in this place

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Inspired by research into mobile music, which allows for the creative process to take place anywhere, at anytime, this paper explores the use of smartphones as a tool for 3D sketching ideas for ceramic vessels. For "In This Place", the intention is to employ an innovative approach to design, utilising smartphone devices to gather and process location specific data to create a series of unique, singular forms. The resulting digital models can then be 3D printed. As well as exploring a new design process, this allows for a kind of collaboration, as users in different locations contribute to designing the complete series of vessels.

Specifically, the aim is to reimagine a pseudo Ming dynasty-era vase form, whereby the vessel has a central, vertical division. One half is redesigned by each user "here", and becomes an unique redesign of the vessel, subtly different to all others designed in their own "here".

Keywords

Mobile devices, generic design tools, 3D printing, location.

Smartphone enabled design: utilising unique markers for re-imagining Ming vases

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Abstract

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1. Introduction

The rapid developments in generative and parametric design methods, and digital additive manufacturing (3D printing), allow the creation and instantiation of an almost infinite range of forms. It is no longer the case that designers are limited to designing only forms they can imagine, and draw and model with more traditional design tools. Architecture has used such methods for several years to simplify the design of complex structures, and there is growing interest in generative methods in industrial design. The individualization of products has become easier, and is now economically viable enough for consumers, often non-designers, to be able to customize products online for printing at home, or delivery. For designers, these processes usually rely on desktop and laptop-based software such as Rhino with Grasshopper, while online services offered to consumers include Ponoko, Shapeways, and Cubify.

Nowadays, smartphones have many features that make them suitable for use as a design tool. They have high-resolution screens, numerous in-built sensors and, although they do not have the processing power of desktop or laptop computers, they have reached the point where real-time data can be processed and used to generate three-dimensional digital models. However, despite these highly portable and familiar devices becoming virtually ubiquitous, they are rarely utilised to explore innovative design processes for industrial design applications.

This research builds on work carried out in the field of generative, mobile-based music, where the smartphone becomes a generic tool for creative tasks. The research explores the feasibility of allowing the generative design process to take place anywhere, and result in the creation of 3D models based on data associated with that place. The digital files can then be 3D printed. It explores connections between “visualizing” place – the difference between “here” and “there” – and using the mobile phone as the creative tool for designing objects. It can be described as a 3D design process whereby 3D forms, in this particular case vases or vessels, can be digitally generated, and then exported for manufacture.

2. Background

Before detailing the study, a brief overview of the use of mobile devices in music creation is provided, along with examples of recent 3D design apps. The choice of design task is explained in section three, with reference to cultural factors and relevant creative work, while a broad interpretation of the concept of “In This Place” frames the research.

For more than a decade, mobile phones have been used as the creative tool for music creation (Essl, Wang and Rohs, 2008), in part because they are ubiquitous, portable and powerful enough to allow the creation of music anywhere (Wang, Essl and Penttinen, 2008). Mobile phones are equipped with an increasing number of sensors, and Tanaka argues that by democratizing access to sensor technology, mobile phones allow for new cultural contexts for interaction (2010) and new forms of expression (2000), properties which apply equally to design as they do to music.

Mobile design apps and tools have similarly democratised 3D design in recent years, but the general approach differs from that of mobile music researchers. For example, Mecube (2013) is a mobile app for iOS and Android that allows users to design 3D printable objects by adding or subtracting individual cubes. The finished objects can be saved as full colour 2D or 3D files, and ordered as 3D prints directly from the app. The creators claim it makes 3D design easy and fun for non-designers. Sculpteo (n.d.) offer an iOS app allowing users to create customized cups (Pixel Cup) and vases (Profile Vase) using the touchscreen of iPhones and iPads. The Profile Vase uses a photograph of the user's facial profile, then a rotation, to create a vase that can then be 3D printed. Autodesk123D (n.d.) offer a range of online and downloadable programs and apps, created to make 3D design and digital fabrication more accessible. Downloadable programs such as 123D Design and 123D Sculpt+, along with online tool Tinkercad (2013), allow open 3D modelling and file saving for 3D printing. Autodesk's recent Project Shapeshifter (2013) provides an easy way of creating complex 3D printable models in a web browser. By moving sliders, the user can modify the shape of a range of base models, and select a texture with which to wrap it.

