Bitplush: Unleashing the Paws-ibilities of Smart Materials in Smart Plush Toys

Albrecht Kurze
Chemnitz University of Technology
Germany
albrecht.kurze@informatik.tu-chemnitz.de

Lewis Chuang
Chemnitz University of Technology
Germany
lewis.chuang@phil.tu-chemnitz.de

Arne Berger
Anhalt University of Applied Science
Germany
arne.berger@hs-anhalt.de

Klaus Stephan
Chemnitz University of Technology
Germany
klaus.stephan@informatik.tu-chemnitz.de

Natalie Sontopski
Anhalt University of Applied Science
Germany
natalie.sontopski@hs-anhalt.de

Stephan Hildebrandt
Anhalt University of Applied Science
Germany
stephan.hildebrandt@hs-anhalt.de

Elisabeth Jost
Textilforschungsinstitut
Thüringen-Vogtland e.V.
Germany
e.jost@titv-greiz.de

Maximilian Eibl
Chemnitz University of Technology
Germany
eibl@informatik.tu-chemnitz.de

ABSTRACT

'bitplush' is a project that will explore how individuals can be emotionally connected through smart connected plush toys. The goal is to explore and formalize the design space of implicit and multimodal interactions that can be supported with and through them, in a way that is tangible, graspable, and meaningful. To achieve this, high-quality, handcrafted plush toys will be equipped with hardware and software for innovative data processing and communication. Off-the-shelf as well as novel textile-integrated and textile-based sensors and actuators will be used to develop novel communication channels that will enable a sense of "closeness over distance" without diminishing other forms of communication. Interdisciplinary tools, methods, materials and theories of social relationships serve as a framework for our design space. We conclude with a brief discussion on the planned iterative stages of this project and seek opportunities for like-minded collaborations.

KEYWORDS

multisensory, multimodal, design, ideation, tools, methods, IoT, Internet of Things, tangible interactive devices, input and output devices, tangibles

1 INTRODUCTION

Several years ago, we designed and developed the *Loaded Dice* [14, 15] (Figure 1a), a multisensory and multimodal hybrid toolkit to ideate Internet of Things (IoT) devices and scenarios, e.g. for the 'smart' home, and with different groups of co-designers [4, 14, 15]. The *Loaded Dice* filled a gap between analog, non-functional tools, often card-based, e.g. KnowCards [2], and functional but tinkering based tools, e.g. littleBits [3], for multisensory and multimodal exploration, ideation and prototyping. *Loaded Dice* demonstrated great potential to initiate innovative ideas for human-computer-interactions—such as *Whether Bird*, an interactive helper tool for blind and visually impaired people [13, 14]. This led to a concept prototype, which was an electronics assembly within a stuffed plush toy in bird shape (Figure 1b). The consideration of shape and material revealed new opportunities as well as challenges, in terms of potential and viable interactions that could be effectively embodied in plush animals and their materials.

'bitplush' is a new project that is motivated to investigate the design space of smart plush toys in its core. We will start with an explanation of the project. We will continue to discuss our starting point, namely the *Loaded Dice* for ideating sensing and actuating capabilities as well as smart textile toolkits for bringing functionality to materials. Eventually, we will briefly discuss how we plan to create demonstrators for use in workshops and field studies.

2 FROM LOADED DICE AND WHETHER BIRD TO BITPLUSH

We seek to open up and make available the technical, social and design facets of multimodal and implicit interactions for plush toys through smart electronics. *bitplush* devices should help users to stay connected and emotionally related to one another – for closeness over distance. Or, in other words and quite literally: **to keep in touch**. Smart plush toys are an excellent use case that bring together many relevant aspects:

- *smart technology embodied in everyday objects:* as a paradigm on its own,

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- *everyday objects that are not ordinary:* plush toys are often associated with a special emotional attachment,
- *the materiality of plush/fur/textile:* offers opportunities for innovative smart textiles for new textile-integrated- and textile-based sensors and actuators,
- *specific interaction opportunities:* in terms of modalities (i.e. touch) and actions (e.g. petting, cuddling, holding, pinching) based both in materiality but also in special shape/body and meaning of a plush toy.

Our main research question is: *How can networked smart plush toys enable multimodal and implicit interactions that will support the emotional bonds between separated family members?* The theoretical starting point of our holistic integration concept is collaborative habituation ([1] with reference to [22]). It is proposed that mediated communication exerts a positive long-term effect when users find a place for implicit communication objects in the ecology of their devices and everyday practices. Over this, this develops and habituates a shared sense of everyday togetherness between users. The practical starting point focuses on a discussion of our existing tools and materials.

This submission focuses on the following: *How can plush toys—as objects with special shape/body and attachment—serve as a meaningful intersection of a) interactions (e.g., touching, cuddling, . . .), b) functionality (sensors, actuators), and c) materials (fur, smart textile, classical and flexible electronics)?*

While we expect generalizable learnings for smart technology, smart textiles, (implicit) interactions, and achievable psychological effects, there is still an idiosyncratic element to be expected [4] when all these aspects come together - resulting in individual specimens of stuffed animals rather than mass products. Thus, we also incorporate traditional manufacturing of high-quality plush toys (Kösener Spielzeug Manufaktur). This allows us to incorporate actual materials and craftsmanship techniques to produce high quality demonstrators in the form of actual plush toys for our workshops and field studies.

