12Pixels: Exploring Social Drawing on Mobile Phones

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Abstract. In this paper we present the design and development of *12Pixels*, a novel interface, application, and social web service that allows people to create and share drawings directly from a regular mobile phone. We detail the release of *12Pixels* as a service in Japan and analyze trends that emerged from user data collected. Our analysis and insights provide useful ground-level experiences with social drawing and mobile content creation.

Keywords: *12Pixels, twelve pixels, drawing, mobile phone, cellphone, art, design, creativity, creativity support tools, content creation, user generated content, social web, web applications*.

1. Introduction

In recent years there has been an explosion of tools and services facilitating everyday creativity. The shrinking size of digital devices such as digital cameras and mobile computers has allowed people to create content at any time and any place. At the same time the proliferation of the internet has supported the distribution of people's creations and lead to a creative boom of 'user generated content' and 'social web' services. The user generated content model brings a ground-up approach to content creation and marks a profound change for computer users and society as a whole.

Despite the growing interest in online content creation, studies have shown that overall time spent with media in the home has not changed significantly for young people since 1999 [1], and has shown overall declines in the three years till 2009 [2]. Any desktop based tool for content creation therefore competes with a large variety of traditional media for an increasingly smaller slice of our free time. However, the ubiquitous availability of modern mobile phones makes them an ideal device to be used for creative means. Current mobile phones are powerful, rich in functionality, and network connected – they have become an important ingredient of everyday culture. Designing interfaces and applications that allow people to create and share content on the mobile phone is an important and crucial direction for pervasive computing technology.

In this paper we present the design and development of *12Pixels*, a novel interface, application and social web service that allows people to create and share drawings

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directly from their mobile phone. The project began at Sony Computer Science Laboratories in 2007 with the question: *'How can we enable people to better express themselves with mobile phones?'*. We observed that while most standard mobile phones offer rich text and camera capabilities, they lack the fundamental ability to draw and communicate pictorially. The goal of our research was to develop a native drawing interface for the mobile phone (Figure 1).

Figure 1: Drawing on a mobile phone with *12Pixels*.

We chose to design a drawing interface for traditional keypad-based mobile phones. The emerging popularity of touch-screen based mobile phone interfaces, such as those found on *iPhone*, has re-introduced many desktop computer drawing techniques onto mobile devices. However, in spite of growing popularity, such high-end 'smart phones' still account for a surprisingly small segment of global mobile phone users. According to recent reports the *iPhone* is still used by less then 1% of users world-wide [4] and has had particular difficulties in Japan where the *12Pixels* project is based. Therefore, developing tools that allow truly everyone to be creative means developing tools for the traditional mobile phone – a challenging interface problem. The design of a unique interface for drawing on the standard mobile phone is the first important contribution that we report in this paper.

12Pixels was released in Japan to the general public as a social web service that allows drawings to be created, shared, and remixed by a wide range of people using a standard mobile phone. *12Pixels* was the first mobile web service for 'social drawing' and we introduce this system as the second contribution of this paper.

By releasing *12Pixels* as a public service we saw it as an opportunity to evaluate our design approach, learn more about our users, and iteratively evolve the system as a whole. Would people be interested in drawing on a mobile phone? Would they be prepared to contribute and share their drawings? What type of drawings would they create? When they would create them? What kind of functionality would be desired?

Although our designs were informed by a range of user observations, the questions above could only be answered by releasing the application and analyzing usage patterns and content from real users. We present analysis and evaluation of the real-world deployment of *12Pixels* as the third unique contribution of our paper.

The remainder of the paper is organized as follows. In the next section we discuss related work and present a summary of content creation and drawing applications for the mobile phone. We then take a detailed look at the *12Pixels* drawing interface and social drawing service, and explore some of the design decisions behind its development. We next analyze important trends that emerged from user data collected during the release of *12Pixels* in Japan, and reflect upon the success of the project. We believe that our analysis and insights have implications beyond the context of drawing and can inform designers and developers in creating richer and more engaging tools for mobile content creation. Finally we discuss future work and identify the most promising research directions in this area.

2.   Related Work

Tools that facilitated content creation on mobile phones were initially very few and very limited in their capabilities. Text based input, available on almost any mobile phone, has been used creatively for some time with everyday communication decorated with text-based icons called 'emoticons'. In Japan, text-based emoticons are referred to as *kaomoji* (face characters) and progressed from simple character combinations to increasingly complex designs expressing a wide range of emotions (Figure 2).

Figure 2: A large variety of *kaomoji* (text based emoticons) has been invented in Japan by mobile phone users and are actively used in text-based communication.