In contrast to these examples, where the aim is mainly to make CAD accessible to new users, we build on the approach used in mobile music, where the in-built capability of mobile devices to record, process and display data are at the core of the creative process. We therefore envisage a creative process for which location itself is fundamental to form generation, and is facilitated by the portability of mobile devices.

3. Design Task

The intention of the research is to test an experimental design process in a real-world scenario. A series of objects therefore need to be designed, and instantiated. The justification for the chosen design task is given in this section.

The advent of large scale production and global export of Ming pottery is the background with which this is framed, for cultural reasons, as the research is based in Taiwan. The Ming Dynasty period (AD1368-1644) saw a rapid increase in the production and export of Chinese porcelain (Dillon, 1992), particularly that from the Jingdezhen kilns which, became highly regarded in Europe during the 17th Century (Hsu, 1988). The mass-produced designs evolved to be very similar for all export markets (Liu and Cao, 2014), and thus did not reflect the unique location from which they were exported. In this research, a generic vase form is reimagined using location-specific markers to instil a notion of “place”, making each design unique, then exported digitally before being instantiated in a single location.

The decision to use innovative design processes for vase design is not without precedent. A number of practitioners are exploring the use of location in the design and manufacturing process, but with rather different approaches. Stratigraphic Manufactury (Unfold, 2012) offered a procedure where the same digital files were sent to different ceramic 3D printing production centres so that each printed cup was unique due to different production conditions, or errors. More recently, in Adaptive Manufacturing (van Herpt and Wassnick, 2014-2015), information measured by external sensors control a ceramic 3D printer, and in Solid Vibration (van Broekhoven and van Herpt, 2015) sound waves cause the 3D printer bed to vibrate during the manufacturing process, creating Moiré patterns in the printed vessels.

Although these ceramic designers are conducting research that is broadly similar, in the described study the design process is approached in a different way. The innovative, mobile-based process is brought to the fore, and applied to the area of ceramics allowing, in a similar vein to mobile music researchers, the creative process to take place in any location; this location then becomes integral to the generative design of the vessels.

Vases are also a suitable design subject because they meet a number of other requirements needed to fulfil the research. While they are functional, they are also decorative, meaning there is an opportunity to create unusual forms; an abstract form will not necessarily make a vase less functional. The physical parameters of a miniature vase are of a workable and executable size, in terms of the size limitations of the available 3D printing technology and the costs of manufacturing.

4. Objectives

The described pilot study had two main aims. The background identified that mobile phones have many characteristics that make them suitable for creative applications, but in industrial design these have not been explored to the same degree as they have in the field of mobile music research. To take initial steps towards building a greater body of research in this area, this study first aimed to test the overall functionality of a prototype app, and the design process for a particular task afforded by it. Secondly, it assessed whether vases designed and manufactured using the described processes offered an innovative interpretation of the theme “In This Place”, in particular the idea of “here” and “there” having unique, demonstrable characteristics.

5. Method

The study consisted of three facets; 1. Identifying a suitable design task (vessel design) from which to, 2. Develop a suitable location-driven design process facilitated by an Android application, and then 3. Instantiation and assessment of the resulting forms.

5.1 Application Overview

By design, the application is very simple. After installation, the interface consists of only three elements. A static, but accurate, 3D representation of the generated vase is displayed in the centre of the screen. Below, the location of the user, and by extension their mobile device, is presented as longitude and latitude, to six decimal places. The top of the screen has a large “EXPORT” button, rendered in bright pink to make this function, the only one the users need, obvious (figure 1).

insert figure 1 here.

The generic vase form is generated as soon as the app runs, and is instantly deformed using GPS data derived from the current user's location. The vase model has a vertical dividing line meaning that, while one half of the vase form is redesigned through the transformation of vertices, the other half retains the generic base vessel form. The app uses decimal degree (DD) notation where latitude is measured from -180° to 180°, and longitude is measured from -90° to 90°. This is purely numerical, and provides accurate but easy to interpret data that is mapped so that 1° latitude or longitude, represents one unit of deformation.

