Fall 2019

CS6501: Topics in Human-Computer Interaction

http://seongkookheo.com/cs6501_fall2019

Shape-Changing Interfaces

Seongkook Heo

Nov 19, 2019

UNIVERSITY of VIRGINIA | SCHOOL of ENGINEERING & APPLIED SCIENCE

Ultimate Shape-Changing Interface

HD

Grand Challenges in Shape-Changing Interface Research

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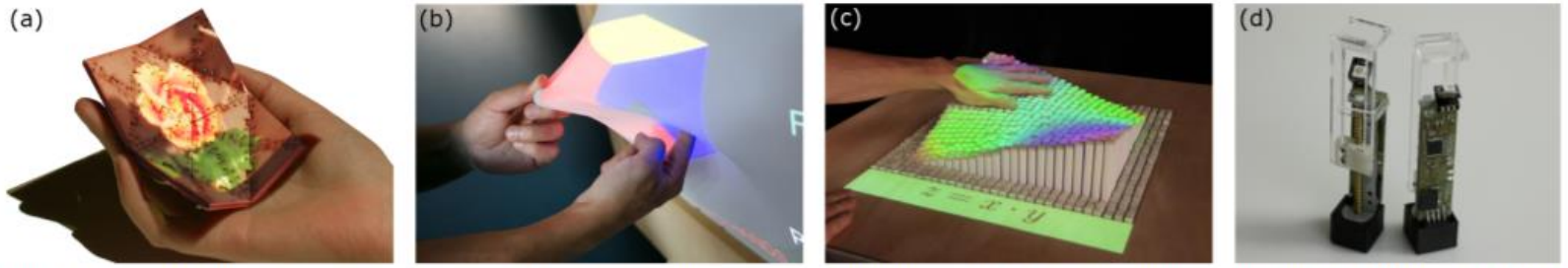


Figure 1. Example shape-changing interfaces: (a) Morphees, a shape-changing mobile phone [75]; (b) An elastic deformable display [102]; (c) inFORM, a self-actuated pin-array [23]; (d) ShapeClip, a prototyping toolkit for shape-changing interfaces [32].

ABSTRACT

Shape-changing interfaces have emerged as a new method for interacting with computers, using dynamic changes in a device's physical shape for input and output. With the advances of research into shape-changing interfaces, we see a need to synthesize the main, open research questions. The purpose of this synthesis is to formulate common challenges across the diverse fields engaged in shape-change research, to facilitate progression from single prototypes and individual

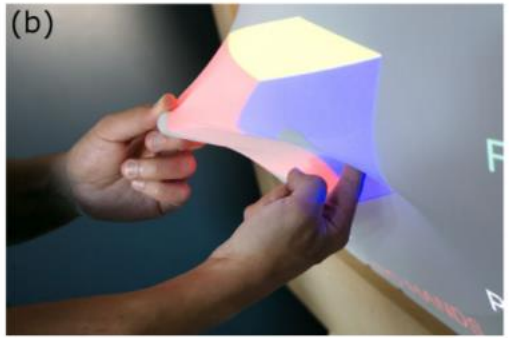
INTRODUCTION

Shape-changing interfaces provide the opportunity to fundamentally transform human interaction with computing machines. Users will change from reading and touching flat glass displays to physically manipulating interfaces that transform their shape and materiality to represent the underlying content and context (see Figure 1). Examples of such interfaces are numerous, and include handheld mobile devices [14, 26], tabletop surfaces [23, 95], furniture [30], and architecture [63].

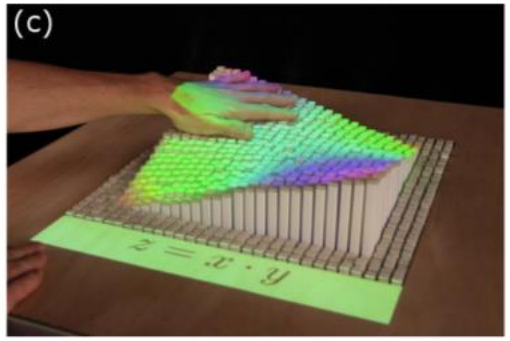
Introduction

- Shape-changing interfaces provide the opportunity to fundamentally transform human interaction with computing machines.

