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# Future Shape-Changing TUIs: Brainstorming & Origami Workshop

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**Abstract**

This paper describes a proposal for a half-day workshop to provide participants with an overview of shape-changing tangible user interfaces (TUIs), through collective fabrication of shape-changing origami and active idea generation of interactions with them. We first present the context of this work, and then detail step-by-step the protocol before concluding on the expected outcomes: from the results of the workshop, the community will benefit from new ideas of shape-changing TUIs, together with feasible application scenarios. Participants will gain knowledge of the state-of-the-art of shape-changing TUIs. Following the workshop, we wish to submit the results to TEI 2017 and will invite all interested participants to contribute.

**Author Keywords**

Shape-Changing TUI; workshop; idea generation; origami folding technique.

**ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

**Introduction**

On the contrary to graphical user interfaces, tangible user interfaces stay confined to few applications in spite

of their various benefits [1]. To explain their difficulty to spread in the industry, hypotheses include:

- 1) Their lack of flexibility to provide proper input method according to different tasks. For instance, a button can launch a function but cannot adjust a continuous parameter like a slider, whereas the mouse cursor can do both.
- 2) The limited dynamicity of their feedback. For instance, a physical button cannot not change its shape to notify the user that it cannot be pressed, whereas software buttons are grayed out when disabled [2] [3].

To explore these hypotheses, HCI research and design started investigating shape-changing TUIs. Theories and working prototypes have already been proposed (see for instance [4]). However, the design space is far from being covered, and empty spaces are yet to be explored: new forms for shape-change can be proposed. As evidence, many techniques being used outside of HCI, such as folding techniques, were not fully leveraged yet. In this workshop, we propose to explore new forms of shape-changing TUIs and affordances through paper folding techniques. Doing so, we plan to uncover areas of the design space. These new forms of shape-changing TUIs will be grounded in realistic applications ideas from the participants.

The workshop would give the participants the knowledge of state-of-art shape-changing research and techniques. We plan to propose participants to contribute to a submission of a paper at the TEI 2017 conference, relating the results of this workshop.

## **Related Work**

With this workshop, we plan for the group to contribute in the area of folding techniques for shape-changing TUIs and their expected applications. We now review related work in these areas.

### *Folding techniques*

Folding techniques has been used before in shape-changing TUIs. For instance, PaperFold [3] and FoldMe [5] allows folding a flat interface as a mean for interaction itself. Folded paper was used in Changibles [3] and PneuUI [6] in order to provide with extensible surfaces, as in Lee et al. work [7]. We wish to go beyond these works during the workshop by considering non-flat objects.

Sticky Actuators [2] were used to animate origami animals. During the workshop, we will consider more objects, and with abstract forms, in order to support for more generic interactions.

### *Applications*

Idea generation of applications for shape-changing objects has seldom been proposed. An example is the public ideation of shape-changing applications [8] that provides with a large set of ideas for applications. However, ideas were based on the manipulation of a rod-like shape-changing display. We wish to consider additional objects and deformation during this workshop.

## **Objectives**

The workshop goal is to provide the community with new ideas of shape-changing TUIs, together with feasible application scenarios. Participants will gain an overview of shape-changing TUIs, through collective

Session	Duration
Ice-breaking	30 min
Origami-driven idea generation	40 min
Socializing break	20 min
Problem definition	20 min
Shape-changing form card	15 min
Brainstorming	20 min
Short break	5 min
Ranking and visualizing Ideas	20 min
Presentation and discussion	40 min
Total	210 min

Table 1: The half-day workshop outline.

fabrication of shape-changing origami and active idea generation of interactions with them.

### Participants

Expected participants are between 10 to 20 students and/or professionals who are interested in TUIs. The participants of the European Tangible Interaction Studio (Master/PhD students and senior researchers in TUIs) will provide an outstanding panel that will greatly contribute to this workshop's outcome.

### Apparatus

We can bring all the necessary paper, engraved paper, tools (scissors, rulers), notebooks, pens, and timers. We will bring the game *Telestrations* planned for ice-breaking.

