

Envisioning Future Challenges and Possibilities for Shape-Changing Interfaces through Speculative Scenarios

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ABSTRACT

In this paper, we present three speculative scenarios that explore the future of living with shape-changing interfaces. Each scenario is concerned with one area of this potential future. Three areas, which originated in a workshop with 25 researchers, are considered: 1) *shape as a service*, 2) *security and trust*, and 3) *personalization and materiality*. Each scenario is critically reflected. We point to future challenges that the research community needs to address, so that shape-changing interfaces can successfully venture out, into people's homes and lives.

CCS CONCEPTS

• Human-centered computing → User-centered design

KEYWORDS

Design, fiction, shape-changing interfaces, speculative scenarios.

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1 Introduction

Advancements in the field of shape-changing interfaces have often been made by building and testing physically dynamic prototypes, i.e. by overcoming technological challenges while imagining new ways of interacting. This approach has led to a wide range of prototypes, from displays (e.g. [22]) to mobile phones (e.g. [33]), faucets [39], computer mice [19], furniture (e.g.

[43]) and even architectural structures (e.g. [29]). This practice-oriented body of work has been complemented by theoretical framings (e.g. [32]), reviews indicating research challenges (e.g. [1]), as well as 'big picture' scenarios (e.g. [16]). Predominantly, this body of work is imbued with a sense of 'technology optimism', focusing on creating new technological solutions and interactive applications for shape-changing interfaces without considering the challenges of integrating these developments into people's lives. For example, what might happen if the mobile phones we use on a daily basis suddenly were able to change their shape (as in [33] or [14])? Would such a phone accidentally change its shape at inopportune moments, such as when worn in a tight pair of pants, ripping the fabric and making it impossible to take it out of the pocket? Or how could a table-scale shape-changing display (such as [43]) be used as a real desk – with coffee, pencils and stacks of paper on it? Consequently, as research on shape-changing interfaces matures, its community needs to balance its enthusiasm with some realism. It should heed Lindley et al.'s [24] call, considering how a newly-developed technology might actually be adopted in the future and what implications it might entail. The necessity to consider the real-world implications of shape-changing interfaces has been highlighted by studies testing shape-changing interfaces in the wild (e.g. [12]), as well as by the fact that shape-change is no longer solely explored within research, but actually implemented into mass-market products (such as LG's shape-changing TV [46]). As a complementary approach to testing shape-changing interfaces in the wild, this paper uses speculative scenarios [20] as a method of illustrating conceivable future challenges and potentials of shape-changing interfaces.

2 Related Work

Research in the area of shape-changing interfaces is driven by a vision of a malleable, digital-physical world in which physical artefacts are dynamic. One of the more extreme visions described for shape-changing interfaces is Ishii's [16] 'Radical Atoms' vision, which stipulates a hypothetical, highly dynamic material that is extremely malleable, computationally reconfigurable, and bi-directionally coupled to an underlying digital model. Another insightful source of future visions can be found in Troiano et al.'s study of 340 science-fiction movies [40], which found 101

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instances of shape change. Research on shape-changing interfaces often uses future scenarios to contextualize technical prototypes, pointing towards their future applications. Often, current technical limitations are ignored in these future scenarios. For example, JamSheets [30] explores material jamming as means of shape change and describes a range of prototypes for this technology, from displays to shoes, and even furniture. Additionally, the authors describe a future scenario in which users save and load different shapes of a chair via voice control. Another example is Shutters [5], a piece of textile with a grid of 25 actuated louvers. Although the prototype is only a comparatively small piece of textile, it manifests the vision of 'responsive architecture' that reacts, via shape change, to changing environmental circumstances. Using a prototype to extrapolate the potential impact of a new interaction technique is also observable in the Morphees project [35]: simple, shape-changing prototypes are presented in real-world applications through scenario sketches – such as automatically bending the top edge of a mobile phone inwards to provide privacy when typing in a password. This work is much inspired by the grand challenges for shape-changing interfaces, as identified by Alexander et al. [1], and aims to enhance the discussion through a series of speculative scenarios. Speculative design is a term that covers a wide variety of (overlapping) practices [25], such as futuristic architectural visions (e.g. [31]), Critical Design (e.g. [9,11]), Design Fiction ([4,7,23,36]), speculative design (e.g. [2,10]) and speculative scenarios (e.g. [20]). All of these provide a means of contemplating, analysing, critiquing and re-thinking possible futures [10]. The following overview focuses on Design Fiction and speculative scenarios. Design Fiction distinguishes itself from other future-orientated critical approaches by its use of world-building to suspend disbelief about change [6]. Common for all works in the area of Design Fiction is that they generally follow the principles of fiction, creating a 'What if?' scenario, often presenting utopian or dystopian worlds [21]. One example of Design Fiction is the Listener, a device for collecting conversations that take place within a council, mocked up with cardboard and taken into the wild [4]. Another one is a wearable reading system that induces emotions to augment a story, presented as a semi-functional prototype [13]. A third example is a book that provides patterns for how to transform bones, skin, teeth and hair into aesthetically pleasing objects, such as a bikini [26]. These three examples illustrate the variety of media used to communicate Design Fiction, ranging from text to video, physical models, collages, sketches and graphics [26]. Speculative scenarios, as defined by Kirby [20], have their origin in the movie industry. They explore future technologies or situations that – while improbable – at least might come true. Speculative scenarios often take their starting point in some aspects of 'real-world' science, leading to easily believable narratives. This approach bears similarity to Design Fiction, but emphasizes believability. As mentioned previously, many papers in the domain of shape-changing interfaces include a vision that reaches beyond current technical capabilities. However, there are very few papers within this domain that use speculative design without tying it to a specific prototype. One example is Sturdee et al.'s