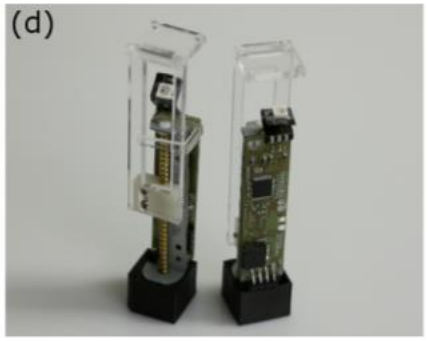
Morphees



Elastic Deformable Display



inFORM

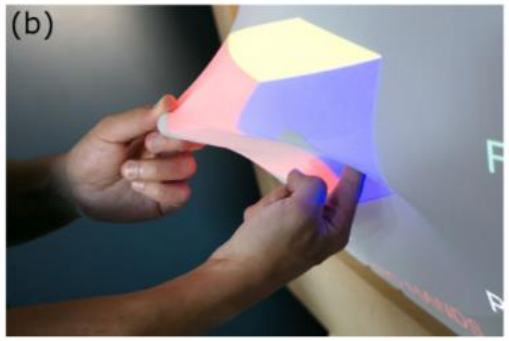


ShapeClip

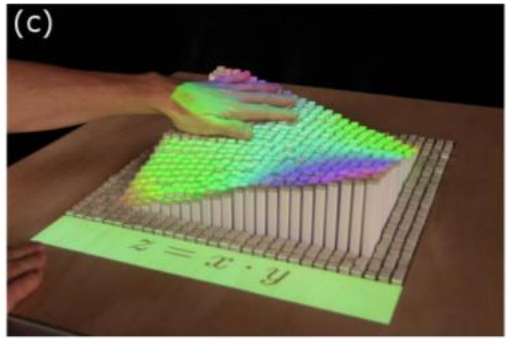
Introduction

- Shape-changing interfaces provide the opportunity to fundamentally transform human interaction with computing machines.

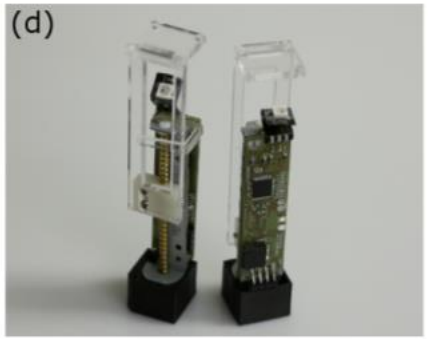
Morphees



Elastic Deformable Display



inFORM

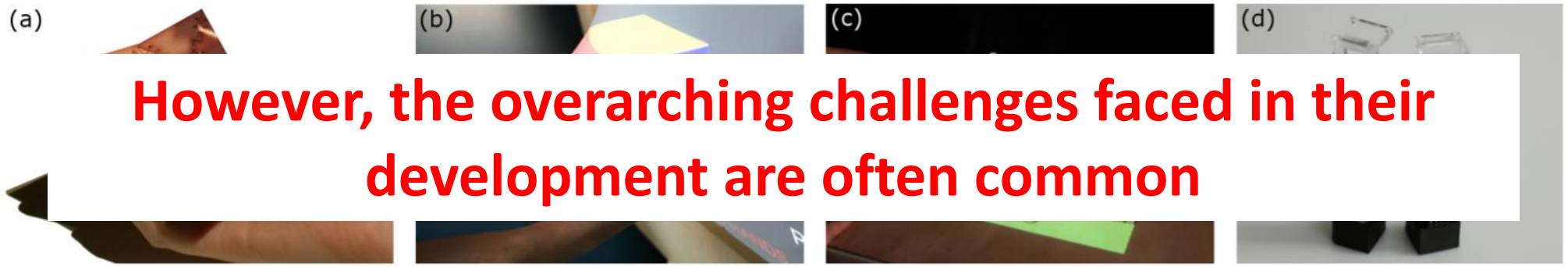


ShapeClip

These are unique and diverse in their goals, fidelity, capabilities, and complexity of construction

Introduction

- Shape-changing interfaces provide the opportunity to fundamentally transform human interaction with computing machines.