Emoticons have not been the only venue for text-based creative expression on mobile phones. '*Keitai shosetsu*' (mobile phone novels) were born in Japan as a new literary genre; each chapter is written on the mobile phone and then distributed via text message. Mobile phone novels have acquired such popularity that in 2007 four out of five top novels sold in Japan originated on the mobile phone [5]. The exact reasons for the popularity of these novels is debated, however it is worth noting they possess qualities unique to the mobile phone and are not easily replicated on the printed page.

Similar to text, mobile photography has become another popular venue for self-expression. Typical services include photo messaging, photo-based mobile blogging, online photo sharing, and mobile photography competitions. Mobile phone music creation has been the subject of isolated research and design projects and impacted

users most in the form of ringtone creation applications. The Digital Minimo D319 handset, released in Japan in 1996, was the first handset that allowed users to compose their own ring-tone melodies. What followed was a brief period of popularity with the release of numerous books listing the ringtone notes of popular songs [6].

Perhaps the earliest attempt at implementing drawing functionality on the standard mobile phone, is the *Draw Picture* application provided on the Sony Ericsson T68 from 2001 onwards. The mobile phone keypad is used to move the pen and draw in a 'turtle graphics' style with imagery saved as monotone bitmap files. The *CONTE* (Canvas ON mobile TElephone) drawing tool developed at Shizuoka University [7] in 2002 was the earliest academic exploration into drawing on a standard mobile phone. As well as offering 'turtle graphics' style pen controls, CONTE also provided more advanced functionality such as stamps, text input, online album upload, and drawing playback. Further work on the *CONTE* system introduced a technique for drawing curved lines using the standard keys of the mobile phone [8]. While both *Draw Picture* and *CONTE* explore interfaces for drawing on the mobile phone platform, they borrow heavily from existing pointer-based interfaces where the user typically creates marks using a pen or mouse. Standard mobile phones do not typically support this form of interaction, making control of the pointer with buttons cumbersome at best. These projects also pre-date the emergence of user generated content and the social web, and therefore do not fully explore the possibilities of community driven content creation.

There have since been numerous approaches to drawing on mobile phones using pen-stylus and touch-screen interaction, however, due to our focus on conventional mobile phone handsets we will not elaborate further on these systems in this paper. An altogether different approach is presented in the *TinyMotion* [9] system by utilising a mobile phone camera and computer vision algorithms to allow users to write letters in the air for text input. While not intended as a drawing system, *TinyMotion* does offer a natural form of gestural interaction that lends itself to drawing. However this form of interaction is not always feasible for mobile phone users in crowded or cramped locations. *TinyMotion* also has very specific hardware and software requirements, meaning it can only be used on a limited subset of mobile phone devices.

Recent years have seen the release of a range of more powerful mobile platforms, which have greatly widened the range of tools available for mobile creativity and content creation. Although much excitement has been generated, it remains to be seen how these new platforms can contribute to mobile phone culture and creativity at large. The *12Pixels* project has been firmly grounded in and inspired by our direct experience with Japanese mobile phone culture. We also drew inspiration from the ever-growing popularity of social tools that encourage people to create, upload, share, remix, reuse, rate, and comment on one another's creations. Through our research we attempted to instigate a culture of drawing on the mobile phone in a similar vein to the social web, we label this 'social drawing'. We embarked on the task of transforming the ordinary mobile phone into a social drawing tool, much like a new type of 'digital brush', allowing people to draw with very simple input devices, but express themselves and communicate in numerous ways. In the rest of this paper we present what we were able to achieve.

3. Drawing with *12Pixels*

The *12Pixels* drawing interface has gone through numerous iterations since it was first developed in early 2007 [3]. In this section we present the most recent application currently deployed by the *12Pixels* service in Japan, and highlight some of the design decisions made during the iterative design process.

Jenkins observes that *low barriers to artistic expression* are one of the key requirements of what he labels 'participatory culture' [10]. Tools for content creation are therefore one of the fundamental ingredients of a user generated content ecosystem. Such tools must not only be easy to use, but should be usable straight away without learning, and able to produce immediate results. In the case of drawing, the user should be able to start drawing on the mobile phone just as easily as they do when using pen and paper.

The importance of immediacy is also stressed in a number of disciplines related to creativity. In developing programming languages for children, Papert uses the metaphor of *low floors* and *high ceilings* [11]. Meaning the language should be easy to get started in but still allow for increasingly complex projects over time. Through their work designing construction kits for children, Resnick and Silverman extend this metaphor by introducing the idea of *wide walls* where a wide range of different projects can be created [12]. These were key considerations in designing the *12Pixels* interface to accommodate a wide audience and a range of different usages.

