[e]Motion: Designing Expressive Movement in Robots and Actuated Tangible User Interfaces

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Figure 1: Materials and Overview of [e]Motion Studio (a. Design Cards describing robotic personalities and motion, b. Prior workshop using the Design Cards, c. toio robot toolkit, d. Prior class employing toio robot toolkit for Aactuated Tangible UI applicaiton.)

ABSTRACT

As robots inhabit more social spheres, human acceptance significantly impacts their functionality and engagement. The way robotic movement is perceived is crucial to their acceptance in society. However, robotic movement is most often a result of function rather than purposefully designed. Working in the continuum between robotic, tangible, and shape-shifting interfaces will enable a deeper exploration of the effects and interpretation of expressive movement. Hence, we propose [e]Motion, a hands-on opportunity for participants to explore design methods and prototype a variety of expressive movements in robotic and actuated and shape-shifting tangible interfaces. We will collectively reflect on evaluation methods and co-develop a visual vocabulary of motion and emotion, mapping movement more directly to personality and emotion. With this, we aim to foster a practical understanding of expressive movement and how it might affect human acceptance of robots and tangible interfaces.

CCS CONCEPTS

• **Human-centered computing → Interaction devices**; **Participatory design**.

KEYWORDS

Expressive Movement, Emotion, Robotic Personality, Actuated Tangible User Interfaces

1 INTRODUCTION AND STUDIO DESCRIPTION

As robots inhabit more social spheres, human acceptance significantly impacts their functionality and engagement. The way robotic movement is perceived is crucial to their acceptance in society. The human tendency to ascribe personality to animated objects emphasizes the significance of movement in shaping our interpretation and acceptance of non-human systems [2, 8]. However, the design of robots has predominately focused on function, and the extent to which robot design applies to their movement has yet to be fully explored. Working in the continuum between robotic, tangible, and shape-changing interfaces will enable a deeper exploration of the effects and interpretation of expressive movement [20]. Hence, in this studio, we explore methods for designing and prototyping robots and tangible UIs with expressive movement in mind.

The goal of the studio is to provide a hands-on opportunity for participants to discover the design space of robotic and actuated tangible interface movement, to emerge new insights and design methodologies, and open a discussion on evaluation methods that foster a practical understanding of expressive movement and how it might affect trust and human acceptance. We will use participatory co-design methodologies and provide a movement design toolkit consisting of a set of Design Cards and a movement-making prototyping toolkit using the toio robots [6, 21]. Participants will work in groups, first to identify the personality they would like their robot to have, using the expressive personality cards. They

will then select movements to express this personality from the movement cards and body-storm these potential movements. Participants will then prototype their robotic and tangible interfaces with toio robots.

We will collectively reflect and evaluate the resulting expressive movements and develop a visual "vocabulary" with more direct mappings of motion, emotion, and personality, using the personality cards and the six basic Ekman emotions [20], reflecting on how other participants perceive the movements in the resulting prototypes. The evaluation results will be made available on the studio website for open-access use by the research community. The studio will finish with a conclusions panel to summarize findings and distill learnings into emerging research themes.

2 BACKGROUNDS

In the realm of Tangible User Interfaces [12], primarily focused on actuation and shape-changing capabilities, researchers have worked to bring physical motion and dynamic transformation to make interaction with responsive digital information tangible [1, 5, 11]. While a variety of toolkits for designing dynamic motion and transformation have been proposed and developed [9, 19]– this studio explores how people can explore and prototype expressive motion design based on toio robots [6], one of the emerging tools in actuated TUIs [18].

Generally, the socio-cultural context profoundly impacts the human-robot dynamic since people are more comfortable interacting in culturally acceptable ways [15]. As a result, studies such as Hoffman and Ju's Designing Robots with Movement in Mind [10], propose a movement-centric design approach, which leads to "sophistication in the way [robots] move instead of the way they look." Similarly, Meerbeek et al. [16] offer a personality design method that aims to integrate a user-centered, artistic approach to designing robots based on the five known personality types rather than their technical requirements.

Our prior research [13] and similar work on actuated and shape-changing tangible interfaces [20], see movement as a rich communicative medium to which humans are highly sensitive [17] – a sensitivity that extends to our innate capability of inferring complex information and intentions based on minimal cues [4]. Hence, humans often ascribe personality to animated objects, regardless of the complexity of the moving entities [7] and across cultures from animism in the East to philosophies of vibrant matter in the West [3]. From abstract moving shapes seen as agents with personality, emotions and intentions to inferring other people's complex intentions from 2D simplified reenactments of non-human forms, movement's expressive power plays a crucial role in our interpretation and therefore acceptance of non-human systems. In this studio, we will leverage this innate human trait to design and prototype robotic and tangible or shape-changing movements that can convey different expressive characteristics.