However, the overarching challenges faced in their development are often common

Morphees | **Elastic Deformable Display** | **inFORM** | **ShapeClip**

These are unique and diverse in their goals, fidelity, capabilities, and complexity of construction

Introduction

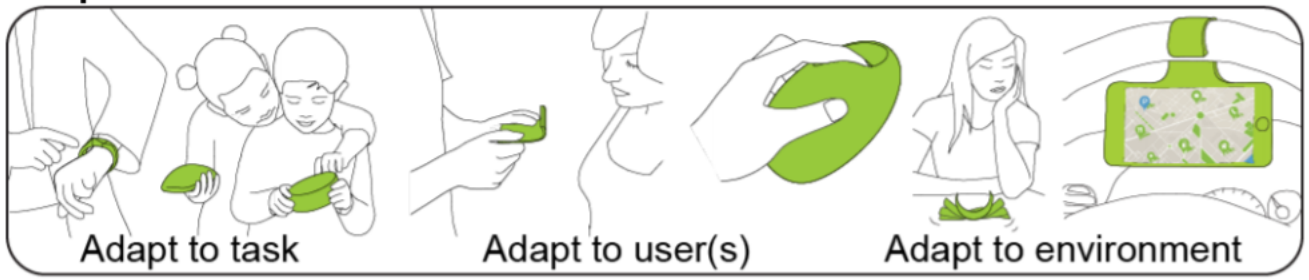
- 25 experts in shape-changing interfaces held a 3-days workshop
  - From Design, Computer Science, HCI, Engineering, Robotics, Material Science
- Wrote this paper to envision researchers to
  - Identify areas of opportunity in the field
  - Situate their work within the larger shape-changing interfaces research agenda
  - Set out new directions for researchers in their own fields
  - Identify current knowledge and capabilities
  - Allow policy makers to better understand the community, state-of-the-art, and potential applications

Shape-Changing Interface

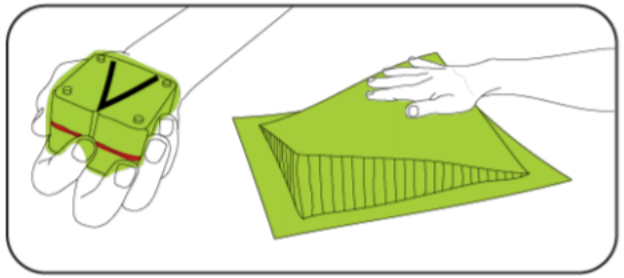
- Use physical change of shape or change in materiality as input and/or output.
- Be interactive and computationally controlled.
- Be self-actuated and/or user-actuated.
- Convey information, meaning, or affect