3.1. 12Pixels Basics

The *12Pixels* drawing technique is based on the fundamental idea that each of the twelve keypad keys on the mobile phone can be mapped to one of twelve pixel cells onscreen. Each pixel cell is not a single pixel but rather a section of the drawing area that mirrors the three by four grid of the keypad. As each cell corresponds to a button on the mobile phone keypad, when the user presses the top-left '1' key, its corresponding cell in the top-left of the drawing area is marked out. This spatial relationship between the keypad buttons and the onscreen interface is immediately apparent and understandable for first time users. Figure 3 shows the spatial relationship between keypad keys and pixel cells onscreen.
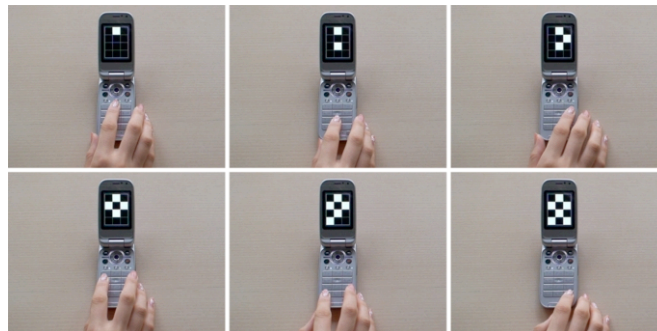

Figure 3: Drawing with *12Pixels*, the buttons of the standard mobile phone are mapped to pixel cells on screen to create imagery.

Similar to other projects within the field of embodied interaction [13] this technique takes advantage of strong tactile cues that the physical mobile phone keypad provides. At any moment the user can find and press relevant keys to mark out corresponding pixels onscreen, relying *only* on tactile feedback i.e. by sliding their fingers over the phone keypad. This is especially important for mobile phone users, as they need to repeatedly shift their attention from the mobile phone to the surrounding environment.

In designing the *12Pixels* interface we also attempted to minimize the number of key presses required when drawing. At any moment the user can select from twelve neighboring pixel cells without having to repeatedly reposition a pointer or cursor. This makes drawing a shape such as a plus sign (+) simply a matter of pressing five different keys on the keypad. Using a pointer-based drawing approach would require an additional six key presses in order to move the pointer then mark each pixel out one by one. The pointer approach also requires significant finger movement back and forward between the keypad and the directional keys.

Our approach also allows users to operate the interface with only *a single thumb*. This is a crucial requirement for any mobile phone interaction as it frees up the other hand for carrying other objects such as a bag or an umbrella, or holding on to a safety railing in the train or on an escalator.

3.2.   Drawing Levels

Spatially linking physical buttons to onscreen interface elements has been used to some degree in existing mobile phone menus and also explored as an interaction technique for previewing information [14], zooming [15], and selecting on-screen elements [16]. *12Pixels* expands upon these techniques to implement a drawing interface with 'levels' that allow incrementally smaller cells to be marked out on-screen for the creation of more detailed and sophisticated images.
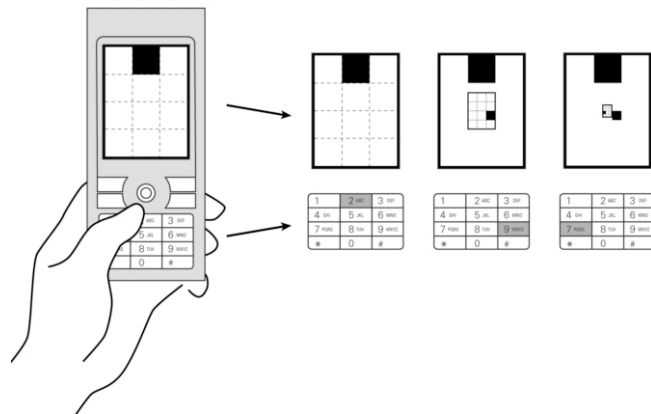

Figure 4: The directional keys can be used to toggle between levels and move the drawing area.

The directional keys of the mobile phone 'joystick' and the center selection key are used to control and navigate through levels. As the user presses the selection key, the drawing area shrinks down a level and can then be repositioned onscreen with the directional keys. Using the keypad the user can then mark out smaller sized cells onscreen to create imagery at a finer scale. Currently three levels have been implemented, with each level becoming incrementally smaller in a fractal like way, as shown in Figure 4. At the top level the drawing area controls the maximum 27 x 36 cell area, with the middle and lower level controlling 9 x 12 and 3 x 4 cells respectively.

3.3. Additive & Subtractive Drawing

Large areas of the screen can be quickly filled to allow drawing using both additive and subtractive methods. It is just as easy to add pixels to a blank area as it is to subtract pixels from a drawn area. Aside from filling each cell individually, the drawing area itself can also be filled with a single press of the clear key. As illustrated in Figure 5, to draw a simple character the user can quickly fill in large areas for the head and body, then mark out finer details such as the eyes, ears, and mouth by subtracting from the drawn area.
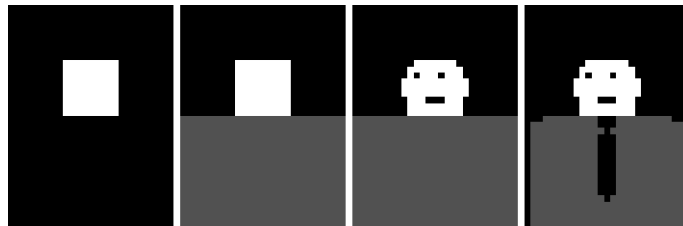

Figure 5: Additive and subtractive drawing with the *12Pixels* interface.

