

From Prototyping Platforms to Delivery Platforms

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Physical interaction technologies are popular in HCI research, yet have struggled to reach consumers. I argue that one reason is the lack of a platform – not for prototyping, but for *delivery* of physical applications. Analogues can be drawn to previous successful platforms such as the desktop computer and the smartphone, which worked as a standardized vessel for a multitude of different applications.

CCS CONCEPTS • Human-centered computing~Human computer interaction (HCI)~Interaction paradigms • Human-centered computing~Ubiquitous and mobile computing~Ubiquitous and mobile computing theory, concepts and paradigms • Human-centered computing~Human computer interaction (HCI)~HCI theory, concepts and models

Additional Keywords and Phrases: Physical user interfaces, tangible user interfaces, prototyping

1 INTRODUCTION

Physical user interfaces are very popular in HCI research, and there have been a large number of compelling prototypes presented at CHI and other conferences. A literature review shows that there are over 3800 ACM-published papers on tangible interfaces alone, and Ishii and Ullmer’s 1997 paper on Tangible Bits is the most cited CHI paper of all time. [3] However, the abundant research interest is not matched by a corresponding quantity of real-world consumer applications. While for instance mobile phones and touch-screen interfaces have taken off to the extent that they are used by billions of people, the number of physical user interfaces in everyday use is still low. The successful examples that can be found seem to be limited mostly to bespoke installations in museums or galleries, rather than reaching a larger audience.

I have previously argued [3] that one reason for the lack of impact of tangible user interfaces is because they are based on atoms, which are inherently *expensive*: to create; to control; to modify; to maintain; and to mass-produce and distribute. Conversely, bits (as in code or pixels) are cheap, modifiable, and offer endless dynamic possibilities for input and output. At the same time, I acknowledge the value of physical and embodied interaction, and would like to see a combination of “the best of both worlds”, rather than one or the other. In this paper I will discuss what can make the deployment of physical user interfaces potentially more efficient and impactful, by moving the focus from prototyping platforms to delivery platforms.

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2 MY BACKGROUND

The very first academic conference I attended was CHI 97 in Atlanta. I was there with a poster about a focus+context visualization technique called Flip Zooming, which was developed to give both overview and detail when viewing large amounts of text (e.g. webpages, which were starting to take off at the time) on a computer screen. [4] All HCI research at my department was focused on standard GUI interfaces and visualization on desktop screens.

At CHI I discovered a very different world of HCI, involving much more of the physical world. I met researchers and saw presentations on the internet of things, ubiquitous computing, and, most memorably, tangible bits. [5] Much of this seemed to come out of the MIT Media Lab, and by good fortune I had already arranged to visit the lab right after CHI, getting further exposure to this innovative meeting of bits and atoms. Soon after, I became involved in mobile computing and attended the first workshop on Handheld and Ubiquitous Computing, HUC 98, which would transform into the Ubicomp conference, still being organized today. During this stage of my research, I focused on building mobile and tangible interactive applications, almost always constructing the hardware from scratch, as there was no readily available mobile platform. With the introduction of more capable smartphones and PDAs it slowly started to become more feasible to create mobile software. However, although Java was promised to be a universal platform for smartphones, in reality it was nothing of the sort: Every application had to be tailored to every phone model, leading developers to have to test on literally hundreds of hardware configurations for every software release.

This all changed with the introduction of the Apple iPhone and the accompanying App Store. This (and the Android platform that came soon after) suddenly made it possible to create mobile applications and distribute them to millions of users. This led to an explosion of new application ideas, and to phones becoming a new viable venue for commercial software distribution. It is a certainty that phones would not have taken off and become as popular as they are now if it had not been for third-party software being readily available. This is not surprising; it is analogous to the success (or failure) of a multitude of previous computing platforms, from the Apple II to PlayStation 5, all of which would have fallen by the wayside without productivity software, games, social media, and other applications and services.