Purposes and Benefits

Adaptive affordances

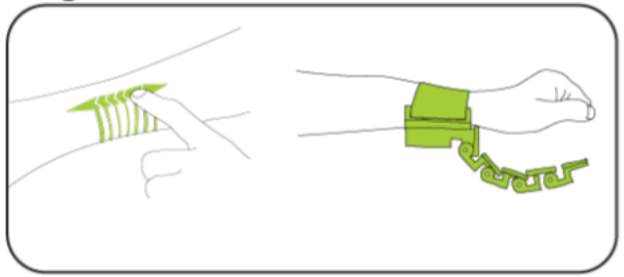


Communicate information

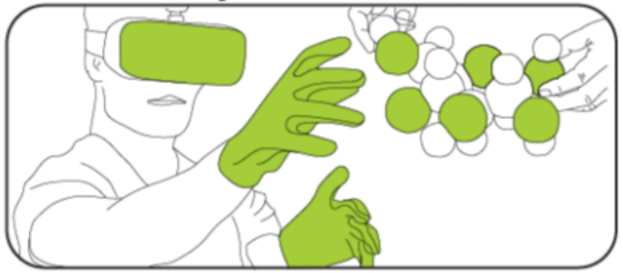


Hedonic and symbolic purposes

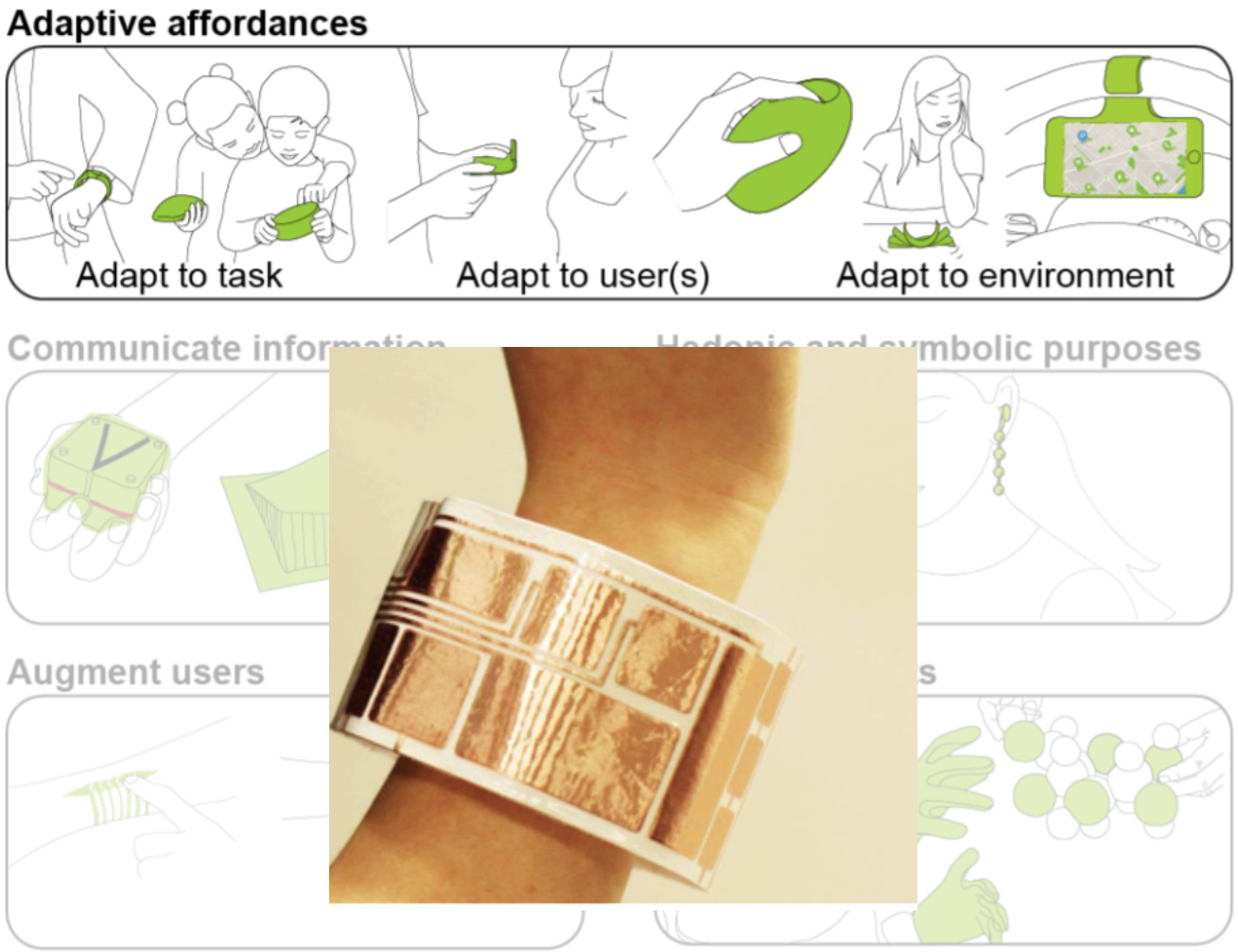
Augment users



Simulate objects