As opposed to traditional drawing, where the artist repeatedly adds color to the canvas, this approach is more akin to sculpting with clay or play-doh. Users can quickly block out key elements before adding further detail. The drawings themselves reflect this process, showing strong composition and contrast.

3.4. Color & Lines

The initial design iteration of the *12Pixels* interface allowed only grayscale drawings to be created. Our motivation was to make the drawing process as simple as possible, akin to sketching pencil lines on paper. However, during the first round of *12Pixels* workshops, color was the single most requested feature. To address this issue we experimented with a number of different designs ideas for adding color in a way that would not impede upon the simplicity of the interface. We explored the use of monotone colors schemes, color blending, and the mobile phone camera to select colors from the physical environment. We decided on using a function key to activate a simple color menu with a preset primary color palette. Shades of color can then be selected by toggling through a sequence of color gradations from dark to light. The

color is then stored so that when marking out subsequent pixel cells the current color is maintained.

In addition to marking out pixel cells using single key presses, *lines* can be created by holding down a keypad key then moving the joystick in the direction desired. The drawing area shrinks down to the size of the single pixel cell according to the level, allowing for lines of different thickness to be created.

3.5. Preliminary Observations

In designing *12Pixels* we strived to develop an interface that could be used almost immediately with minimal time spent learning. We wanted users to begin drawing at once, and learn the more advanced features of the interface, such as drawing with shades of color or lines, along the way.

It is often the case that the developers of tools and interfaces become very proficient in their use, however, what would an average person be able to draw with *12Pixels*? To answer this question we conducted a two month long experiment where the application was provided to members of the general public visiting the Sony ExploraScience centre in Tokyo. The range of drawings produced by visitors to the exhibition was surprisingly extensive and showed a wide range of skill for first time users. Looking at the quality of drawings fuelled our enthusiasm for the project and gave us some valuable insights into the type of drawings people want to create.

We next conducted two workshops at the Science Gallery in Dublin. The aim was to gather direct feedback on the drawing experience, establish ways in which the interface could be improved, and test out the initial implementation of our social drawing service. The first group consisted of 13 high school students aged between 15-16 and the second group were 10 adults aged between 20-40. We began with a simple demonstration followed by a period of drawing time where we observed how quickly they came to grips with the interface. A communal screen was setup so that participants could optionally upload their drawings to be displayed to everyone else. This feature was used heavily in both workshops as participants were eager to share their drawings with one another. Much to our surprise it was common for written messages to be created and uploaded; this proved to be a popular way to use *12Pixels* in both the initial workshops and the subsequent public release.

These early user observations were an invaluable experience and proved to us several important points. Firstly, the Sony ExploraScience exhibition showed us that drawings of high quality and wide creative range could be created by first time users. Secondly, the Science Gallery workshops proved to us first hand that sharing one's creations is a key component of the creative process. These points encouraged us to continue improving *12Pixels* and further develop our concept of 'social drawing'.

4. Social Drawing

Jenkins notes that another fundamental element of 'participatory culture' is the infrastructure for sharing content and building a community of like-minded creators [10]. In this section we outline details of the *12Pixels* infrastructure that share many of the aims outlined by Jenkins to support and encourage content creation.

4.1. Release & Implementation Details

12Pixels was released publically as a free service via Sony Style Japan in March 2009. The Japanese market we believed would be an ideal real-world situation to test both the *12Pixels* service and our ideas about mobile content creation and social drawing.

To date there have been two official releases of *12Pixels* in Japan. The first release consisted of monotone drawing with five differently colored applications available in black, red, blue, green, and pink. Users could select their favorite color to download and draw using its five shades. This approach allowed us to test the core interface design in the field, and evolve the use of color in later releases based on user feedback. The second version of *12Pixels* was released in late July 2009 and implemented full color drawing, along with a range of updated web service functionality such as commenting, ranking, and advanced gallery features.

12Pixels is implemented as a Java-based frontend mobile phone application, with a web server backend used to exchange drawings and information from a central database. Three separate applications are compiled and distributed for the main Japanese mobile networks, NTT docomo, Softbank Mobile, and au by KDDI. Despite recent trends towards install-free web applications for desktop computers, this approach has yet to become a reality for mobile phones. By dividing the functionality between a frontend mobile application and a backend server we gain the superior functionality and reliability of an installed application with online connectivity when needed. In the discussion that follows we present the core features of *12Pixels* that facilitate social interaction between users.

