Report from Dagstuhl Seminar 17082

Shape-Changing Interfaces

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Abstract

Shape-changing interfaces use physical shape change as input and output; such interfaces are emerging as an alternative way of interacting with computers. This seminar brought together researchers working on shape-changing interfaces to discuss three key themes: (1) The technologies involved in shape-change, including soft and modular robotics, smart materials, and mechanical actuation. (2) The design of shape-changing interfaces, including their key application areas, and their industrial and interaction design. (3) The user experience of shape-changing interfaces, including evaluations of such interfaces and psycho-physical evaluation results. The seminar set out to strengthen this new community, create opportunities for active collaborations, and to reach-out to other fields.

The seminar was attended by 25 researchers from around the world. These researchers represented the disciplines of Computer Science, Design, Engineering, Robotics and Material Science. This seminar had no formal presentations, but instead focused on working-group discussion and report-back sessions. This report outlines the key findings of these sessions.

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1 Executive Summary

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The Shape-Changing Interfaces Dagstuhl seminar aimed to bring together researchers from the disciplines of Computer Science, Design, Engineering, Robotics and Material Science to strenghten this new communinity, discuss grand challenges, form a research agenda, and to create opportunities for active collaborations.

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Shape-changing interfaces use changes in physical geometry to convey input and output and are emerging as an alternative interaction method for communicating with computers. Discussions at the seminar were based around three key themes: (1) The technologies involved in shape-change, including soft and modular robotics, smart materials, and mechanical actuation. (2) The design of shape-changing interfaces, including their key application areas, and their industrial and interaction design. (3) The user experience of shape-changing interfaces, including evaluations of such interfaces and psycho-physical evaluation results.

To encourage active discussion, the seminar had no keynote speakers, but instead used brainstorming activities and small working-groups to understand challenges, explore the literature, and plan an agenda. Specifically, the following sessions were run:

Benefits and Applications of Shape-Change: A whole-group brainstorming session developed categories of benefits and potential application areas for shape-changing interfaces.

Related Work: Small working-groups focused on one of five related-work areas (materials, hardware, experience and interaction, design, or applications), researched, and then presented summaries of the five ground-breaking and five most over-looked works in that sub-field.

Grand Challenges: A whole-group brainstorming session generated ideas and themes of grand challenges, small working groups then took a theme and dug deeper into the challenge, generating avenues of work and research agendas.

Worst Case Scenarios: To understand why this field could fail, a brainstorming exercise asked participants to develop a series of 'failure' situations—these were used as a method of creating awareness of the reasons progress in this field could stall.

Personal Reflections: To conclude the seminar, four participants were asked to provide their personal reflections on the experience, and their key take-home messages.

The seminar was attended by 25 researchers from around the world; all of who found the experience invaluable. This report outlines the key findings of these sessions.

2 Table of Contents

3 Seminar Sessions

Jason Alexander (Lancaster University, GB), Sean Follmer (Stanford University, US), Kasper Hornbæk (University of Copenhagen, DK), and Anne Roudaut (University of Bristol, GB)

3.1 Benefits and Applications of Shape-Change

While participants at the seminar universally agreed on the benefits and potential of this field, articulating these benefits and potential applications provided a communal base for understanding everyone's perspectives and setting a research agenda. Participants were asked to brainstorm ideas in this area. These ideas were themed, falling into the categories of: accessibility, adaptability and reusability, collaboration and communication, portability, and returning the physicality and tactility of the real-world to computer interfaces. A large range of application areas and specific ideas were also generated.

3.2 Related Work

Seminar participants were then tasked with summarising the key related work in a particular sub-theme of shape-changing interfaces, with the organisers asking to see four groundbreaking papers and the four most over-looked articles in that sub-theme. Presentations were provided on Materials, Hardware, Experience and Interaction, Design, and Applications. Briefly, these reported on:

Materials: a range of novel materials and approaches for the implementation of shape-change devices, including work from Soft Robotics, Mechanical Meta-materials, inflatable materials, and epidermal electronics.

Hardware: the difference between between internally-powered and externally-powered shape-change, self-assembly and programmable matter, pin-arrays, mid-air/untethered shape-change, and self-actuated surfaces.

Experience and Interaction: progression from the Ultimate Display to Relief and InForm, taxonomies of shape-change, stiffness, and the under-representation of public installations.