3 TOOLS, MATERIALS AND THEORIES - OUR STARTING POINT

3.1 The Loaded Dice – Sensors and Actuators for Ideation of Smart Things

The *Loaded Dice* are a set of two cubical devices wirelessly connected (Figure 1a). Each cube has six sides, thus allowing six unique sensors in one cube and six actuators in the other. Each sensor/actuator is presented on one side, suitable for multisensory and multimodal environmental and user interactions. The sensor cube normalizes a raw sensor value that is transmitted to the other cube that actuates a mapped output on the presented side. The cubical shape intuitively communicates that the top side is active, like a die. Together, this approach offers an easy and spontaneous way to re-combine sensors and actuators. The sensor-in and actuator-out pairings allow for 36 combinations in total [10]. Nonetheless, the technical platform's constraints meant that we could not address all human senses with sensors and actuators. Overall, the *Loaded Dice* holds sensors and actuators equivalent to some human senses directly (see Figure 1a and 1 for details). Combined with an adapted interaction vocabulary, the *Loaded Dice* can provide insights on mappings of functionality, interactions and emotional interaction qualities [11]. From our preliminary work, we know that smart everyday objects equipped with appropriate sensors and actuators are suitable for enabling low-threshold habituated proximity over distance for communication pairs, while promoting data-saving and imaginative interaction. Thus, even simple sensors and actuators allow for paired-interactions with and through smart objects [10], in a way that is meaningful for those who know (while appearing arbitrary for those who do not), thus enabling a multimodal "secret language" [14].

In workshops we found some repeating themes for a mapping between certain interaction characteristics and suitable sensing as well as actuating possibilities [11]. Some examples (more in [11]): The thermo-element was associated with slow and warmth literally but also with 'love', tender and poetic. The distance sensor can detect a hand in proximity in different ways – either graded, if done slowly, allowing for gentle gestures without touching something, without any force poetic and very tender like petting something – or detecting powerful, targeted and harsh movements like a punch. The HOW of the interaction is depending on the emotional state of the user and the WHY of interaction. Therefore, it makes a difference what a user tries to express in an end-to-end view of interactions 'through' devices [10], from one device to another device, as communication to another actor – and not only in an interaction with a device. [11]

3.2 Smart Textiles – Soft, Flexible, Functional

In terms of smart textiles and functional demonstrators, it is meaningful to differentiate between:

(a) *textile-adapted:* existing electronic modules (sensors, actuators, energy, communication) in electronic boxes [17, 20],
(b) *textile-integrated:* standardized electronic components and (flex) circuit boards by means of conductive threads [19],
(c) *textile-based:* functionality directly embedded in the textile [23], e.g. for sensing conductivity or generating heat.

Currently, the most common approaches on the market are for stitchable electronic boards with the desired functionalities, sequins with functional units, and electronic boxes applied by means of snap fasteners. In the do-it-yourself (DIY) range of these technologies the Adafruit "Flora" and "Gemma" product lines are examples to mention here. These products, intended mainly for makers, are also interesting for prototypes and use in workshops by designers and product researchers. New smart textile DIY kits even provide easy usable access to textile-based technology, i.e. for conductive tissue, heating and light emitting textiles (Figure 2) [8].

3.3 Theories

As mentioned, collaborative habituation [1] with reference to [22] serves as a theoretical starting point for this *bitplush*. It proposes that medially mediated communication has a positive long-term effect when users find a place for low-threshold communication objects in the ecology of their devices and everyday practices. These objects allow users to develop and habituate a shared sense of

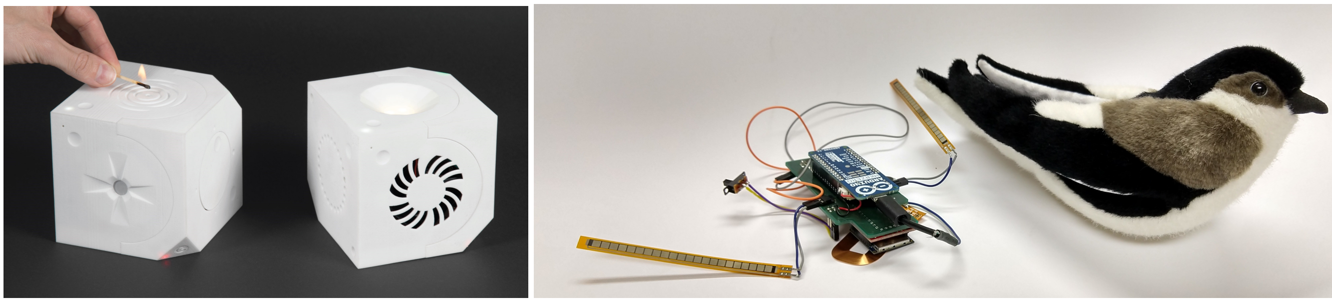

Figure 1: a) The Loaded Dice - example of devices in use, turning heat into light (sensor die with temperature sensor active and actuator die with power LED active) [14]; b) Whether Bird – early concept of electronics assembly and example of plush toy bird.