The deformation itself is based on Perlin noise, and thus has the appearance of being random (Perlin, 1999). By default, the noise function would use a different Perlin noise algorithm each time it is run within the app. However, the app has been constrained to always use the same algorithm. The latitudinal data drives the horizontal noise, while the longitudinal data drives the vertical noise, with higher values giving greater amounts of transformation. In this way, the differences between vase transformations are determined only by the latitude and longitude of the user's location. The transformed half thus provides a visual representation of “here”, contrasting with the “there” of the other vessels in the series.

5.2 Programming and Hardware

Processing for Android software was used to create the app. Processing is a free, open source Java-based programming language aimed at designers and musicians (Processing, n.d.). It allows applications to be programmed, tested, and ultimately compiled for use on mobile devices running the Android operating system. Apps created with Processing are freely available and easy to distribute.

In this research, Processing was installed on a Windows laptop computer, and used to code a series of developmental applications. These were tested, modified and refined until a usable iteration had been created. This application was compiled to run on the participants' smartphones. Processing allows apps to be compiled directly as a signed Android Application Package (APK) file, a file format similar to a .zip file, that users can install.

Mobile and smart devices develop rapidly, and are becoming increasingly suitable for 3D modelling. However, not all users have access to the latest model. With this in mind, the 3D models produced during the study were of relatively low-resolution, and the amount of data processed was limited to enable the app to function on mid-range, or older, Android devices.

5.3 Testing the Application

Participants were a diverse group in terms of age, gender, and background. Aside from being known to the authors, their common characteristics were a willingness to participate in the study, and ownership of an Android device. They were however, divided into two distinct groups for the purposes of the study, with one group of 3 located in the UK, and another group of 7 scattered across the globe in various locations namely, Taiwan, Japan, Sweden, Slovakia, Ireland, and Peru.

The APK was distributed to participants via e-mail, for them to install on their own mobile device. A short document explaining the purpose of the app and instructions on how to install and use it was also provided. As 3D models of the vessels are generated automatically, and are only influenced by the location of the user, once installed, the app only needs to be opened once. Participants were asked to note down, or take a screenshot of, the GPS data displayed on the screen, and then press the EXPORT button to save the generated vase form as an .stl file. The resulting .stl files were then e-mailed back to the authors, with the GPS data used as a reference of the users' locations, and to identify the created vases.

5.4 Instantiation of vases

A RepRap Mendel desktop Fused Deposition Modelling (FDM) additive manufacturing machine (3D printer), using white polylactic acid (PLA) plastic filament material, was available for the instantiation of the vessels.

6. Results

All 10 participants managed to install the app, facilitate the creation of a vessel, and e-mail the required .stl files to the authors. In addition, all the files proved to be suitable for 3D printing, demonstrating that in terms of basic functionality the app, and the process it affords, work as intended. It must be stated that only two of the vessels were actually printed, as it became clear that the quality of the prints was not sufficient to demonstrate the subtle differences between them (figure 2).

insert figure 2 here.

Digital renderings of the created files however, show that the vessels designed by participants located in the UK (figure 3 and figure 4) were very similar to one another, as would be expected as each “here” of the users is, globally, close to the others. That said, subtle variations can clearly be seen, making each one in the series unique.

insert figure 3 here.

insert figure 4 here.

The forms created by the global group (figure 5 and figure 6) were both more distinct from one another than those created by the UK group, and from those created by the UK group as a whole. Again, this would be expected as the individual locations are not only further away from each other than those of the UK group, but are also distant from the UK.

insert figure 5 here.

insert figure 6 here.

7. Limitations

It is acknowledged that the current app, and the process as described, have a number of limitations. Firstly, the app allows only one kind of vessel, of a pre-defined size and generic base form, to be created. This however, was a conscious decision as, at this stage, the intention is to create vessels with subtle variations that capture and highlight the differences between those created “here” and those created “there”. While a wider range of forms and sizes would have added greater aesthetic diversity, it would make direct comparison between the vessels more difficult; it would not be clear which variations were driven by location, and which were the result of the user's own design decisions.