4.2. Social Interaction

The *12Pixels* service offers much of the functionality that has become common in desktop based user generated content web applications. It supports the distribution and sharing of drawings both through formal online services and via user-to-user messaging.
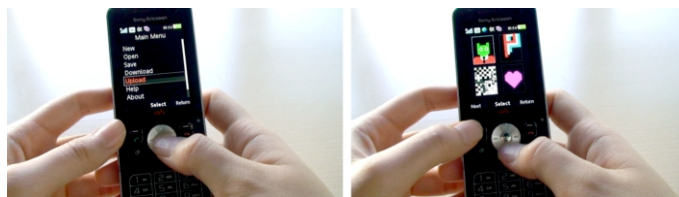

Figure 6: Drawings can be shared by uploading (left) and downloading (right) directly within the *12Pixels* application.

Sharing, browsing, and searching drawings. Drawings created in *12Pixels* can be uploaded with descriptive keywords directly from the mobile phone application. Drawings are then added to the communal gallery on the *12Pixels* server and can be accessed immediately from either the *12Pixels* application or a web browser. From within the *12Pixels* application the drawing gallery can be browsed by date created,

keyword, and popularity rating. When a user finds a drawing they like, it can then be downloaded directly to the *12Pixels* drawing canvas for further editing and remixing (Figure 6). All content submitted to the communal gallery is accessible to all users, and can be freely downloaded and edited at any time.

Commenting and rating. Comments can be added to drawings by browsing to the drawing inside the application and then launching the drawing's comment page in the mobile web browser. This page displays the user comments so far and also allows individual users to rate how much they like the drawing.

Templates and premium content. To showcase the creative possibilities of *12Pixels* we provide a special gallery of 'premium content' created by well known artists and designers. This serves as useful example imagery and a source of inspiration for users. Drawing templates such as speech bubbles, heart shapes, and face outlines are provided as an easy starting point for quick drawings. An additional 'Campaign' gallery is also provided for seasonal drawing challenges and official tie-ins.

Local save. To give drawings a life outside of the *12Pixels* application, drawings can be saved as standard GIF image files. This allows drawings to be utilized for any number purposes including mobile phone wallpaper, address book images, or sending them to friends via e-mail.

Creating emoji. One specific drawing usage for Japanese mobile phones is the creation of custom emoticons called *emoji*. Most Japanese phones have a pre-installed set of several hundred graphical *emoji* icons, but also allow for other custom icons to be embedded in rich-text email messages. We implemented a special *emoji* mode for *12Pixels* where users can create their own original *emoji* straight from their phone. *Emoji* are saved locally to the phones memory and can then be easily added to email for truly personalized communication. Figure 7 shows a selection of *emoji* created with *12Pixels* and an example of rich-text email usage.

Figure 7: A selection of custom *emoji* (emoticons) created with *12Pixels* (left) and an example of their usage in rich-text email (right).

Personal manufacturing. As another way for *12Pixels* drawings to be shared between users a special service was created to manifest drawings into physical form. The 'crystal accessory' service turned user created drawings into custom fashion accessories as shown in Figure 8. By drawing on one of the templates provided, users

would submit their design online to Ginza-based jeweler *Lights Style* and order original crystal jewelry such as dog tags, mobile phone stickers, and key holders.

Figure 8: Drawing with *12Pixels* to create an original accessory.

5. Usage Analysis

User studies can be used to evaluate the efficiency of specific tasks or identify specific application weaknesses, but they do not necessarily indicate if a new idea will become successful or popular with the general public. Releasing a project to the wider population and observing its reception is the only true way to find such results. This is particularly true for Japan, which has developed a very unique mobile phone culture. Will people be interested in *12Pixels*? Will they be able to draw interesting images? What kind of images will they draw? How will they use the drawings? Without releasing *12Pixels* we believed it was all but impossible to convincingly answer these questions.

In this section we present analysis of the data collected following the public release of *12Pixels* in Japan. As *12Pixels* was released as an official service, we were fortunate to benefit from advertising and promotion of the application and quickly gathered a relatively large number of users. However this approach had certain disadvantages such as having to adhere to the Sony corporate privacy policy that did not allow us to access personal data or to directly contact end users for research interviews. Although we did collect a significant amount of data, we were only able to analyze it indirectly. This analysis is interesting and important for several reasons. Firstly, we discovered certain usage patterns for *12Pixels* that are applicable to a wide range of content creation applications. Secondly, our analysis suggests that creativity based applications and services are a promising direction for mobile phone development. Finally, we hope our analysis can inspire the development of new services, applications, and ideas for mobile creativity in general.

5.1. Data Analyzed

We made a comprehensive analysis of data from the first month of service after the initial release, from March 21 - April 21, 2009. The results of this analysis allowed us

to re-think aspects of the *12Pixels* design and evolve new features for the subsequent release. Here we introduce this analysis and also make comparisons with data from the first month of the second release, June 30 - August 30, 2009.

