The Modular Backward Evolution – Why to Use Outdated Technologies

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ABSTRACT

In this paper we draw a picture that captures the increasing interest in the format of modular synthesizers today. We therefore provide a historical summary, which includes the origins, the fall and the rediscovery of that technology. Further an empirical analysis is performed based on statements given by artists and manufacturers taken from published interviews.These statements were aggregated, objectified and later reviewed by an expert group consisting of modular synthesizer vendors. Their responses provide the basis for the discussion on how emerging trends in synthesizer interface design reveal challenges and opportunities for the NIME community.

Author Keywords

Modular Synthesizer; User Interface; Social Impact

CCS Concepts

•Human-centered computing → Haptic devices; User interface design; Interaction design theory, concepts and paradigms; *HCI theory, concepts and models;* **•Social and professional topics → History of hardware;**

1. INTRODUCTION

Over the last ten years a constant growth of the interest in modular synthesizers (short: modulars) could be observed (see Figure 2). New specialized companies were set up, dedicated to this format, trade fairs (Suberbooth, KnobCon, SynthFest) appeared all over the world to give a wider audience access to this previously relatively unknown/forgotten technology. But where does all this interest come from? Contrary to our Western mindset of progress and consume-fixation, where typically new technologies surpass outdated ones, it now seems that musicians are actively choosing regression. They prefer limited devices as analog synthesizers over the more flexible machines they use everyday such as PCs and smart/mobile devices. At first glance this may seem illogical or even paradoxical - like a step back on the ladder of evolution - but comparable with Darwin's finches, who developed highly specialized beaks or with dwarf elephants who lost their body size (allopatric speciation), we as musicians also adapt, consciously or unconsciously, to internal and external influences (needs vs. zeitgeist).

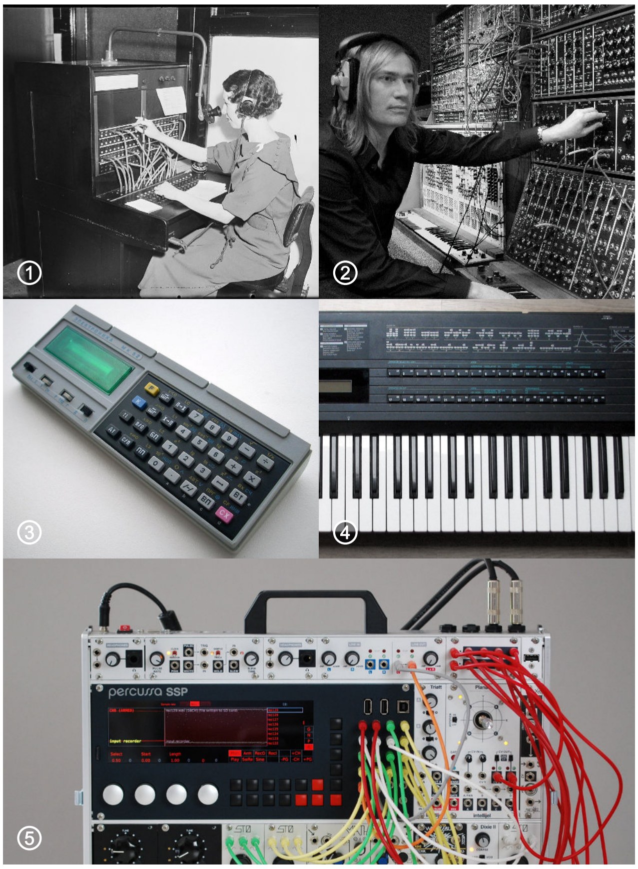

Figure 1: From the synthesizer's advent until today one can see the influence of at that time current technologies: from the switchboard workflow over calculator style button based systems to large displays, peripheral interfaces and processor powered DSP engines. | ① Harris and Ewing "Woman working at switchboard" (1935). loc.gov ② paultench "Benge Portrait" (2008). wikimedia.org ③ Yordan "Elektronika MK-52" (2009). wikimedia.org ④ Speculos "Yamaha DX7s" (2013). wikimedia.org ⑤ Percussa "percussa SSP" (2018). percussa.com

What requirements do modulars meet, not being covered by today's mainstream music technologies? What can we as designers/developers learn about the fundamental processes that define how musicians want to perform with digital/analog technologies. The following aspects are discussed:

What societally and technological influences have led to shifts in importance of music technologies over the last six decades? A historical summary is given.