This leads directly to the second limitation. The app does not allow the user any input into the design process, aside from the “opportunity” to be in a place different from that of the other participants. The user is there simply to facilitate the collection of location data, and ensure the processes of app installation and running, and 3D file generation and transference, take place. While this is still a collaborative design process in that each user makes a unique contribution to the series of vases, this results in an app that is of little interest if used outside this particular research activity. Again though, this was intentional, as allowing users to make design decisions would add design variations driven by factors not related to location.

Thirdly, while the process is collaborative in the sense that each user is contributing to a single collective endeavour, it does not allow direct collaboration, or co-creation, between participating users. The collaboration is exclusively between the authors and the individual users. In the current process, direct collaboration between users in different locations is not possible.

Finally, although successfully completed by all 10 participants, some users reported that they found the process not particularly user-friendly at times, especially when trying to locate the exported .stl file. Although the app was specifically designed to export these files to the SD card of the device, the way some Android devices or user settings are configured, can make it difficult to locate them.

8. Discussion and Conclusions

While the app, and the described procedure as a whole, does show the ability for mobile devices to facilitate design processes through the utilisation of location data, it does not describe the full potential of the process.

This paper described a prototype process that was successful in meeting the stated objectives, and a number of opportunities for further exploration were identified. In future work, the app will be extended to include real-time connectivity between users, so they can each design half, or a smaller section, of the same vessel simultaneously. This will provide a truly collaborative, or co-creative, design process, where each vessel is the work of two or more designers, rather than designers individually contributing to a series of objects. This could be further enhanced by allowing the 3D files to be saved to a central database so vessels designed in different locations can be presented as part of a global map for easy comparison, or to allow them to be accessed for multiple deformations.

Further research should take into account more data than only GPS location. While this is sufficient in the described study, GPS location used in conjunction with other data sources would perhaps provide a more rounded visualisation of the differences between this place "here", and that place "there". As discussed in the introduction, mobile devices are capable of measuring data from numerous sources, and this should be explored more deeply.

The 3D files require high resolution printing to demonstrate the subtle differences between the designed vessels. This was unavailable during the study but is a necessity when the research is developed further. The study did not directly consider the implications for the ceramic field. The use of plastic material for high resolution 3D actualisation would be an adequate medium for the described research, but printing the vases in a higher quality material, preferably ceramic, would not only enhance their aesthetic value but also be more in keeping with the notion of re-imagining Ming vases.

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List of figures

Figure 1: App interface

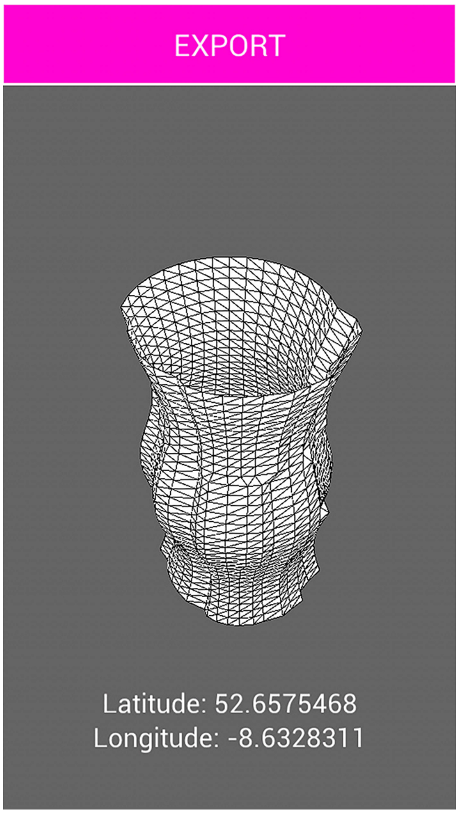

Figure 2: 3D printed vases

Figure 3: Vases (UK group – side view (digital rendering))