work [38], which uses Design Fiction as a method to inform the design of shape-changing interfaces. It is presented in the form of a printed instruction manual, describing the game concept 'First Hand'. 'First Hand' is a role-playing game in which users can 'terraform' a planet and thereby indirectly control its population through a high-resolution, shape-changing display. Sturdee's PhD thesis [37] discusses this approach in great depth, pointing out the dialogue-enhancing potential of scenarios when co-creating new applications with potential users. Another example is Vallgård et al.'s work [41], which – although it does not position itself within a specific speculative design direction – speculates about potential future concepts and tools for programming material and shape change physically, without using a computer. The work presented in this paper can be categorized as belonging to the area of speculative scenarios, as the three themes presented in the following neither focus on the physical design, nor on storytelling for 'world building' in the reader's imagination. Instead, this paper seeks to create plausible scenarios, taking their origin in both existing shape-changing interfaces, as well as in current challenges from other types of technology. The three speculative scenarios presented in this paper originate from a discussion of themes and concerns at a research seminar, conducted with 25 international researchers, all familiar with the field of shape-changing interfaces. This work consolidates and contextualizes the results of this discussion.

3 Speculative Scenarios

The following three speculative scenarios examine different facets of the same fictional future in which shape-changing interfaces have become widespread, where nearly every new product comes with physically dynamic capabilities.

3.1 Scenario 1: Shape as a Service

John is having a dinner party for his colleagues tomorrow. Looking around the apartment, he is unsatisfied with how it looks. His pieces of furniture were cheap, he bought them rather for their price tag than for their aesthetics. John wants to impress his colleagues, so he grabs the phone and surveys the ShöpIT App store. He finds a new design that he really likes, but when clicking it, he discovers that it isn't compatible with his 2nd generation couch. Other designs, while compatible with his couch, are far too expensive for him to buy, so he opts for just renting them. 'Just \$1 per day, billed by the hour', says the advertisement. He subscribes to the new design and all of a sudden, his flat looks like a designer loft. He makes some adjustments to the shapes and starts preparing the food for his guests. After a spectacular dinner with his colleagues, which lasted almost until midnight, John receives a notification. 'Your credit card has expired; your subscription will be cancelled by 23:59:59. Please, update your credentials to keep your subscription.' 'Jesus – that's only two minutes left!' – he rushes into the kitchen, where he last saw his wallet. Everybody else is having a good time on the couch; the table is full of drinks and the spectacular dessert, which they kept for midnight. 'Less than a minute, come on... 5231...' John's fingers are jittering while entering the numbers of the new credit card he

received a month ago, but with all the accounts to update, he completely forgot to update it in his ShöpIT account. The clock rings midnight, the couch decompresses from a five-person corner sofa to a two-person couch: one of John's colleagues gets thrown on the ground; another colleague's hand is trapped underneath the armrest. From one second to the next, the table doubles its height while three chairs transform back into plant pots.