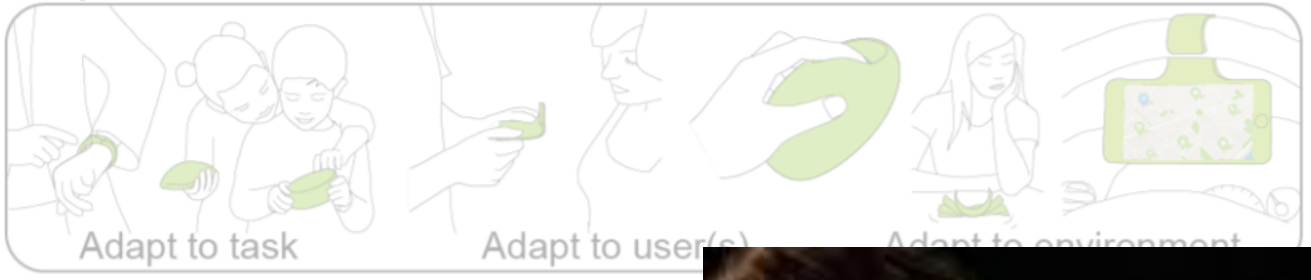


Purposes and Benefits



Purposes and Benefits

Adaptive affordances



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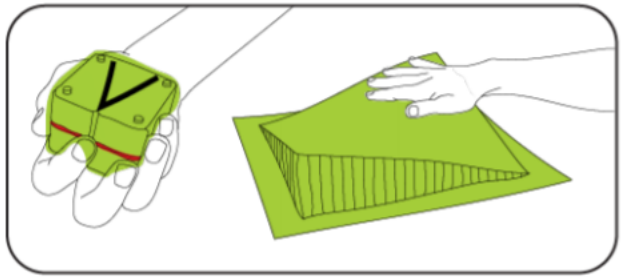

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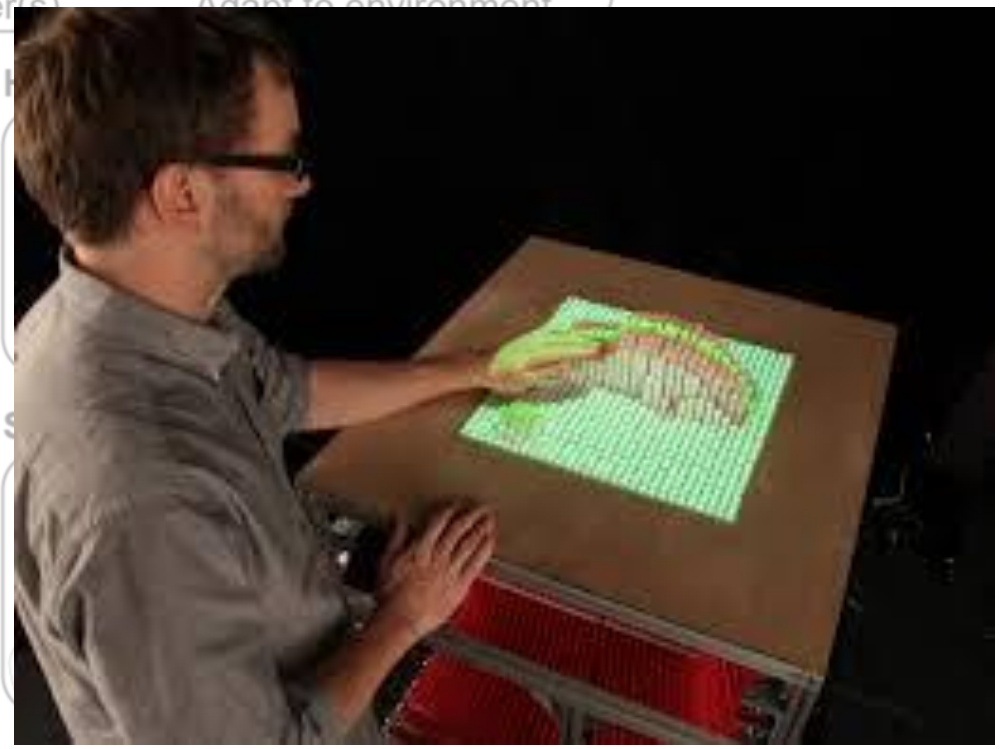