5.2.   Can People Draw with *12Pixels*?

Figure 9 shows a small sample of drawings created by *12Pixels* users since the initial release. It can clearly be seen that the variety of drawings is surprisingly extensive and complex; the quality and creativity of these drawings is nothing short of amazing.
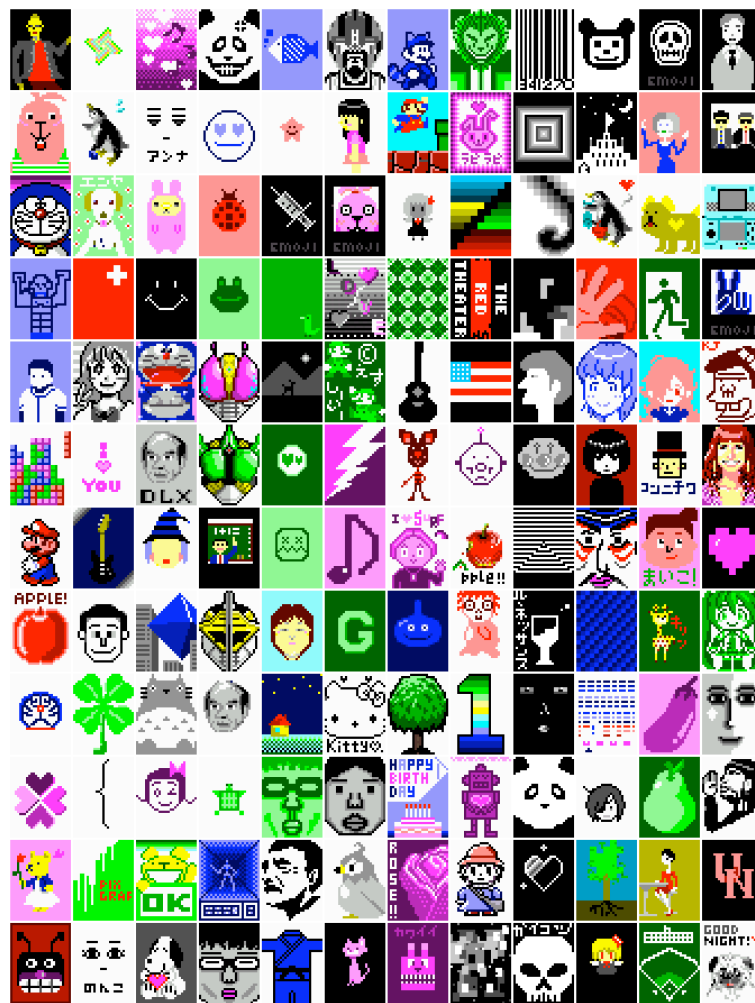

Figure 9: A small sample of drawings created by *12Pixels* users in Japan.

It is also apparent that technical drawing skills are not necessarily required to express oneself in interesting and unique ways. Indeed many of the simplest images are

among the most expressive and enjoyable. Our experience with *12Pixels* demonstrates that like many user generated content services, social drawing can be a truly democratic medium that allows anyone to be creative.

5.3.   Is *12Pixels* Creatively Limiting?

In the process of designing and implementing *12Pixels* an often-expressed concern was the possibility of encountering a significant degree of repetition in user drawings. In other words, does the low resolution limit creativity?

The 27 x 36 pixel canvas offered by *12Pixels* may at first seem limiting, however the actual amount of unique imagery that can be created is very much vast. The vastness of the design space can be understood with a simple thought experiment. According to McCormack [17] if you were to spend every second of your entire life looking at a different variations of a black and white 6 x 6 pixel image, by the time of your death you would have seen less than 1% of all possible images. This suggests that the possibility space *12Pixels* provides is theoretically more than adequate for its intended purpose.

By analyzing the drawings we found the overwhelming majority were unique and special. There were however, some interesting exceptions. The first theme we noted was repetition when users drew *pervasive cultural symbols*, such as the heart mark or well-known characters. The second theme involved repetition when *remixing* and *repurposing* drawings from other users, this is discussed in more detail below.

These cases do not contradict our basic conclusion that low resolution and 'enforced' simplicity did not limit user creativity. From observing the thousands and thousands of drawings created since the initial release, there has been no indication that the canvas size became a limiting factor on user creativity. On the contrary, and as has been suggested by Boden [18], we found that the introduction of constraints on the creative process is what makes creativity possible by mapping out a territory of structural possibilities to be explored. This also creates a low entry barrier where users are less intimidated by the complexity of drawing and worry less about making mistakes.

5.4.   Remixing and Repurposing

When we analyzed drawings uploaded to *12Pixels* over the first month, we observed that about 59% were original drawings, and the remaining 41% were repurposed original content.

