Is Research on Shape Change Heading in the Right Direction?

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Abstract
In this paper the present state of research on shape-changing interfaces is reflected upon, and questions whether the research is presently on the most propitious path. The paper proposes three perspectives for directing further research on shape-changing interfaces: 1) a purpose perspective, 2) a theoretical perspective and 3) a user experience perspective.

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H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

Introduction
As research on shape-changing interfaces are maturing, we as a community need to begin asking ourselves, whether we are just fascinated with making things that change shape, or if we believe that the research we carry out lead towards making dynamic artefacts that have a positive impact on how people interact, live and relate to the artefacts they surround themselves with?

Looking at the past decade of research on shape-changing interfaces, then an ever increasing amount of research have shown intriguing, fun, imaginative,

beautiful and impressive examples of shape-changing interfaces, such as for example inFORM [5], ferrofluid sculptures [9], coMotion [6], NinjaTrack [7] or LineFORM [13], just to mention a few. Beyond the examples from research, shape-changing interfaces are also becoming a commercial endeavour, as can be seen by LG launching a shape-changing TV [18], which is able to change shape from flat to curved. Or Tactus Technology's Phorm [19], a shape-changing iPad cover, where see-through physical buttons can appear at the touch of a button, overlaying the virtual keyboard.

However, despite the breadth of the examples, then presently research on shape-changing interfaces often seem more concerned with imagining new ways of using shape-change, and the technical challenges of doing so, rather than how they relate to, and would fit into the users daily lives. Furthermore, there are few examples that clearly and convincingly illustrate how making artefacts dynamic has a positive impact on people's interactions with artefacts in their daily life.

Visions for shape-changing interfaces

Consequently, we as a community need to pause and begin to consider whether we are on the right path, or whether the quest for novel interfaces has resulted in loosing focus on the potential use of shape-changing interfaces.

Surveying some of the visions (e.g. [10,16]) put forth for shape-changing interfaces, they present a range of both abstract and concrete potentials for shape-changing interfaces. From envisioning radical atoms, a *"hypothetical generation of materials that can change form and appearance dynamically, becoming as reconfigurable as pixels on a screen* (p. 37 [10])". To creating app stores for physical form (p. 598 [16]), or envisioning that "*information and interaction is everywhere, and it not only blends into the world around us, but can also physically reach out* (p.10 [12])". While the visions point towards a great potential for shape-changing interfaces, then the ensuing examples in some cases tend to become more about the newness and exoticness of the interface, rather than the practicality and desirability of making artefacts self actuated.

Despite the continuous efforts in overcoming the present material and technological challenges associated with making shape-changing interfaces. The community needs to begin to move beyond these challenges, and start critically reflecting on why and where it is useful and desirable to have artefacts that are capable of changing shape, rather than simply accepting that everything from TVs [18] to mobile phones (e.g. [16]), clothing [2] or faucets [17] benefit from being physically dynamic.

Challenges and future work

While the present work illustrates that shape-changing interfaces provide designers with new opportunities, as form transcends from 3D to 4D [4], then it is also evident that more work needs to be carried out. Tree promising perspectives for future research on shape-changing interfaces, is evident from surveying the literature; 1) a purpose perspective, 2) a theoretical perspective and 3) a user experience perspective.

A purpose perspective

Although shape change has been applied to a range of different application domains, both functional and hedonic [15], then there seem to be invented far more

ideas, than there are solved problems. Consequently, while research has illustrated examples of how shape change can address daily challenges, whether to support stroke rehabilitation (e.g. [11]) or practical considerations in relation to transportion or ergonomics (e.g. the inflatable mouse [8]). Then there is a need for further research in this direction, which goes beyond inventing new types of input and output, and begins to apply it to address real world challenges, which can be improved by making artefacts physically dynamic.

An theoretical perspective

Surveying research on shape-changing interfaces, then the work on shape-changing interfaces seldom presents a systematic reflection on how the results relate to findings and theoretical framings from other fields. Taking metaphors as an example, then despite being widely mentioned within research on shape-changing interfaces (e.g. [7]), then the work does not consider established *categories* of metaphors, such as the taxonomy provided by Barr et al. [1]. Consequently, there is a need to begin consolidating the work on shape-changing interfaces, with the related bodies of work from for example HCI and design. And furthermore, to begin a more systematic reflection on the use and meaning of terms, such as for example metaphors and affordance, in relation to shape-changing interfaces, and what it entails when a temporal dimension is added.

User experience perspective

Despite an increase in user studies [3,6]) then there is a need for furthering the understanding of how users experience shape-changing interfaces, and whether or where shape change would be desirable. Surveying the literature [14], three potential directions for future research is evident. 1) Carrying out user studies, which explore peoples experience with shape-changing interfaces over a longer period of time, as hitherto all user studies have only focused on users first encounter with the shape-changing interface. 2) Exploring shape-changing interfaces in context, bringing them out into the wild, into homes, offices and public spaces. 3) Beginning to engage with users beyond the testing phase, for example by involving them in the design process, and thus, allowing the design and use to be influenced and inspired by the potential users.

Conclusion

The paper asks the shape-changing community to pause and reflect on the present direction of research on shape-changing interfaces, and proposes three fruitful perspectives for directing further research: 1) a purpose perspective, 2) a theoretical perspective and 3) a user experience perspective.

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