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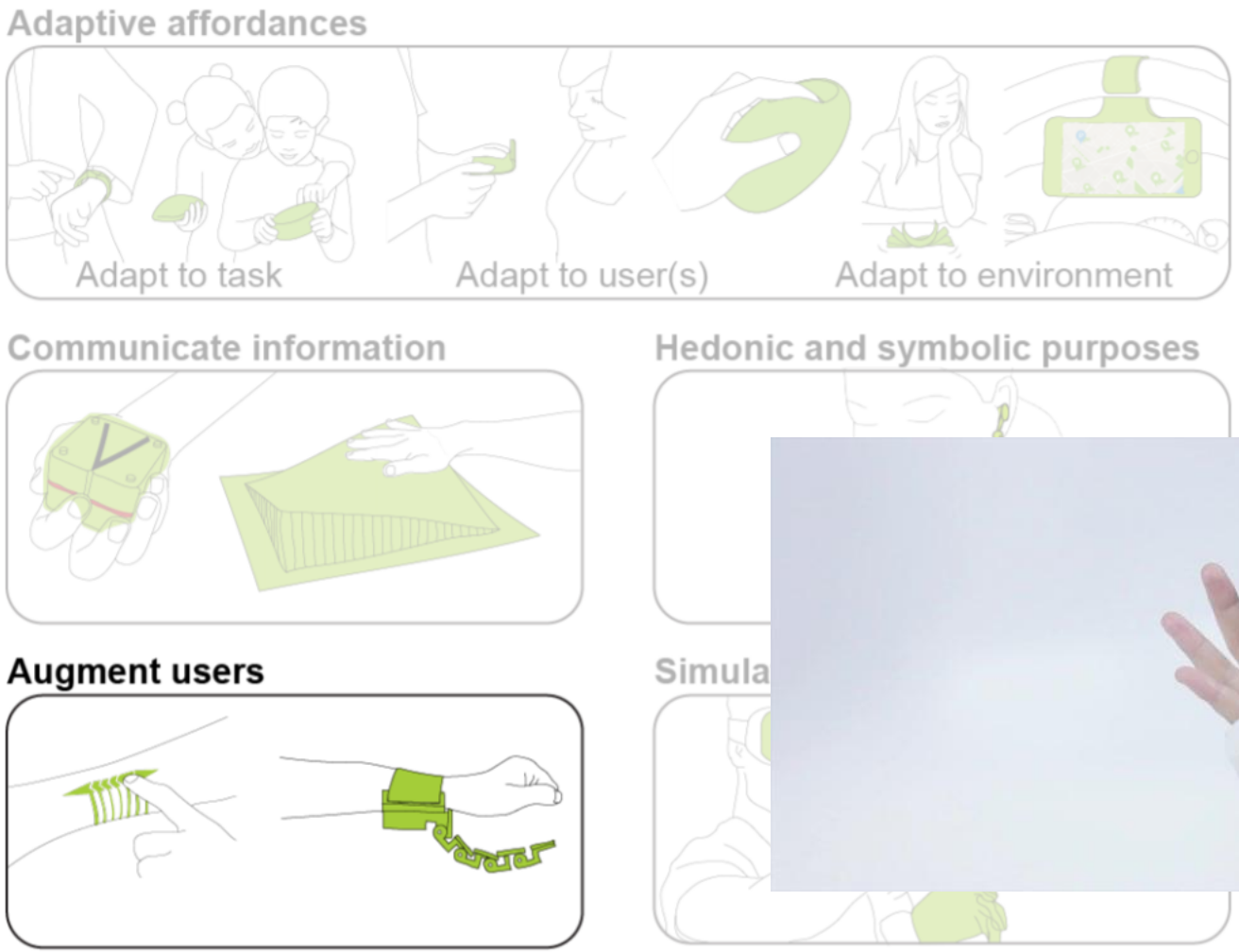

Purposes and Benefits

Adaptive affordances

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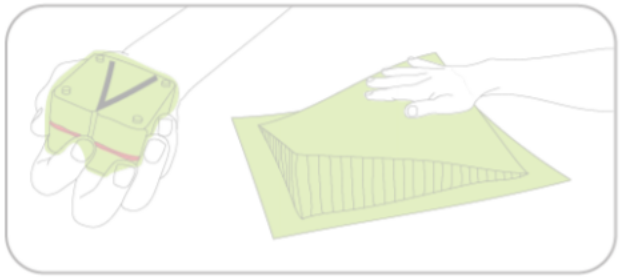

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Augment users

Simulate objects

Purposes and Benefits

Adaptive affordances

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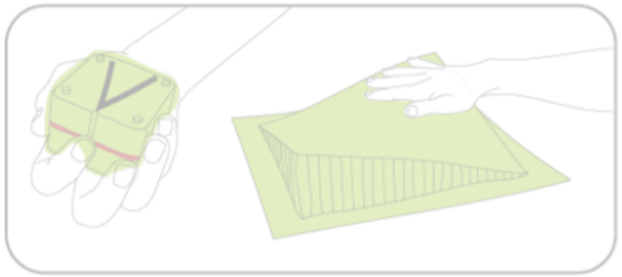