3 DEMOCRATIZING PROTOTYPING

In contrast, despite the interest from the research community, physical interaction devices have had comparatively little consumer and commercial impact. When researching a number of research-based startups based on the concept of tangible interaction, I found that all of them had folded. [3] One reason may be that producing and testing applications in hardware is more difficult than software. As a way to make physical interaction more accessible, the research community has therefore given considerable attention to prototyping. The reasoning has been that if we make it easier to create applications, it will lead to a greater number of potentially successful prototypes, and ultimately products that can make its way to industry or consumers. Already, popular platforms such as Arduino, Raspberry Pi, and other toolkits have greatly reduced the effort required to create and test fully working prototypes, although they generally are not scalable to consumer applications.

There are a number of components required for making prototyping and production of hardware applications more accessible, but one common thread is that the transition from small-scale prototype to mass-market product is still difficult. Mankoff et al [7] showed that fabrication technologies such as 3D printing could enable the production of more personalized physical devices, particularly for disabled or otherwise marginalized users. However, to empower end-users requires more accessible design and production tools. [ibid.] Hodges [1] argued that the transition from the prototype phase to production is still complex and costly, and suggested support for low-volume production and scaling to mitigate this. However, as Khurana and Hodges note, [4] there has still been little work on proceeding from prototype to product in the

research community. They interviewed 25 people with experience in low-volume production, and identified a need for new tools and processes to support the transition from prototype to product. Finally, Hodges and Fraser [2] call for a “citizen manufacturing” approach that would support the transition from prototype to product. They envision a more organic approach, where the prototyping stage naturally leads to scaling for further evaluation and early adoption.

4 FROM PROTOTYPING PLATFORMS TO DELIVERY PLATFORMS

As noted above, prototyping only captures one half of the problem. Even if we prototype the greatest and most user-friendly physical application ever, it has little value if it cannot reach users. But rather than making the transition from prototype to bespoke hardware product easier, it may be better to re-think the nature of the end product. As noted, earlier platforms such as the desktop computer and the smartphone not just made it easier to produce software, they also provided a vessel for that software to reach consumer. For instance, the Apple Appstore created an explosion in innovative mobile applications. But this success was completely dependent on there also being enough end-users who were already in possession of the appropriate hardware to run these apps. Looking at the suggestions above to democratize hardware production, they all still involve producing a new piece of hardware for every user. To be somewhat pointed, the equivalent of this approach for smartphones would be to require the purchase of a *new device* to every user for *every new application*, which is clearly not scalable.

I argue that this is the time to look at the other side: what I call the *delivery platform*. What is the analogue of an iPhone or Windows PC for physical user interfaces? How can we possibly design a platform that can enable an embodied and tangible user experience, but is flexible enough to be adapted for a multitude of different purposes? And how can this platform be distributed and made accessible to not just a few developers, but to large groups of end users as well? This would sidestep the problem of having to transition from prototype to product hardware, as the hardware would already be in the hands of the consumers.

5 CONCLUSION

Creating a new delivery platform for physical interaction is a daunting challenge and I do not yet have the answer. My own approach would be to look at the low cost, flexibility and dynamic properties of pixels, and combine them with the physical world, something I call *liberated pixels*. [3] Such pixels need to be perceivable, addressable, and persistent in the physical world, properties which current systems do not yet achieve. The closest that current technologies come to this may be projected augmented reality systems, such as the proposed *I/O Bulb* [10] or the *Everywhere Displays* approach. [8] There is also recent research into making actual display elements more flexible and more configurable in their own right (e.g. [9]) but this again may require access to a bespoke hardware platform that may not be easily accessible. However, this is just one way forward. Other technologies, such as shape-changing interfaces, metamaterials, or even head-mounted virtual/augmented reality may also take us closer to this goal. In any case, I believe it is vitally important to take this step now, because no matter how compelling physical user interfaces can be, it will be nigh on impossible to have any real impact and reach users before there is an affordable and accessible way to deliver the experience to everyone.

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