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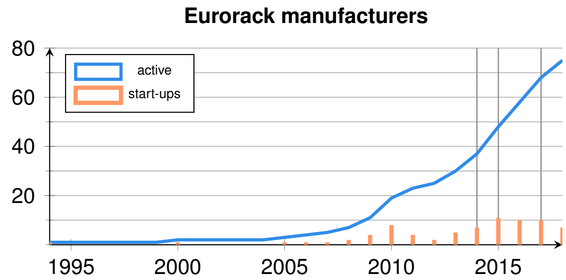

Figure 2: The number of active modular synth companies has been growing rapidly since 2010. We have collected data from 75 vendors and compiled a list of 190 active companies. The entry of Roland, Moog and Behringer is highlighted by the vertical gray lines in the named order.

What motivations drive musicians to choose modular synthesizers for live and studio performance? 35 manufacturers were interviewed to check statements, mindsets and mentalities of such musicians for their conformity with a wider community.

What can we as designers, researchers and developers do to learn from this development and create concepts, ideas and tools for the musician of tomorrow?

In summary this paper contributes to the community by capturing the current state of cultural and social impact of modular synthesizers and provides starting points for research and design experimentations based on these insights.

2. A HISTORY OF THE MODULAR

With the advent of broadcast technologies in the first half of the 20th century (radio, telephone), engineers and inventors began to apply their new knowledge to the field of music in order to solve contemporary problems. The amplification of the voice and of acoustic instruments in the context of ever louder live music [12] as well as the creation of new instruments, that support the low frequency spectrum of bands, led to new artistic expressions [13] as well as creative possibilities. Soon they realized that they could use the same technological building blocks, they already used for amplification and sonic manipulation of real world noises, to generate new, to this date even unheard, sounds.

2.1 The Rise

The brake through of such sound generators came with the industrialized manufacturing of transistors [5] which replaced the tube as the former key building block of electronics and led to cheaper, smaller and more durable devices. As two pioneers of audio synthesis Robert Moog and Donald Buchla [21] independently developed synthesizers on the East and West Coast of the United States in the 1960s.

Although both systems were able to generate sounds both used different technological approaches as well as mindsets for their machines. Moog focussed on subtractive synthesis (frequencies are dampened/removed from harmonically rich waveforms such as square waves) whereas Buchla designed additive synthesizers (harmonically pure waveforms such as sine waves get sonically enriched by folding). As different as their synthesis techniques, they designed completely different interfaces for controlling their sound generators.

Where Buchla designed new interface paradigms to open up musicians' minds (sequencers, logic an trigger modules leading to algorithmic compositions), Moog identified the musicians' need to find familiar input methodologies (keyboard: see Figure 1.2) to ease the entry to the easily overwhelming possibilities of audio synthesis. Moog's approach led to a huge commercial success and helped to establish the synthesizer in popular music. The influence of Buchla's machines is still present in generative and experimental electronic music [8] today. Both approaches are indeed different in the way they are played and controlled, but similar in the way the signal flow is patched. With patch cables musicians could route the audio signals and control voltages (CV) of basic modules (VCO, VCF, LFO, ENV, VCA). The same set of modules opens up nearly infinite routing variants to constantly generate new sounds, melodies, or noises. The patching approach was inspired from switchboards (see Figure 1.1) popularized through the telephone. Jacks for injecting CV and knobs/faders for manually entering such voltages were the interface of choice [3].

2.2 The Fall

The fall of the the analog modular began with the advent of polyphonic synthesizers and portable consumer products (Minimoog[1]) [20]. Beside the advantages of analog synthesis, this technology also had some drawbacks. Analog circuitry needed heat up time to hold tune and even after preheating, the synthesizers' tune still drifted causing problems during live performances or recording sessions.

Further, building polyphonic modular systems was expensive and space consuming. The production of chip sets that performed as VCOs, VCFs and VCAs helped to build and decrease the costs polyphonic instruments. These products came internally pre-patched and in smaller packages than modulars. They contained key-beds, control wheels and well designed user interfaces, had fewer sound design capabilities as modulars but convinced due to simplicity and convenient handling. Patch bays and jacks for injecting CV and audio disappeared from synthesizer's control surfaces. Faders and knobs were the interface of choice [2].