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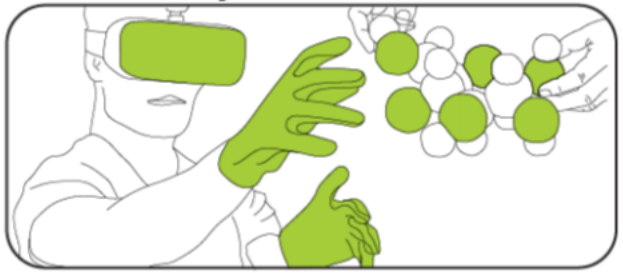
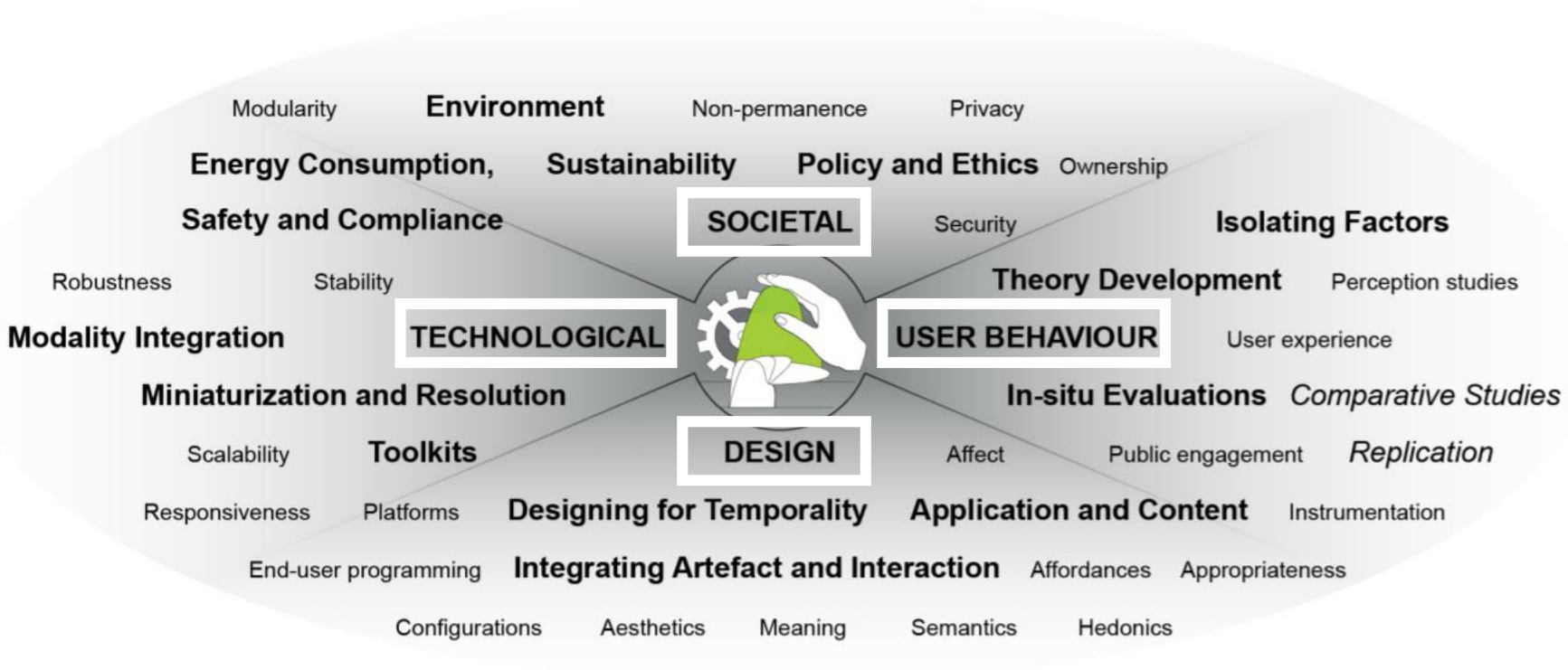


Grand Challenges



Technological Challenges

- Toolkits for Prototyping of Shape-changing Hardware
- Miniaturized Device Form Factors and High Resolution
- Integration of Additional I/O Modalities
- Non-functional Requirements

Technological Challenges

- Toolkits for Prototyping of Shape-changing Hardware
  - Building such interface requires EE & ME knowledge

    ➔ Toolkits may help

  - To address this challenge, we need
    - A standard platform for hardware prototyping, dealing with some aspects of actuation
    - A cross-platform software layer for applications
    - Tools for end-user programming

Technological Challenges

- Miniaturized Device Form Factors and High Resolution
  - Trends in shape-changing interfaces are changing
    - Stationary → mobile → wearable form factors
    - Rigid → Flexible → Stretchable → floating shapes
  - Humans' haptic and visual perception far exceeds that possible in shape-changing interfaces.