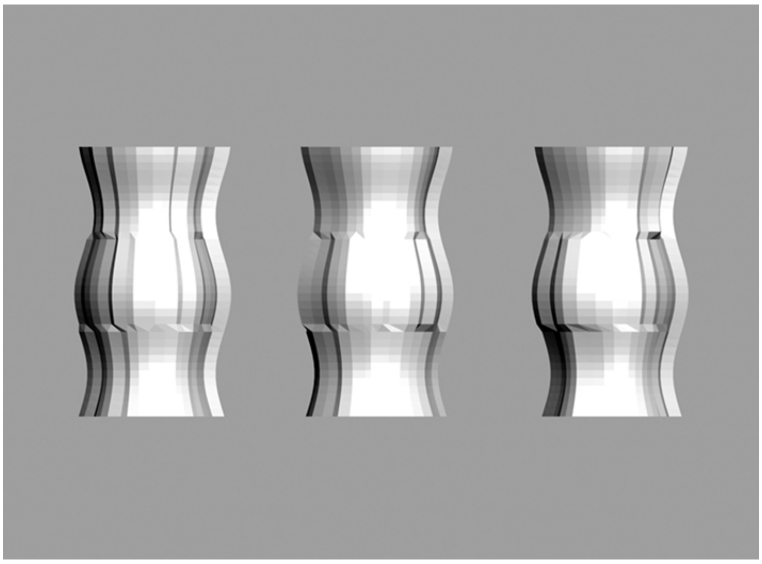

Figure 4: Vases (UK group – bottom view (digital rendering))

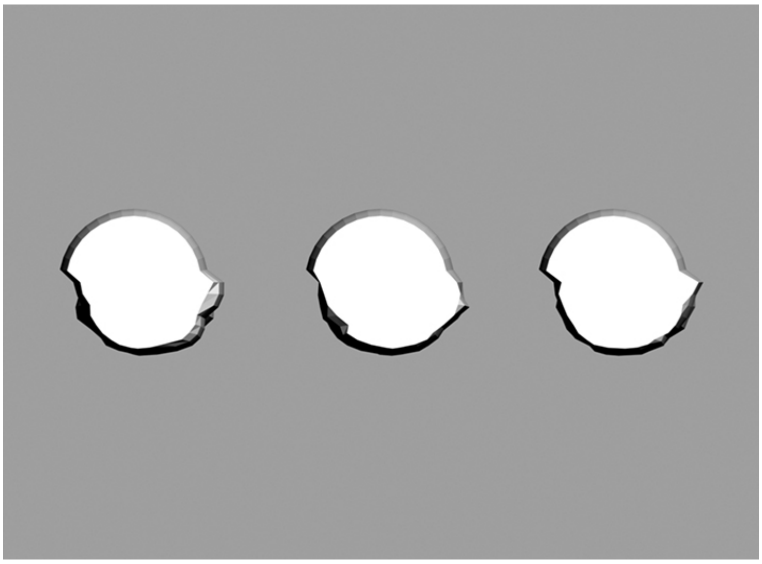

Figure 5: Vases (Global group – side view (digital rendering))

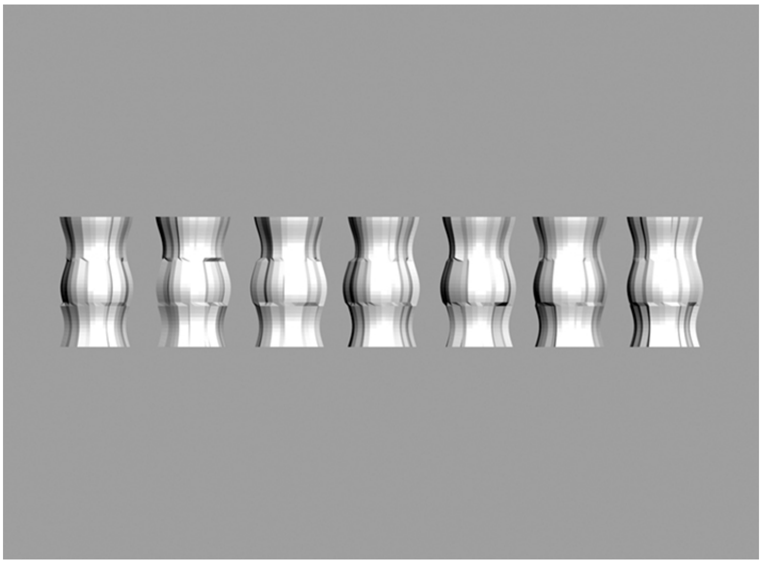

Figure 6: Vases (Global group – bottom view (digital rendering))