The development of the FM (frequency modulation) technology for broadcasting applications in the 1930s opened up a new method of sound synthesis in the 1980s. The digital implementation of FM synthesis done by Yamaha in the 1970s led to synthesizers (DX7: see Figure 1) which convinced with sounds that could neither be produced by additive nor by subtractive synthesis [6] and brought tuning stability and sound presets to further ease synthesizers' handling. FM synthesis positioned itself as the defining sound of the 80s and outperformed analog systems in price, polyphony and stability, therefore contributing to the decline of analog synths which were displaced to large studios or collectors. Personal computers, calculators (see Figure 1.3), digital watches and game consoles made their way into the homes of thousands of families in the 80s and made digital products and sound sources prominent in the consumer market and in listening habits. This opened up the advent of Digital Signal Processing (DSP) [26]. Interfaces of digital synthesizers adapted to current technologies. Faders and knobs were mainly replaced by buttons and displays.

2.3 The Renaissance

With computers becoming ubiquitous, powerful and thus indispensable the computer today often totally replaces physical gear. Software instruments, virtual emulations of iconic equipment and music applications offer independence of music hardware. Advantages are space and portability related, a reduction in price leading to better accessibility for new societal groups but mainly of practical nature with features as preset managing and handling the whole process all in

[1] Sophie Weiner: redbullmusicacademy.com

one box (recording, mixing, mastering, performing). Algorithms can replicate the entire range of common synthesis techniques [28] and even offer new ones (granular synthesis [23]). Thus, the computer itself becomes the instrument[15].

One could assume, that future improvements would focus on hardware optimization, miniaturization and algorithmic improvements. But since the early 1990s, contrary to this assumption, a renaissance of modular synthesizers can be observed triggered by the brand Doepfer that defined an accepted standard (Eurorack) for dimensions and voltage levels to make modules of different vendors compatible.

As reasons for the format's success the following points can be cited: The reduced form factor and the use of common hardware components decreased the price and thus improved accessibility. The compatibility of modules made by different companies opened up combinations of several synthesis mindsets and increased the sound diversity. Cheap micro controller chips, able to perform DSP, enabled new concepts, possibilities and thus designs of modules fertilized by the parallel developments in mobile phone technology and electronics. Accessibility of parts, algorithms and knowledge supported the emergence of DIY and Open Hardware communities in the synthesizer niche and the creation of high end music computers fitted into the Eurorack standard (see Figure 1.5).

3. IMPACT ON NIME DESIGNS

The historical developments as well as techno-cultural trends presented here naturally had a lasting influence on the NIME community from the very beginning. Surges [27] explored the augmentation of analog modular systems by connecting them to computers and control their parameters with a provided tools-set or Mayton et al. [16] experimented with connecting modulars to global networks enabling multi-user access and remote control of these systems. Further, Böttcher et al. [4] reused interface elements such as patch-points for controlling virtual physical modelling synthesizers and experimented with different input modalities. In the same way, Mann et al. [14] took step sequencers, transferred them to everyday objects such as toys and thus created tangible musical interfaces. On the highest level of abstraction we find many interfaces conceptually based on modularity in the sense of block-wise representation of musical tasks. Most prominently, with the reacTable [10], users can construct with elements that represent VCOs, VCFs, and others, as discussed earlier. Block jam [19] and AudioCubes [25] both explored tangibility and modularity of musical interfaces from early on. Other interfaces [9, 11] explore in Buchla's tradition new ways of interfacing with and especially sequencing audio generators.

4. WHY TO MODULAR?

To better understand the individual reasons why musicians tend to choose modulars for music performance, we designed a methodological process to converge from subjective opinions to objectified statements. This process helps to define user needs and to identify design challenges/opportunities.

In our study, we interviewed manufacturers of modular synthesizers and confronted them with statements from musicians/manufacturers. One can argue that manufacturers have a different perspective and therefore cannot evaluate the reasons and goals of the artists, but we see this as the first step in evaluating the matter with musicians from around the world, with different factors and needs. Currently, manufacturers represent a homogeneous group of people who are involved in the modular community and who are or have been users themselves.