Table 1: Human senses vs. sensors and actuators in the Loaded Dice [12]

Human Sense	Sensor	Actuator
sight (visual stimuli)	luxmeter (visible light luminosity/brightness) passive infrared detector (PIR movement) ultrasonic transceiver (distance)	power LED (brightness) LED ring-graph (count, overall brightness, color)
hearing (auditive stimuli)	microphone (amplitude / loudness)	sound (modulated note for instrument) (vibration motor, rattling noise) (fan, air flow noise)
touch (tactile stimuli)	potentiometer (manual angular dial of 270°)	vibration motor (vibration) fan (mechanical stimulation on hairs)
temperature (thermal stimuli)	thermometer + infrared thermometer (thermopile for thermal radiation)	Peltier element (cooling and heating plate) fan (cooling by chill effect on skin)

Figure 2: Smart textile DIY kits (© imbut GmbH [8]): a) e-Web conductive tissue, b) set for textile heating, c) set for textile lighting.

everyday togetherness. This stands in contrast to screens that simply "mirror" the household but do not promote social contact [5]. Multimodal extensions of communication at a distance are successful when, like MarkerClock [18] or Messaging Kettle [1] allow synchronization of everyday routines and are habituated by the users. They allow implicit interaction, coexist with existing audiovisual communication infrastructure and, thus, have the potential to sustainably support social bonding across distances [9]. They allow low-threshold exchange of implicit information that expresses closeness and community and, thus, have a positive impact on psychological well-being [7]. They serve as "transitional objects". Related to this, attachment theory suggests that we develop attachments to objects when they serve as reliable available substitutes for an attachment figure [16, 26]. Thus, transitional objects could mediate the role of attachment persons if they can reliably contextualize, interpret, and respond [6, 24]. Soft toys as transitional objects could fulfill this in a special way, for example, by initiating interaction [25]. They can provide haptic support as a safe haven, for example by returning hugs [21]. Importantly, attachment theory makes clear predictions of how individuals will respond emotionally and physiologically when their needs are not met by an attachment figure, but are met by an object in their place. In *bitplush*, we investigate whether transitional objects equipped with the insight of a real attachment figure can effectively support the role of attachment figures. Thus, *bitplush* differs from previous work, which has examined the role of objects alone and not in interaction with real human referents.

4 DEMONSTRATORS, WORKSHOPS AND FIELD STUDIES – OUR NEXT STEPS

Initial exploration: For the initial exploration of the possibilities of meaningful combinations of functionality (sensors and actuators), multimodal interactions, and material aspects, we will start with existing tools (*Loaded Dice*, interaction vocabulary) and materials (smart textile kits and plush material samples). These should allow a first and early involvement of participants as co-designers in workshops. We are aware that a piece of fur on a hard sensor or actuator is far from perfect. However, our previous work has demonstrated that sensory sensations and modalities do not need to be perfect, at least for ideation of interactions and interaction qualities. We expect a similar effect also for material properties. It might even be possible to negotiate the mentioned aspects of a "secret language" through smart connected objects. Small textile-adapted electronics for sensing and actuating will support this. From this starting point, we will proceed iteratively.

Workshop and study cycle 1: We will create a first series of demonstrators mainly based on available materials and technology (textile-adapted). That means using the existing DIY kit material and textile-adapted electronics (sensors and actuators) stuffed in and stitched on and in plush toys for workshops and studies in the home. Demonstrators in the form of actual plush toys are intended for a first cycle of workshop and field studies with them. We plan the field studies for around two months duration to have the abilities to research the intended effects. For the first study we intended to start with grandparents and grandchildren as participants.

Workshop and study cycle 2: Next, we will go on and use more textile-integrated components for a second series of demonstrators and, finally, pure textile-based smart materials. These demonstrators will be adapted based on the learnings of the first cycle – in materials, technology but also manufacturing. We will run another series of workshops and field studies. There we will aim for an additional user group that might also be interested in "closeness of distance" besides grandparents/grandchildren, e.g. international students or workers abroad etc.

5 SUMMARY AND CONCLUSION

We presented with *bitplush* a new project that is motivated to investigate the design space of smart plush toys. We aim to achieve "closeness over distance" that aims on implicit, even non-verbal and innovative interactions with smart technology, to keep people emotionally connected through smart technology. We explained our research questions, tools (namely the *Loaded Dice*), approaches for integrating smartness into textiles, theories like collaborative habituation and attachment theory. We discussed our approach to bring all together in demonstrators, workshops and field studies. With this submission, we hope for inspirations and ideas as well as synergies and opportunities to start collaborations.

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