This scenario points to a significant potential for shape-changing interfaces in the future, as they may enable a revolution of how physical form is sold and distributed. Combining shape-changing interfaces' possibilities for upgrading and altering both their physical form and software with Nes and Cramer's [28] strategies for extending the longevity of products could encourage more long-term use of technological products: upgradability should be taken into account when designing shape-changing interfaces, considering long-term use and encouraging changing function and shape over time. The scenario also highlights potential challenges with creating objects that can change both shape and purpose drastically, such as for example from a chair to a potted plant. How can we, as users, understand which objects are capable of changing shape – and into what? The scenario pushes the possible types of changes in shapes, from small changes in form or size to changing from a chair to a plant. This underlines the need for further reflections on shape-changing interfaces and their affordances (e.g. [34]) – if this concept can be applied to them at all – in a 'radical atoms' world. Just as MP3 revolutionized the music industry; 3D-printing is expected to do the same with product design [8]. Shape-changing interfaces, with the size and resolution described in the speculative scenario, might push the digitalization of design even further. Making design accessible as a 'downloadable' and, perhaps, even subscription-based service raises the question of how to deal with piracy and digital rights management (DRM) in the future. Related to this, the scenario also highlights compatibility as a challenge. If we don't begin to consider how to develop a 'standard' for shape-changing interfaces, we face a future of potentially incompatible shape-changing interfaces. The other extreme, a 'shape-changing interface monopoly', ruled through a single app store for everyday objects, also does not appear desirable. This scenario also highlights another relevant aspect to consider for shape-changing interfaces in the future: safety. Using large-scale shape-changing interfaces, people can get hurt: fingers might get crushed, people might be thrown on the floor. Consequently, research on shape-change should include safety issues, considering measures against undesirable and even dangerous situations.

3.2 Scenario 2: Security and Trust

Mark is at the airport, just about to leave for a quick visit to New York; on his wrist, he is wearing his new shape-changing phone. He is still amazed by its dynamic capabilities, packed into such a small shape. 'A phone that isn't bigger than a watch when it's on my wrist, and still as has a huge shape-changing display – amazing!' Standing in the queue for the security check, the phone suddenly tightens around his wrist. At first, he thinks it's just someone calling, but the straps continues to tighten. The surface, usually displaying a water

ripple pattern, is now spiky and sharp. Mark frantically tries to turn the phone off and to get it off his wrist. Suddenly, it stops and Mark sighs as the strap loosens. For a moment, he wondered whether this was one of the shape-change hacking attacks he had heard about – he decides that it must have been just the new update acting out. Arriving at the security check, Mark feels a sense of relief taking off the watch. Not overly excited about his new gadget, he places it in the tray, alongside his other items. 'Sorry sir, is that a DynaPhone II?' the officer asks him. 'Yep.' He smiles. 'Well, you can't take that on the flight.' 'What? Why not? It's just a phone!' 'Well, there were some incidents. Until the new shape blockers have been installed in planes and airports, TSA regulations only allow permanent objects to go on planes. No shape-changers.'

As the speculative scenario points out, shape-changing interfaces could have severe implications in terms of security. This entails a psychological problem: networked everyday objects, once having lost their trustworthiness through an incident, may be perceived as dangerous. Digital attacks, or simply malfunctioning software, could impact our trust in the objects that surround us, which we potentially even live and sleep in. How can we design for trustworthiness, helping people to be at peace with the technology that surrounds their everyday lives? Relevant topics in this area might include the question of how to deal with predictability in shape-changing interfaces: how can form, materials and movement be used to communicate a device's capabilities in advance? The scenario illustrates the potential for shape change in the design of products, where a phone does not have to just have one form – a trade-off between screen size and portability. Shape change could allow designers to design a range of shapes, each tailored to a specific use. However, in this scenario, the phone can also be a bracelet, a tablet, and potentially a range of other shapes. Consequently, as shape-changing objects might contain many 'unseen' shapes, they might pose a challenge for current laws, as current laws are based on the concept of 'object permanence': a gun is a gun and a phone is a phone. Shape-changing interfaces do not follow this, as their shape is not permanent. Thereby, whether or not a shape-changing bracelet may be taken onto an airplane as hand luggage is unclear: it might, in the end, shape-change into a gun.

3.3 Scenario 3: Personalization and Materiality

Mia isn't an overly emotional person, but since her mother passed away, she began to pay attention to what's important in life. Having just arrived at home, she glances at the shelf where she keeps the shape-changing cup that she inherited from her mother. Her mother had bought the cup five years ago. It's made out of a new shape-changing ceramic material, which changes shape depending on how it is handled. Though use, her mother had left her clear imprint on the mass-produced cup, as she always used to bang the cup hard against the table when she put it down, creating a thickened part at the cup's bottom. Also, her mother was left-handed, which has led the cup to change its shape accordingly, over time. Mia enjoys that this reminiscence of her mother's habits still holds up – it reminds her of the long chats the two of them had over tea, which she always enjoyed. Mia grabs her own shape-changing cup – every time she

touches it she is amazed by the material – it feels smooth and hard, almost indistinguishable from the old types of ceramics, but still able to change its shape. It feels alive, almost magical. Two weeks later, Mia takes down the shape-changing cup. However, when picking it up she is shocked to see that it has completely lost its unique shape. Either her boyfriend had used it at some point, or she made a mistake when trying to activate the cup's 'shape-lock' function through the app she had to download for it. Ultimately, she is able to restore the shape from a shape-cloud backup that she wasn't aware of – but a feeling inside of her won't go away – the traces of her mother had been erased, and simply downloading a copy of them won't make up for that: 'Even though that shape is the same, it's not the... same.'