Figure 3: In the 19th century artist left their ateliers to directly work in the nature. Today musicians leave their studios/homes to find inspiration in remote spots, perform there and generate music from it. | ◐ J.S. Sargent "Claude Monet Painting by the Edge of a Wood" (1885). Oil paint on canvas. ©Tate, London. CC-BY-NC-ND 3.0 (Unported). tate.org ◑ modular on the spot "Modular picnic in LA" (2016). instagram.com

4.1 Method

Our methodological process is divided into the following three steps: *subject collection*, *statement collection* and *statement evaluation*. To collect statements of many active musicians we analyzed publicly available resources in our case interviews published on video platforms. An important factor in ensuring consistency is the definition of and compliance with guidelines on the selection of information to be used. We committed to using videos published from one music journalist collected in a podcast series[2] to guarantee thematic stringency. In the course of the episodes musicians and manufacturers talk about their background and connection to the format as well as their experiences and practices with modular synthesizers.

Out of that pool of ten interviews covering roughly 17,5h of video material we transcribed statements concerning the musician's **benefits**, their **workflow** and **experiences** with modular synthesizers. We used Affinity Diagramming [1] to further condense the collection by aggregating statements concerning the same message into a generalized statement. Four categories were used to structure these statements into cohesive groups. The following categories were used based on the research experience of product development performed by a partnering company: *Social Connection*, *Inspiration and Improvisation*, *Simplification and Focus*, *Creative Control and Transparency*.

Five general statements were collected for each category. To show a broader validity of the statements, an expert group consisting of 35 modular synthesizer manufacturers was used to reflect upon these. The questionnaire contained 20 statements which had to be judged using a 7-level Likert-scale (ranging from -3, which means "totally disagree", to +3, which means "totally agree"). Some items were randomly inverted to avoid biasing the participants during the process. As the items of interest, we defined the ones where participants consistently expressed high/low agreement or the items that polarized and thus led to spread responses.

4.2 Study Subjects

The 35 participating manufacturers divide into one female and 34 male participants. On average their age is about 41 years (24-63 yrs) and they had about 21 years (5-44 yrs) of experience with electronic musical instruments. Their experience with modular synthesizers averages around 11 years

[2]Mylar Melodies: whywebleep.com

ID	Statement	IQR	m
S1	The closeness of the modular community supports me as a musician.	3	1
S2	The modular/customizable aspect creates an emotional connection between me and the instrument. I am much more attached to something that I made myself.	1	3
S4	Everything is moving more and more in the direction of personal computers. Everything is in the box. I work on the PC every day, answering e-mails, editing tables and so on. This makes me feel under pressure to perform when playing music on the PC.	3	0
S5	I think people don't realize the difference if the music I perform is improvised or not.	4	0
S7	The hardware aspect of modular synthesizers does not encourage me to experiment.	1	-3
S9	The usage and control of randomness introduces a bidirectional creative feedback loop between me and my instrument.	1	2
S12	I don't think the aim of developing digital modules is to make them easy to use. Screens, submenus and hidden functions are good ways to pack as much functionality as possible into a module.	3	-1
S14	I can design my system to be my own musical easel.	1	2
S16	I don't find it more enjoyable to have a physical interface to play with then a virtual one.	1	-2
S17	With modular synthesizers I find it hard to think music. Compared to classical instruments as e.g. the guitar where I can predict the outcome of my play.	3	-1
S18	I find it much more enjoyable to have a physical interface to look at.	1.5	2
S20	By introducing shift buttons or alternate functions of buttons, immediacy does not get lost in the interface.	3.5	0

Table 1: 35 Eurorack-manufacturers evaluated 20 statements with a 7-level Likert-scale (-3, +3). The inter quartile range (IQR) was used as a measure of clustering around the median (m). Items of very high cluster ($IQR <= 1.5$) or high spread ($IQR >= 3$) are shown above. The full questionnaire and the results can be viewed at https://goo.gl/forms/HYY7cI99w3bRsPrS2.

(2-44 yrs) and they have been running their companies for 6 years (1-27 yrs) on average. All participants agreed that their data is used anonymized for scientific publications.

4.3 Anaylsis

In the following section the items of the questionnaire, which provoked the highest polarization (see Table 1), are analyzed. As a measurement for the responses' spread we used the interquartile range (IQR) [17]. It shows the grade of cluster thereby low values indicate high clustering whereas high values indicate high spread of the responses around the median (m). By choosing thresholds we excluded some statements from closer examination.

