enabling direct manipulation of content and thereby engaging the whole human body.

DESIGN CONSIDERATIONS

The design of Woodie was led by several goals, which we defined based on previous work related to: media architecture dealing with the integration of digital media in urban environments [3, 8]; digital placemaking [6, 12]; and the design of social robots [14].

- *Integrated.* Display technology and media installations should be seamlessly integrated into existing physical structures, and respect and respond to the urban fabric [3].
- *Aesthetic.* Architects and designers have been appropriating visual displays as an aesthetic design material rather than a technological solution, for example by using more flexible and ambient lighting displays [10] or non-digital natural materials [12].
- *Inclusive.* Urban interfaces should be accessible to all urban dwellers, thus enabling barrier-free interactions without excluding users due to digital literacy or not having access to mobile devices [11].
- *Infrastructure-independent.* For placemaking activities to be inclusive, the intervention setup should not be dependent on costly infrastructure, thus also making them accessible in communities of low socioeconomic status.
- *Facilitating.* Previous work has reported that the presence of a researcher functions as a spark to facilitate engagement with digital placemaking interventions [12]. Social robots have been attributed to provide the potential to replicate these effects to a certain extent [14].



Figure 3: During one of our early tests in public space, a boy was sitting on the ground and observing the robot drawing with chalk.

DESIGN PROCESS

Behaviour. Our aim was to create a robotic device which could render digital drawings in a physicalized form, deeply *integrated* into the existing urban environment. In regard to the design goal of ensuring *independence* from any additional infrastructural support, we decided for a self-moving, autonomously powered platform which uses the ground as a large canvas. During early testings with an off-the-shelf omni-wheel platform, we observed that children were coming close to the robot (see Figure 3). Therefore, slow movements emerged as another requirement to allow children to observe Woodie from a close distance, but also to avoid compromising pedestrian flow.

Interaction. Related to our goal of designing for *inclusive* urban interactions, we abandoned any form of direct control of the robot: this would either require people to access an interface on their mobile

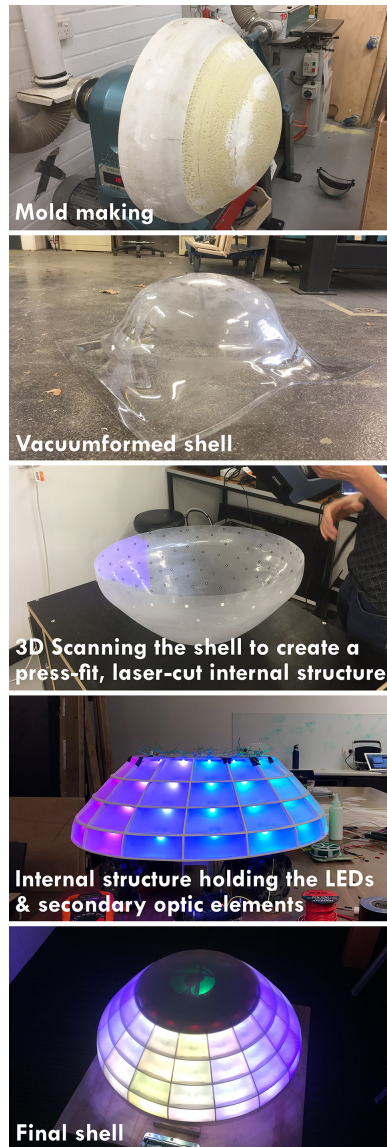


Figure 4: Crafting the appearance of Woodie, using physical and digital materials and tools.

devices [11] or, in case of a situated digital kiosk, limit the control to only a few simultaneous users [7]. Instead we build on the notion of pulverized urban displays [8], which enable natural tangible interactions through the fact that content is emitted in a physicalized form. This affected also our decision to let Woodie draw on the ground with conventional chalk-sticks, which could be also handed to humans for replicating, extending or drawing over the robot's content, as well as sharing their own stories individually or with others. Though simple in its implementation, this opens up a wide range of opportunities, allowing for collaborative, social and embodied interactions.