Before the first industrial revolution, all products were hand-made, uniquely tailored to an individual's needs. Mass production introduced standardized and identical products for large groups of people [44]. Today, companies and designers are increasingly looking for ways to differentiate their products, by developing means of production that allow for customization and personalization [3,44] or by seeking ways to attach their customers to their products through 'emotional responses and experiences' [27]. Shape-changing interfaces might offer new ways to customize products: they could still be mass-produced, but allow people to change their functionality and appearance through use. People could create unique objects, physically imbued with stories, tailored to them. As described in the speculative scenario, this would increase the personal relevance of the object for its owner [3]. Furthermore, while the scenario illustrates implicit interactions that create personalization, personalization might also be achieved explicitly [33]. Creating the possibility of physical customization might also contribute to the longevity of products, by potentially making the products irreplaceably meaningful for their owners [17]. The challenge here is that such a personalization is, even though it is physical, is a result of digital control. Thus, it can also be lost, copied, and freely manipulated. This is problematic, as people usually have emotional relationships to specific objects, and not to look-alikes of them. This raises the question of how future shape-changing interfaces could fulfil users' needs for *original* objects, and if our sense of their uniqueness is different from ordinary objects? Another aspect addressed by the scenario is the challenge that electronic products often have a much shorter lifespan than non-electronic products [42]. Consequently, longevity should be a central concern for shape-changing interfaces, as technology might become a part of many more everyday objects, not just our phones, TVs, computers, but also in our furniture [12,43], lampshades [45], carpets [5], and many others. Consequently, if shape-changing interfaces are to find their way into real-world products, we need to expand the material repertoire. To do this, we must engage directly with the development of new materials, which have tactile and aesthetic qualities equal to materials used in other everyday products, such as for example wood, ceramics or metal. Furthermore, when we begin to think of shape-changing interfaces as products that people use over a long period of time, shape change might occur much slower than in today's prototypes: over hours, days, months, or years.

4. Reflection

This paper aims at highlighting untested (and often untestable) scenarios, balancing believability with unexpectedness. Thereby, it hopes to inspire the research community to address the questions posed by the speculative scenarios. The speculative scenarios presented in this paper are intentionally placed in a future that in many ways is very similar to the present – apart from extensive progress made on shape-changing interfaces. By moving the technology into the future, while keeping situations familiar, it helps to emphasize the challenges that shape-changing interface might pose in the future, once we overcome today's material and technological limitations – a future in which the technological and material foundations advanced far beyond the present day's struggles with even creating a knob that turns into a slider [18], a door handle that changes from smooth to spiky [15], or a bench that can shift the position of the seat [12]. Hence, this paper aims to connect fiction with research: combining plausibility with speculation. Rather than using fiction as a method for highlighting future research directions, papers such as Rasmussen et al.'s [32] review paper and Alexander et al.'s [1] paper seek to highlight grand challenges for shape-changing interfaces. These papers use existing research to highlight where more work is needed and point to new topics of interest, narrowing down at very specific concerns and widening up to larger concerns such as policy, ethics, and sustainability [1]. Review-based and fiction-based papers alike take a broader look than purely technology-based papers, but they differ in their time focus: review-based papers focus on the past, while fiction-based papers focus on potential futures. The reflections in this paper, when viewed in critical hindsight, have shown to be a helpful means of bringing the speculative scenarios into a meaningful relationship to today's everyday life.

5. Conclusion

This paper used speculative scenarios as a method for envisioning future research directions in an evocative way. It illustrated future possibilities and challenges, extrapolated from current research, but reaching beyond present technology. By using speculative scenarios, potentials and challenges have become more tangible. By presenting them in context, possible futures are easier for us to imagine: we see a group of colleagues getting squashed into a small couch while their glasses are smashed on the floor, a man panicking to get a device of his wrist, or an inherited cup losing its sentimental value after being restored from a backup. Hopefully, these speculative scenarios will encourage researchers in the area of shape-changing interfaces to consider the challenges that shape-changing interfaces need to overcome, including safety, security, trust and longevity. Addressing these challenges is fundamental if we want shape-changing interfaces to successfully venture out of the lab, into people's lives.

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