4.3.1 High Cluster

The items **S2**, **S7**, **S16** and **S18** were related to the hardware aspects of modulars and focus on the emotional connection people create to physical objects (**S2**, **S16**, **S18**) as well as to their inviting character which fosters hands-on experimentation (**S7**). Both aspects are important factors differentiating virtual from haptic real-world objects. Instruments have a long tradition as design objects and some musicians build up really personal relationships to their instruments. The tactile experience of a physical object combined with the creational aspect of realizing musical thinking in building a modular system also support this bonding.

The aspect of a modular system as a creative tool is present in items **S9** and **S14**. **S9** is concerned with the idea of a modular system being a creative partner in the performance context. By introducing randomness and algorithmic patterns, musical ideas arise that musicians typically not think about. In this way, the system becomes more of a partner rather than a tool. Musicians can design their systems to be the assistance they need (**S14**) or to be the empty canvas they want to create music with. Either way, the system becomes an extension of the musician helping to compensate or to realize.

4.3.2 High Spread

Items **S1** and **S5** are both concerned with social interaction. First, in the context of musician-audience interrelation (**S5**) and second, in respect to musician-musician interrelation (**S1**). Both statements are traceably controversial, thus e.g. learning from and with others is mainly dependent on character features like openness and extraversion [7] and not on the used platform (digital vs. analog, pc vs. hardware). The same goes for the musician-audience interaction. However, the high dissent shows that some manufacturers believe in the idea that improvisation based live sets can create strong emotions that transfer to the audience.

Item **S4** is concerned with the statement that the PC as a tool creates pressurizing expectations. The underlying consideration is that productivity, workflow and speed experienced in every day work and social interaction have an effect on musician's subconscious expectations when performing music with such machines. Software used in music production today is a likewise optimized tool to support productivity. A growing number of musicians want to slow down when making electronic music and explore creatively instead of pursuing concrete goals, comparable to taking a short break and jamming on a guitar. Apparently, this is dependent on the person, its objectives and the context. A trend you can follow on social media is the exploitation of nature by electronic musicians such as jamming in the woods or in other remote spots. This can be compared to the art movement *En plein air* where artists left the ateliers to capture their motifs directly in nature (see Figure 3).

Different mindsets about modular synthesizer interface design are questioned in item **S12** and **S20**. A lot of synthesists are analog purists and refuse even the slightest digital influence in the modules they use. Topics like the usage of screens/ displays (**S12**) to pack more layers of functionality into such modules are highly discussed. Even the introduction of shift buttons (**S20**) to give access to alternative functions is sometimes a momentum of disruption for some musicians. Comparable to "what you see is what you get" exists the idea of "one knob per function" in the context of music interfaces. For a lot of people this is the optimum way to design and control synthesizers because everything that can be controlled is always controlled by the elements you see on the instrument. Others instead strive for flexibility and variety in their modules and therefore accept increased complexity and reduced directness as a consequence.

High disagreement under the participants was also provoked by item **S12** which stated the difficulty for musicians to picture musical outcomes or to translate musical ideas into sound when performing with modulars. This statement is related to the context of comparing synthesizers to acoustic instruments. Experienced instrumentalists can "think" music before they actually play it based on the instrument's (guitar, piano, etc.) physical behavior, their experience and motor memory. Synthesizers and especially modulars are harder to predict partly because of their "re-patchability" and further because of the often-used complex synthesis techniques. Even a small set of modules can generate a wide palette of sounds and are not controlled as direct as acoustic instruments because additional control-layers (sequencers, etc.) separate musicians from their instruments.

5. DESIGN CHALLENGES AND OPPORTUNITIES

Condensed from the previous section the following aspects help to define design challenges worthwhile for the NIME community to consider:

Object Character: What musicians appreciate about modulars is the immediacy the instrument has as an object. Turning it on, twisting knobs and patching cables happens instantaneously. Further they enjoy to touch, to watch and to care about the instrument.

Personalization and Flexibility: Identification with these instruments happens based on the effort people put into their systems during the design and assembly. Making the instrument their own based on the needs and preferences they have and condensing the possibility space down to a personal and flexible solution.

Instruments as Creative Extensions: The modular synthesizer becomes more than just a tool for most synthesists. From a blank canvas to a supportive environment, it can be anything a musician imagines.