We expect from the ETIS organization to provide one room, 6 tables and 1 projector with VGA connection.

### Procedure

First, participants are gathered in groups of around 5 persons (2 to 4 groups). The members of each group are carefully composed to maximize their involvement and participation. For instance, we balance introvert/extroverted participants, mix familiar/unfamiliar members within each group. The list of participants is required in advance of the workshop.

Halfway through the workshop, we have a 20 minutes long break to elaborate social activities and prepare the next session. Another short break is provided to prevent tiredness.

The workshop takes place for 3h30min in total and the duration for each session can be adjusted depending on the progress.

#### *Ice-breaking (30 min)*

The board game *Telestrations*<sup>1</sup> is used to entice participants to talk to each other as well as to engage them into the workshop activity. *Telestrations* encourages participants to engage in communication for the benefit of the whole workshop, and also introduces the form of activity for the second part of the workshop. The rule is explained by the facilitator (10 min). After the game (15 min), a voluntary group shares their play (5 min).

#### *Origami-driven idea generation (40 min)*

Various shape-shifting origami patterns are provided, such as origami flashers [9], flexiballs [10], and bi-stable columns (Figure 1). The origami items were selected based on:

1. Their diversity to allow more ideas of interactions and applications,
2. Their easiness of folding to ensure the session ends in time.

Participants are asked to make shape-changing objects using the patterns provided (15 minutes). In case the origami seems to take too much time, the facilitator proposes pre-cut papers to reduce the time and the level of difficulty.

<sup>1</sup> <http://telestrations.com>



Figure 1: A bi-stable origami column by Paul Jackson [12]. (Left) The vertical valleys are unfolded and vertically extended. (Right) The top part is rotated clockwise and the height is lowered.



Figure 2: Shape-changing objects in daily life. In a workshop for Master's students facilitated by authors

Then participants are asked to manipulate and deform the objects and suggest as many ideas of interactions and applications as possible (10 minutes).

At the end of the origami session, the participants are asked to share their ideas of interaction and applications within each group and choose the group's favorite. Representative from each group then share their best idea, and every participant are encouraged to suggest more ideas (15 min).

#### *Socializing break (20 min)*

Music is played to facilitate the participants' social activities as well as to keep the atmosphere high. The facilitator prepares materials for the next session.

#### *Problem definition (20 min)*

First, participants are asked to find at least two problems (pain points) that can be solved by deformable TUIs. The problems should be grounded on their own experience, or they should have directly witnessed the problem. Every problem should be written or drawn on post-its (10 minutes).

They are asked to define one concrete problem by selecting and developing a plain problem. The problem should be specific and descriptive including the context, the user and the events. For example, they can define a problem such as "When I went to see a doctor, she explained two charts to me using a pointer. She wanted to compare the same part from two charts, but it was cumbersome to move the pointer and directly compare them." The defined problem should be written on papers (10 minutes) so that every member in the group can easily remind it, and it will be referred when

they present their ideas during later presentation and discussion.

#### *Shape-changing form card (15 min)*

A deck of shape-changing form cards is given to each group. The shape-changing forms are from daily life, conference paper prototypes, or conceptual designs. Part of the shape-changing objects in daily life has been collected in a workshop for Master's students held by the authors (Figure 2). Each member of the group selects objects that give them insights for a shape-changing TUIs relating to their problem. They explain to the other members the object, its change of shape and why they selected it.

#### *Brainstorming (20 min)*

All participants generate as many ideas as possible to solve the predefined problems (10 minutes). All ideas are written even though it seems irrelevant, so that all participants can iterate on them. Using drawing is recommended to illustrate the ideas. The introductory ice-breaking game helps participants to draw and iterate quickly. Different colors of post-its or pens are used to easily find the original proposer later. It allows for participants not to worry for unclear handwritings or drawings.

Participants then share ideas within the group for 10 minutes.

#### *Short break (5 min)*

Ten minutes of short break allows relaxing and resting.

#### *Ranking and visualizing ideas (20 min)*

Participants in the groups select their 5 best ideas (10 minutes), based on their usefulness, novelty, and

feasibility. While doing this, they can continue to develop and merge the ideas to support more functions or to facilitate more benefits.