Figure 10: Examples of *remixed* (left), *recolored* (middle), and *progressive* drawings (right).

Within the 41% of repurposed content we found three distinct drawing sub-categories, example drawings are shown in Figure 10.

Remixed drawings (22%) are original drawings that were modified to produce a different variation by adding or removing various graphical elements.

Recolored drawings (4%) are drawings where only the color of the original drawing was changed without changes to the drawing itself.

Progressive drawings (12%) are uploads of a single drawing at various stages of development.

Other drawings (62%) are identical drawings uploaded multiple times by the same user or tests of the upload functionality such as blank images.

Analysis of drawing repetition demonstrated that 38% of drawings were re-used for purposeful reasons, as users actively modify drawings and contribute them back again. For the second release we were able to track how many times each drawing was downloaded to the *12Pixels* canvas specifically for repurposing (rather than just browsing). Of the 2276 drawings created in total, they were downloaded for repurposing 3790 times. This suggests that remixing and repurposing other drawings plays a major part in the creative cycle of *12Pixels*.

These observations lead us to rethink the distribution of the 'premium content' drawings we provided as examples. While this content was viewed frequently, it was not designed with remixing in mind and therefore was seldom appropriated. For the second release we shifted our focus to providing templates, rather than completed drawings, to accommodate easy remixing and repurposing.

5.5.   What People Drew

What would people draw with *12Pixels*? We felt this question was important because it directly impacts upon the type of tools users require. To answer this question we surveyed drawings from the first month of the *12Pixels* release and identified the following most common image categories: *People* (11%), *Animals* (22%), *Pop Culture* (7%) i.e. artifacts commonly found in everyday culture, such as game characters, *Original Drawings* (7%), i.e. original characters; *Messages* (23%), i.e. drawings where text is the key element, *Objects* (7%), i.e. various objects such as such as cars, planes, etc, *Symbols* (20%), i.e. abstract or highly stylized imagery such as heart marks and *Others* (7%), i.e. drawings that do not fall into any of the above categories. Examples drawings from each category are shown in Figure 11.

Figure 11: Drawing categories: A: People, B: Animals, C: Pop Culture, D: Original Drawings, E: Messages, F: Objects, G: Symbols/Abstract.

While the above categorization is certainly an approximation, it provides an interesting insight into what and why people would draw on the mobile phone. It was quite unexpected that *Messages* represented the largest category with 23% of drawings. In retrospect, it is a quite understandable – drawing messages creates highly personalized content that is both expressive and quick to create. This is particularly true for the Japanese language as it is very graphical by nature and lends itself to pictorial representation. *Animal* (22%) and *Symbols/Abstract* (20%) drawings follow closely, with the *Symbols* category prominent as it includes the heart symbol, which by itself constituted nearly 30% of drawings within the category.

Our analysis of the drawings suggests that one of the most important reasons for people to draw on the mobile phone was to *support communication*, rather than simply express oneself creatively. This trend is even more evident when we estimated how drawings were used once created.

5.6.   How Drawings are Used

While we cannot track how people use drawings locally on their phone, e.g. as custom wallpaper, we can track the use of *12Pixels* services to create *emoji* and physical accessories. From the first release 45% of the images uploaded to the communal gallery were *emoji* icons and roughly 4% of images were drawn to create physical accessories. For the second release, *emoji* icons accounted for 39% of drawings uploaded during the same one month period.

This observation indicates that a large percentage of *12Pixels* drawings were used as a means to support self-expression when communicating via email. Hence, *12Pixels* had significant use as a tool for *supporting communication*, rather than creative expression alone. We were somewhat surprised that creating physical accessories did not prove very popular with users. The expense of ordering the accessories is one possible reason, and it is also possible that *12Pixels* is viewed as a casual drawing tool rather than for 'serious' accessory design.

5.7.   Usage Patterns

In highly urban areas such as Tokyo, long periods are spent with mobile phones while commuting to and from work, a 2005 survey calculated the average one-way commute time to be an astonishing 67 minutes for workers and 72 minutes for students [19]. We envisioned *12Pixels* as a tool to be used during these 'downtimes' on the train to and from work, while waiting for friends, or in any other in-between times. From the data collected from the first release we analyzed drawing upload times to gain a better picture of usage patterns. Figure 12 shows the distribution of uploads by hour over the course of the day. We can see that the peak upload time occurs when people are commuting home after leaving work around 6pm. The second peak comes after dinner at around 9pm and another lesser peak around lunchtime. While not a definitive answer to the question of when and where people are using *12Pixels*, this data provides a useful insight. It in part substantiates our assumption that *12Pixels* would be used during small pockets of downtime, however we were surprised to find that there was sparse activity during the morning commute and continued activity after returning from work.
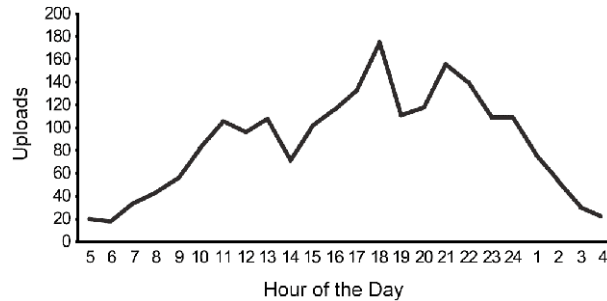
Figure 12: The distribution of drawing uploads over the course of the day.