Experimentation and Randomness: By creatively exploring the capabilities of a system and working with sources of uncertainty the musician positions themself as an explorer. Musical outcomes are thus results of discovery voyages instead of plain fixated work.[3]

Directness: The dividing factor between acoustic and electronic instruments is the directness between input and output. Interaction with acoustic instruments generates direct results based on the interwoven sound determining factors whereas audio synthesis recreates this interrelation and often limits the interaction to an indirect parameter level.

Individualism and Uniqueness: The modular, with its patchable signal flow, not only offers huge flexibility and thus possibilities for sound-design, but also force the musician to go beyond presets. The absence of presets to recall custom or factory sounds or to save them for later use

[3]Philip Sherburne: pitchfork.com

Figure 4: COMB acts as a typical step sequencer, beside that instruments are selected by changing the interface's shape. (COMB on vimeo)

pushes the synthesist to ever new territories. The other way around, it is also harder for others to replicate, therefore it is a good choice if one aims for unique and individual results.

Further trends that were addressed in some of the statements and their analysis above but are even more present in social media and online communities are:

En plein air: The studio as the main place of creation is extended by musicians making music on the go (downscaled, light weight, self-contained). Electronic musicians are thus empowered to exploit nature and remote places to perform, create and capture music. Nature is incorporated dialogue-like into the process.[4]

DAWless: The computer is rationalized from setups as the source of control. The modular moves towards being a highly specialized Digital Audio Workstation for its owner.[5]

DIY and Open Hardware: The DIY and open hardware culture [22] acts as a fertilizing factor. Now, the community itself becomes the innovation and driving force replacing the big players. Creative minds are empowered and supported through divided knowledge and open resources to create new modules. The accessibility of DIY kits acts as an entry to the domain of electronics and as a pool of inspiration.

6. DISCUSSION

Considering our investigations in retrospective we acknowledge that many of the previously mentioned concepts are already part of the NIME community's spirit [18]. Building upon these concepts, we focus, in our own research, on *explorability*, meaning playful interaction as well as on the incorporation of haptics for instance of shape as an input method. Here, our modular interface COMB [24] allows functionality changes by reconfiguring the shape of the modular interface inspired by children's play with building blocks (see Figure 4). The main opportunities we have right now as user experience designers are based on the new openness consisting of user's desire for exploration and their will to participate in the design and development process.

The challenges we have to tackle consist of giving our interfaces relevance in everyday situations. Direct and immediate use as well as feedback are the core of a close and persistent musician-instrument relationship. Flexibility and personalization of instruments, not meaning to superficially mimic modulars by adopting patch points and CV capabilities but offering highly customizable solutions to open up great potential for creative and artistic evolvement. Portability and independence from PCs will allow for new free and experimental use cases and freedom in when and where electronic musicians perform their music.

[4]instagram: @annannie, @modularonthespot, @lightbath
[5]instagram: #dawless

Benefits and Limitations: By providing our results we acknowledge that we have only selected a small sample size in specific regions of the world to conduct our research survey on Eurorack manufactures. Hence, it would be too far fetched to summarize our insights as general global trends. On the other hand our research findings reflect reoccurring patterns of manufacturers thoughts and actions which all share similar goals: supporting a physical interface experience when experimenting with electronic music generated through synthesizers. We conclude that there is a real user need that is fueled by both active musicians that take pleasure in using a more expressive and emotional stimulating physical medium instead of interacting solely with screen based interfaces and hardware manufacturer that correspond to this user need by providing suitable hardware solutions. In our ongoing and future research work we will therefore address these circumstances by experiments with flexible and modular interfaces that could provide further usability advantages in this domain.

7. CONCLUSION AND FUTURE WORK

In summary we have reported on the evolutionary and contemporary turn in the development and utilization of analog modular synthesizers. We consider the current device development of many manufactures as a strong indication for a return of *tactile experiences* in this domain reflected by the interface components losing their pure digital nature. In the near future we aim at further substantiating our research through insights and prototypes. An extension of our survey focussing on musicians will address the next phase of tackling persisting questions in this domain. Further, the reduction in component costs of sensors and display materials (e.g. flexible display solutions) provides an extension of the design space and includes items (flexible physical interfaces) we will take in close consideration for our future interface explorations.

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