Their best idea is presented on a paper with a short scenario (10 minutes). Drawing for explanation is highly recommended. The scenario contains usage context, user, problem, and how the proposed shape-changing TUI works. They are asked to write down the remaining 4 best ideas so that they can be used for future work.

#### *Presentation and discussion (40 min)*

Representatives of each group are asked to present the group's best 5 ideas (30 minutes). All participants can react and propose additional ideas.

After the presentation, all participants are asked to give feedback on the workshop (10 minutes).

#### **Conclusion and Expected Outcome**

In this proposal, we described how the half-day workshop in ETIS would be facilitated. A number of steps are proposed toward our goal of actively exploring folding techniques for future shape-changing TUIs. We plan for this workshop to contribute to shape-changing TUI area with a submission to TEI 2017. We would respectfully ask interested participants to join us as co-author of this paper. The ideas generated during the workshop would be presented, to show the community the potential of origami for shape-changing TUIs.

#### **References**

1. Orit Shaer and Eva Hornecker. 2010. Tangible User Interfaces: Past, Present and Future Directions, *Foundations and Trends® in Human-Computer Interaction*, 3, 1-2: 4-137
2. Niiyama, Ryuma, Xu Sun, Lining Yao, Hiroshi Ishii, Daniela Rus, and Sangbae Kim. Sticky Actuator: Free-Form Planar Actuators for Animated Objects. *In Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction*, (TEI2015), 77-84.  
<http://doi.org/10.1145/2677199.2680600>.
3. Anne Roudaut, Rebecca Reed, Tianbo Hao, and Sriram Subramanian. 2014. Changibles: analyzing and designing shape changing constructive assembly. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems (CHI 2014)*, 2593-2596.  
<http://doi.org/10.1145/2556288.2557006>.
4. Hiroshi Ishii, David Lakatos, Leonardo Bonanni, and Jean-Baptiste Labrune. 2012. Radical atoms: beyond tangible bits, toward transformable materials. *interactions* 19, 1: 38-51.
5. Mohammadreza Khalilbeigi, Roman Lissermann, Wolfgang Kleine, and Jürgen Steimle. 2012. FoldMe: interacting with double-sided foldable displays. In *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction (TEI 2012)*, 33-40.  
<http://doi.org/10.1145/2148131.2148142>.
6. Lining Yao, Ryuma Niiyama, Jifei Ou, Sean Follmer, Clark Della Silva, and Hiroshi Ishii. 2013. PneuUI: pneumatically actuated soft composite materials for shape changing interfaces. In *Proceedings of the*

*26th annual ACM symposium on User interface software and technology* (UIST 2013), 13–22.  
<http://doi.org/10.1145/2501988.2502037>.

7. Johnny C. Lee, Scott E. Hudson, and Edward Tse. 2008. Foldable interactive displays. In *Proceedings of the 21st annual ACM symposium on User interface software and technology* (UIST 2008), 287–290.  
<http://doi.org/10.1145/1449715.1449763>.
8. Miriam Sturdee, John Hardy, Nick Dunn, and Jason Alexander. 2015. A Public Ideation of Shape-Changing Applications. In *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces* (ITS 2015), 219–228.  
<http://doi.org/10.1145/2817721.2817734>.
9. Jeremy Shafer. Video. 2009. Origami Flasher. Retrieved December 11, 2015 from <https://www.youtube.com/watch?v=lgX9PHrpxI>.
10. Jorge Pardo. 2011. Origami Flexiball. Retrieved December 11, 2015 from <https://www.youtube.com/watch?v=knMEBSXM6WU>.
11. Antonio Gomes and Roel Vertegaal. 2015. PaperFold: Evaluating Shape Changes for Viewport Transformations in Foldable Thin-Film Display Devices. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI 2015), 153–160.  
<http://doi.org/10.1145/2677199.2680572>.
12. Paul Jackson, *Structural Packaging: Design Your Own Boxes and 3D Forms*. Laurence King Publishing, 2012.