5.8. Evolution of *12Pixels*

The second release of *12Pixels* has included a number of improvements driven by the analysis that we presented above. A refined color menu interface was added, the process of creating *emoji* was significantly improved, content available online was rethought to cater for remixing, and we also significantly strengthened the social capabilities by adding a commenting and rating system.

The result of these improvements was a significant increase of drawings uploaded to the server. In the first month of use, the number of drawings uploaded increased by approximately 300% from 780 to 2276 in the second release. The number of repeat users, i.e. those who uploaded 2 or more drawings, increased from 42.8% to 61%. This data supports the validity of our observations and shows a growing real-world interest in *12Pixels*.

6. Discussion

With the current proliferation of social web applications there appears to be genuine and growing interest in all forms of computer based creativity and content creation. Through the *12Pixels* project we have explored the approach of 'social drawing' on the mobile phone and uncovered new ways for people to express themselves. This section presents some of the conclusions drawn from our experiences.

6.1. Mobile Phones for Creativity?

One of the main questions our research sought to answer was: *Are people interested in using their mobile phone creatively and in particular for drawing*? We believe that our observations point to a positive answer to this question. Indeed, the drawings and creative output that we observed from thousands of people surprised and amazed us. At the time of this writing nearly 25,000 drawings have been contributed to the *12Pixels* gallery in under a year. This suggests that using *12Pixels* is an engaging and appealing process. We believe that tools for creative expression on the mobile phone provide a unique and special experience that is not found on traditional desktop computing platforms.

6.2. Simplicity Vs Expression

User discussions and observations suggest that the *simplicity* of the drawing interface was one of the key reasons behind *12Pixels* appeal. Throughout the process of developing *12Pixels* we were constantly forced to consider the trade off between ease of use and expressive ability. It was critical to find the appropriate balance; users frustrated by the difficulty of interaction will soon give up, as will users bored by the limited possibilities of expression. In the words of Levin we strived to create an instrument that like the pen and the piano is 'instantly knowable, indefinitely masterable' [20].

Have we been able to achieve this balance with the *12Pixels* interface? Based on the amazing quality of drawings created, we believe we have come close. One memorable comment received from an interaction designer working in the mobile phone industry described *12Pixels* as being: 'Simple to use, difficult to draw'. This may seem contradictory but it very much echoes Levin's maxim above. As deceivingly simple as the pen and the piano are, without mastery there can be no masterpiece.

We believe that striking the balance between expressiveness and ease of use is a crucial challenge for developing any interface for creative expression. Achieving this balance requires careful consideration of the creative process, and its immediate context. We found that the technical constraints of the mobile phone, while challenging, can be utilized to define a very specific area of creative activity. In our case using the specific style of pixel art may at first seem like a major limitation, however it in effect acted as a mechanism to free up the creative process by posing well considered constraints and encouraged participation.

6.3. Creative Communication

We found that one of the most important reasons why people would use *12Pixels* was to enhance communication. This was evident in the number of drawings created with message based content and in the surprisingly high percentage of *emoji* icons created for personalized email communication. We believe the role of communication should be carefully considered for any usage of the mobile phone as a creative platform – adding communication capabilities is extremely important. Exploring the link between creativity, communication, and mobility can be a fruitful and exciting area of research for the pervasive computing community.

7.   Future Directions

We believe that developing applications to support everyday creativity is an exciting and promising area of future research for pervasive computing applications. The *12Pixels* project explored only a limited range of the possibilities for mobile creativity. Areas we have yet to explore include developing an enhanced drawing interface for animation, with functionality to create and share quick animated sequences. Drawing interfaces can also explore the use of the mobile phone camera to

capture color, provide images for annotation, and develop simple digital image processing techniques.

As the functionality of the mobile phone extends to include more and more web based services, there are numerous opportunities for enhancing them with *12Pixels*-style drawing functionality. For example drawings can be used as custom 'visual tags' to mark out distinct locations on an online map or even be used as input in a visual search engine. Drawing is a form of expression that has to-date been largely ignored by mobile phone research and there remain a surprisingly wide range of innovative applications yet to be developed. We hope this work will encourage researchers and practitioners to explore this exciting area.

Acknowledgments

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