3 MATERIALS TO BE EXPLORED

We will use participatory co-design methodologies and a toolkit consisting of Design Cards and toio robots.

3.1 Design Cards

We plan to use two sets of design cards (Figure 1a), an expressive personality set, and movements set, which are developed for participatory co-design research. The expressive Personality Cards is a set of 50 cards based on prior work [14], each containing one word denoting a human strength (e.g., analytical, creative, empathetic, structured). The movement cards, a set of 10 cards, each grouping a number of movements together (e.g. walk, shake, bow, etc), will be combined with bodystorming [20] and used to explore and decide which movements to prototype, as explored in our prior workshop (Figure 1b).

3.2 Toio Robots

For prototyping, we plan to employ a software toolkit to control toio robots [6, 21] (Figure 1c) designed by AxLab at the University of Chicago, based on toio API, released by Sony. This tool allows people with introductory programming experience to control the robots with simple coding using Processing. It enables people to easily control the behavior of robots driven by two-wheels to locomote on a 2D plane, and it has been used in the University's interaction design class (Figure 1d). Toio mats are embedded with localization information for toios to detect their relative position on the mat, making it easy for users to make location-based control and interaction (e.g., moving one robot's position based on another one) as well. While AxLab has been employing this technical platform for prototyping novel tangible interaction [18], this workshop makes this tool accessible to researchers and designers in the TEI community as a medium to prototype and brainstorm expressive movements quickly.

Together with toio robots, toio mats (required for toio robots to localize), and other materials such as Lego, craft materials (paper, strings, tapes, etc), and mechanical components will be provided so the participants can prototype advanced movement with them. These additional materials would expand the movement design beyond 2D motion on a table for deformative and expressive 3D movement designs.

4 LEARNING GOALS

The studio will aim to explore the design space of movement in tangible and robotic interactions with the following learning goals:

Goal 1) Design Methods: *How might we **design expressive movement** in the context of tangible user interface and human-robot interaction?* - In this studio, we explore expressive movement through co-design and hands-on prototyping, offering participants opportunities to learn and expand their design methods and develop new ways of designing movement within the TEI community in the future. Furthermore, according to constructivist learning, hands-on prototyping is the best way to learn as an active learner, the best way to learn as an active learner, trying out concepts first and reflecting upon the learning experience afterward.

Goal 2) Motion and Emotion, Trust, and Acceptance: *How might **different movements improve engagement, trust, and acceptance** of robots and tangible interfaces?* - We explore what types of emotions different movements elicit in participants and how these might influence human engagement, trust, and acceptance. Participants will develop a visual "vocabulary" by associating

expressive movement with personality cards and reflect on the emotions the developed prototypes elicit in other participants.

Goal 3) Evaluation Methods: *How can we **evaluate** movement design to inform emerging design methodologies for robotic and tangible interfaces?* - Lastly, we want to start a discussion on evaluation methods for designing expressive motion and its links to acceptance, engagement, and trust. We will a) provide an evaluation worksheet, b) the visual "vocabulary" of expressive motion, and c) link expressive movement with human emotions based on the six basic Ekman emotions [20]. These will be made available on the studio website for broader dissemination and open access by the TEI community.

5 OVERALL STUDIO FLOW

We will start with an introduction to the theme and the goals of the studio, self-introductions from participants, and their goals in joining the workshop and group forming. This will be followed by a participatory, hands-on co-design session where participants will work in groups, first to identify the personality they would like their robot/tangible interface to have, playing a personality game using the expressive personality cards.

Using the movement cards, participants will then identify movements that might express this type of personality. This will be followed by a body-storming session where each participant uses their hands to move toio, which is directly tracked and replayed using the toio robots software kit, allowing participants to explore further the movements and their association to the personality traits. These movements will be recorded to start forming a visual language of mapping movement and personality, which will be further explored during the evaluation session.

We will then provide participants with an in-depth tutorial on the toio robots extended kit prior to prototyping. This will build participants' skills in programming the robots to generate a variety of movements in 2D and also using purposefully built extensions for movements beyond the table surfaces by attaching craft materials, mechanical parts, Lego, and so on.

Prototyping will enable participants to work in groups and materialize a number of prototype movements in robots and actuated tangible interfaces. Following this, participants will present and evaluate the resulting prototypes. Participants will reflect on the other groups' prototypes using the personality cards and the six basic Ekman emotions. These data, together with the body-storming captured motions, will form a rich visual "vocabulary" of expressive motion and how it links to emotion and trust, co-created with participants. This will be made available on the studio's website.

We will further provide participants with an online evaluation worksheet, and the anonymized data will be made available on the studio's website for open access by the TEI community. The studio will conclude with reflections and insights for further research and emerging methodologies in designing expressive movement in robotics and actuated and shape-changing tangible interfaces.

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