Design: a tour of Stewart Platforms, the Computational Design of Mechanical Characters, thin-film based design, toy-inspired scenarios, and inspiration from commercial future visions.

Applications: scoped a wide range of applications already in the literature, including gaming, communication, notifications, collaborations, understanding data, sport, healthcare, rehabilitation, accessibility, and assisted living.

3.3 Grand Challenges

In this session, participants were asked to brainstorm and categorise grand-challenges in the development and deployment of shape-changing interfaces. The key challenge themes that emerged were: affordance and signifiers, arts and aesthetics, collaboration, economy, environmental impact, ethics and law, end-users, society, technology, and theory. Three of these themes were then chosen for deeper exploration:

Theory: this group identified many issues around theory in this space including: what is the purpose of theory for shape-change, there are many descriptive theories but nothing for future exploration, there is no theory for how we perceive motion, can we take theory from other disciplines, the unknown quantity of 'good' shape-change, what does the lack of theory stop us doing?

Cross-disciplinary Collaboration: there are significant issues to be tackled during cross-disciplinary collaboration. These include applications and visibility, cost efficiency, cultural challenges, ethics, geographic distance, language/terminology, publication (the 'what is a result?' question, author order), methods, proof/evaluation, and time-scales.

Affordance and Signifiers: this group studied the question: how do we communicate the fact that an object is shape-changing? We can consider the computer-as-tool, the computer-as-partner, and the computer-as-medium. We can use mapping, visibility, transfer effects, and feed-forward to illustrate the presence of shape-change.

3.4 Worst Case Scenarios

To better understand why and how the shape-changing interfaces field could fail, participants were asked to brainstorm their 'worst case scenario' for research and progression in this space. The resulting brainstorming input was classified into a number of themes: economic infeasibility, ethical and legal issues, lack of applications, other disciplines (e.g. robotics) achieve better solutions, never becomes socially acceptable, physicality becomes unnecessary, technology limitations, safety and trust, sustainability issues.

Despite the 'negative' approach of this activity, awareness of potential risks helps to enable mitigation strategies and reduce their chance of occurrence.

4 Personal Reflections

Panos Markopoulos (TU Eindhoven, NL), Pierre Dragicevic (INRIA, FR), Marianne Graves Petersen (Aarhus University, DK), and Isabel Qamar (University of Bristol, GB)

To conclude the seminar we asked four participants to provide their personal summary and review of the seminar and the key messages they would take away.

Professor Panos Markopoulos: Panos' review noted that we did not try to agree on a definition of shape-changing interface (a positive thing) and challenged us to consider how we should go beyond 'interfaces', suggesting the field could instead focus on 'physically interactive things'. The articulation of the large number of challenges faced by the field provides an excellent agenda for future research.

Dr. Pierre Dragicevic: Pierre's review encouraged participants to consider the differences between shape-changing objects and interfaces and to consider why shape-change is necessary. Further, understanding what is 'lost' by including shape-change in interfaces is just as important as what is gained. He ended with the question of what the new 'C' should be in HCI.

Dr. Isabel Qamar: Isabel underlined the importance of collaboration across disciplines in order to make this field successful. She raise the important question of how we disseminate research results during these collaborations, with different research fields valuing different contributions. As a material scientist, Isabel emphasised the importance of communicating the 'H' in HCI: what the humans need and want from other disciplines.

Dr. Marianne Graves Petersen: Marianne reflected on the scale of issues that were discussed during the seminar, noting we touched on small implementation issues through to large, meta-questions about economy and ethics that will ultimately dictate the success of shape-changing interfaces.

5 Conclusion and Next Steps

Jason Alexander (Lancaster University, GB), Sean Follmer (Stanford University, US), Kasper Hornbæk (University of Copenhagen, DK), and Anne Roudaut (University of Bristol, GB)

Joint work of All seminar participants.

This Dagstuhl Seminar was found extremely valuable by all attending researchers and it acted as an excellent conduit to strengthen the community around this exciting and innovative topic. As a result of this seminar we have created an active mailing list and are planning to create trimestrial email newsletter to keep the community strongly connected. We are also planning to develop a roadmap document using the output from this seminar to provide focus and direction for accelerating research in this area. All attendees expressed a desire to return to Dagstuhl in 3–5years to review progress and developments in this fast-moving field.

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