Morphology. As Woodie itself should act as a *facilitator* for people to engage in embodied and social interactions, considerations about the robot's size, shape and incorporated materials played an important role during the design process. Building on previous design contributions in HRI, we decided for a non-anthropomorphic device-like appearance [14]. To evoke a sense of curiosity, we followed ludic design principles, such as placing familiar objects in an unfamiliar context [4]: thus, the initial rough design and characteristics of Woodie have been inspired by increasingly popular home cleaning robots, which normally come with a round monolithic shell. Taking into account the urban scale and providing a new perspective on those existing everyday service robots, we decided for a slightly larger size of about 60 centimeters diameter for Woodie's body. As Woodie should attract people, but also provide visual cues about its drawing process and behaviour, the shell incorporates a low-res lighting display [9]. In respect to *aesthetics*, and given Woodie's hedonic role, we decided against any conventional tablet-like screens, which are predominantly attached to utilitarian robots [20].

To give the robot a unique spherical shape (see Figure 5), we created a hand-make mold from styrophorm, which is cheaper compared to the use of a CNC-machine and provides greater freedom for refinement during the crafting process. We used a 1.5mm polypropylen plastic sheet to vacuum form around the mold. In the next step, we designed the internal structure of the 4x16 pixel display. For a homogeneous distribution of light, we first had to 3D-scan the hand-made shell, in order to later design a laser-cut structure, which could sit flush within the shell. Inspired by pixel art display designs [1], each pixel should be distinguishable from another, which we realised through the design of a waffle timber structure. For a homogeneous diffusion within each pixel cell and increasing the light quality, we added a white opaque reflector sheet behind each LED, and a diffused sheet at the front of each cell. To maximise this diffusion effect and create a nice finish, we sandblasted the vacuum formed shell.

Aesthetic Integration. As Woodie was initially designed for a public art festival (see Figure 2), for this particular setup, we abandoned the goal of outright *infrastructural independence*, to set the scene for a sublime atmosphere: we therefore, installed ultra-violet (UV) lamps around the area, under which the luminescent chalk drawings would glow and fluoresce. This created a visual, immaterial connection



Figure 5: Overview of interactions observed around Woodie and excerpts of drawings created by people.

between visitors, Woodie and the shared public space, which was occupied by glowing words and stories at the end of each exhibition night.

PRELIMINARY OBSERVATIONS

We deployed Woodie over the period of three weeks, during evening hours, in a quiet laneway situated within a major business and residential district. For operation purposes, we implemented a simple tablet application which allowed festival volunteers to start a new drawing. Due to the slow movement, Woodie was usually not drawing more than four individual drawings per hour. In the following, we report on our preliminary observations related to the various roles of ‘embodiment’. First of all, the physical presence of Woodie itself lured people to approach the installation site. This was mainly affected by the round-shaped low-resolution lighting display, which was visible from a distance and described by people as aesthetically pleasant. When Woodie was drawing, we often saw people standing in a circle around it as it were a street performer. In particular, children were curious about the drawing process, and often lied on the floor to see the chalk stick touching the ground. We also observed various forms of appropriation, which might indicate the expectation of interactive behaviour: for example, people were tapping on the shell, stamping in front or stretching out a leg towards it, and even talking to Woodie as if they were interacting with a conversational agent.

During most of the evenings, we made chalk sticks available to people so that they could add their own drawings. One of the visitors whom we interviewed, referred to those hybrid placemaking activities as follows: *“I like the fact that it’s kind of a mixture of something, let’s say, non-tangible and tangible. So it is a combination of we can draw ourselves, but the robot draws as well, and that is a nice touch. It makes it more human, I suppose, than only a robot [drawing].”* The collaborative aspect was also apparent through the content that people were adding on the ground: thus, we observed people copying or adapting patterns, such as the stacked hearts, or relating to Woodie’s presence by either depicting its shape as it was, or through more abstract depictions of robots known from popular culture. The possibility of co-creating with Woodie had also further implications on the spatial arrangement of people, their physical activities around the precinct and the emergence of social interactions. For example, visitors themselves became street performers while others were watching them. Further, we observed that people were walking between the various human-made drawings to “read” them and add new content, which resulted in a wider and more even crowd distribution over the whole area. Physical activities were additionally induced by some of the drawings, such as hopscotch fields, often drawn by children.