We need small, lightweight, and high-resolution actuators

Technological Challenges

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Technological Challenges

- Integration of Additional I/O Modalities
  - Today's shape-changing interfaces typically focus on shape input and output

  ➔ Acceptable for early prototypes, but successful real-world interfaces will need additional input/output modalities

  - Additional I/O Modalities may include
    - High-resolution touch sensing
    - In-place visual output
    - Adjustable material properties
    - Accurate sensing of the device's physical shape

Technological Challenges

- Non-functional Requirements
  - Energy consumption
  - Safety and compliance

User Behavior Challenges

- Understanding the User Experience of Shape-change
- Shape-Change Theory Building

User Behavior Challenges

- Understanding the User Experience of Shape-change
  - Shape-change combines modalities (e.g. visual, haptic) —isolating their relative effects is hard.
  - The experience of using shape-change spans diverse goals such as communicating affect, reducing task completion time, and task fit.
  - Current systems are often not robust enough for in-depth evaluations.

We need to be able to characterize their value, understand in which domains and for what tasks they are beneficial, and support their design and construction

User Behavior Challenges

- Shape-Change Theory Building
  - Theories are used to integrate and explain empirical results, to identify gaps in our understanding, and to make predictions.
  - But current use and development of theory in shape-change research is rare.

We need to develop theoretical statements that articulate propositions on how shape-change affects interaction

Design Challenges

- Designing for Temporality
- Integrating Artefact and Interaction
- Application and Content Design

Design Challenges

- Designing for Temporality
  - Shape-changing is dynamic: it requires temporal design
  - Dynamic form has temporal aspects that are difficult to compare in parallel
  - No language that supports the articulation of properties, experiences, or sensations, such as color or material properties in traditional product design.

Design Challenges

- Integrating Artefact and Interaction
  - Designers need to develop devices that are satisfying both in the form and dynamics of interaction
  - Designers need to understand theory, heuristics, and dynamic affordances.

Need to develop more tools that support the design process and design methods that couple action and reaction

Design Challenges

- Application and Content Design
  - When should we apply shape-change?
  - What shape-changes should we apply?
  - What applications should we build?
  - How do we design the content for those applications?

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
- Sustainability and the Environment

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
  - Security, privacy, and control
  - Content, and appropriate use
  - Ownership and responsibility
  - Implications of non-permanency

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
    - They must be built so as not to harm users or bystanders or cause damage to physical property
  - Security, privacy, and control
  - Content, and appropriate use
  - Ownership and responsibility
  - Implications of non-permanency

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
  - Security, privacy, and control
    - They must be subject to the same security and privacy expectations of other digital systems
  - Content, and appropriate use
  - Ownership and responsibility
  - Implications of non-permanency

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
  - Security, privacy, and control
  - Content, and appropriate use
    - They must prevent inappropriate content being shown to particular user groups
  - Ownership and responsibility
  - Implications of non-permanency

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
  - Security, privacy, and control
  - Content, and appropriate use
  - Ownership and responsibility
    - Individual users are likely to own the hardware for these devices with remote service providers delivering content
  - Implications of non-permanency

Policy, Ethics, and Sustainability Challenges

- Policy and Ethics
  - Safety
  - Security, privacy, and control
  - Content, and appropriate use
  - Ownership and responsibility
  - Implications of non-permanency
    - Today’s shape-changing objects do so in a predictable and repeatable fashion

Policy, Ethics, and Sustainability Challenges

- Sustainability and the Environment
  - Shape-changing interfaces are a ‘double-edged sword’

- Increased demand on natural resources
- Increased challenges for recycling

- Morphing ability should ultimately reduce the need for multiple instances of similar devices
- Therefore reduce long-term resource requirements

Policy, Ethics, and Sustainability Challenges

- Sustainability and the Environment
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Need long-lasting devices, component standardization, and support for developers

Conclusion

- The field of shape-changing interfaces has greatly expanded during the last few years
- It is important that we also recognize and deal with limitations of shape-changing interfaces and temper this optimism
- We hope you will join us in developing these interfaces to shape the future of human-computer interaction

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Thank you!