CONCLUSION & FUTURE WORK

Given the exploratory nature of our investigation, the aim of designing Woodie was not to serve utilitarian tasks or services, instead exploring for which new contexts and experiences urban robots could

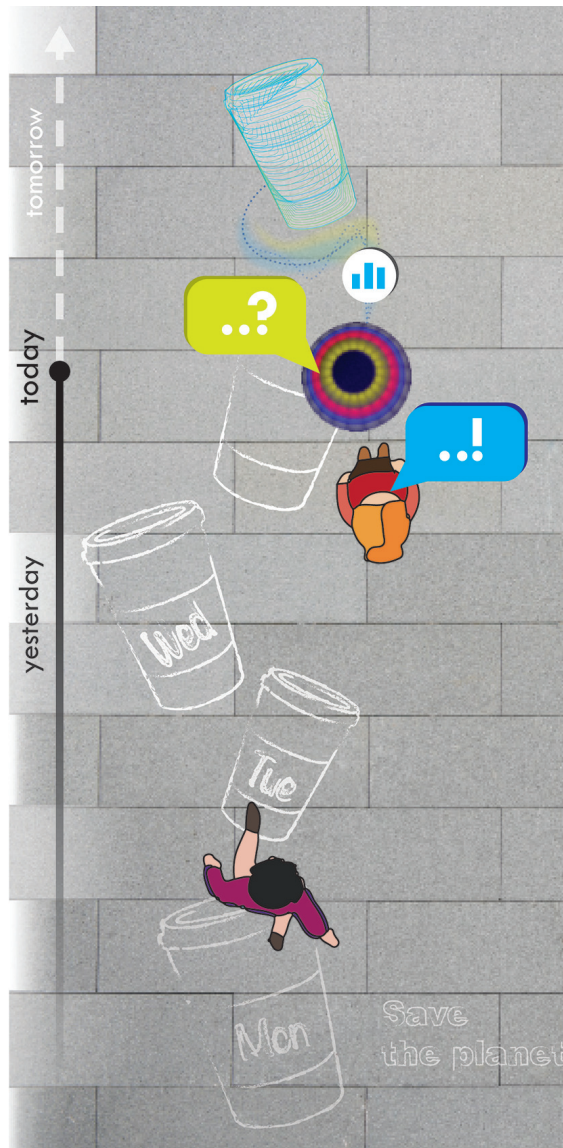


Figure 6: Artist impression of Woodie's drawings as infographics.

be designed for [15]. Using the ground as a 'display', we transformed the laneway from a functional space, in which people ordinarily rather rush, into a diversified one which invited people to sit on the floor, dwell and explore. Keeping the design of the robot ambiguous and therefore remaining open for personal interpretations, our observations revealed interesting insights on how people attempt to interact with Woodie in a natural way. Further, the ability of co-creating with Woodie informed us as designers in regarding to which type of content and visualisations could be adapted by the robot in order to tell *"more meaningful stories"* as suggested by one of the interviewees.

For a next iteration, we are therefore planning to deploy Woodie as a tool for creating large-scale situated data visualisations, providing more relevance to the local community in which Woodie will be integrated (see Figure 6). Building on previous research which suggests that polling activities increase the engagement and reflection around urban data visualisations [2], we intend to further develop Woodie's capabilities to act as a facilitator in public space by exploring two new features: (1) a voice user interface for the robot, thus enabling Woodie to talk to people around it and collect their votes and opinions on a certain topic, (2) expressive light patterns and in-situ motions [17], enabling Woodie to convey emotional expressions to people's responses, thus enhancing the two-way dialog between robot and humans. Potential polling questions will be further examined through workshops and interviews with the local community, which could, for example, shed light on the topic of environmental awareness, e.g. by asking people about their usage of take-away coffee cups. Through the use of specific light patterns, audio cues and in-situ motions, Woodie could provide immediate feedback on individual responses, while the overall polling results would be 'displayed' by Woodie in the form of large-scale chalk infographics. Using the ground as a canvas and arranging the visualisations in the form of hopscotch fields, we could further elaborate on the aspect of embodied interactions, so that reading and reflecting on urban data could become a truly physical experience. Building on previous studies, which suggested that delayed, periodic update cycles can create additional anticipation and reflection [12], the overall polling results would not be updated in real-time, instead collected throughout a day and then 'displayed' the day after. Over the course of a week, the visualisations would slowly take over public space, while earlier segments of the visualisations might slowly fade-out due to erosion through rain and passers-by [8]. Building on those transient qualities and slowing down the rendering process, we plan to further investigate how physical display approaches and slow technology artefacts can shed a new light on urban data visualisations in the context of the real-time city, thus inverting the obtrusive, fast-paced characteristics of conventional digital screens.

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