3D Printing for Repair: A Paradigm Shift in Fixing Our Relationships with Things

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Introduction

Before the industrial revolution and more recent rise of the concept of disposability the majority of people were makers. Now we buy the things that people used to make, and we throw away the ones they used to repair (Crawford, 2011). Our relationship with objects has completely changed and unfortunately it is now in crisis. However, grassroots movements such as the maker movement, DIY culture, open design, and repair cafes demonstrate that we are potentially in the middle of a paradigm shift with regards to fixing our relationships with the objects. The evolution started with the digitalisation of information now passed into the physical level (Hagel, Brown, & Kulasooriya, 2014).

3DP is an additive manufacturing process that builds up objects out of individual layers based on a digital file (Warnier, Verbruggen, Ehmann, & Klanten, 2014). A great variety of 3D printers exists in terms of different technologies and materials used (Warnier et al., 2014). Since its invention twenty years ago, 3DP has drawn attention from a wide range of disciplines, used in diverse application areas (Manyika, Chui, Bughin, Dobbs, Bisson, & Marrs, 2013) and affected the way we think about manufacturing. The interest in 3D printers has grown further after the maker-movement become widespread (Hagel et al., 2014). The technology has developed very fast and paves the way for businesses that provide 3DP services as well as low-cost desktop 3D printers. Although the main application area of 3DP is prototyping in product design, today it is possible to produce many products and current examples include bicycles, buildings, cars and even organs using living cells as a raw material.

Methodology

The aim of this research is exploring the opportunities and barriers of 3DP through understanding human engagement with repair activity. The uniqueness of interaction between product and the individual can only be understood if the method utilised allows the meaning and the rich, subjective and expressive qualities to emerge in interaction. The researcher engaged in exploratory product repair activities which can be described as materialisation of theoretical ideas into tangible objects. Initially, various damaged products were explored. Then particular repair methods were designed considering the research aim. The resulting artefacts are intended to help stimulate exchanges between the researcher and the audience. All repairs were numbered and the photographs of the repairs can be found at the end of this article.

Opportunities

Producing Spare Parts

Unavailability of spare parts is one of the common barriers to product repair. It is very hard and sometimes impossible to find spare parts to repair or upgrade products as current linear economic system expects users to buy new products when they are damaged. Consequently, it is common user behaviour to throw away an umbrella with a broken handle similar to the one in Figure 1. However, 3DP the handle and fixing the umbrella and extending its lifespan is a more environmentally friendly option.

Figure 1: 3D printed umbrella handle

Although it is not widespread currently, it is possible to download CAD models and 3D print spare parts with desktop 3D printers or in 3DP facilities. Besides, it could be more convenient and cheaper to 3D print a spare part for repairing a product rather than buying a new one for particular products. Prescription glasses could be a good example. It could be easier to 3D print and replace temples as can be seen in Figure 2, instead of finding suitable frames for your face and buying the lenses.

Figure 2: 3D printed eyeglasses temple

Improving Product Design

3DP is capable of creating complex shapes different to those that can be created with conventional manufacturing methods (Warnier et al., 2014). This opportunity makes it possible to create even eccentric designs. The spare parts do not have to be the same as the originals; rather they could be designed in a different way for improving the products or personalizing them. The toy sword in Figure 3 and the lustre in Figure 4 could be good examples for this category.

The owner of the sword wanted it to be stronger and longer than before. Additionally, he wanted his name written on it.

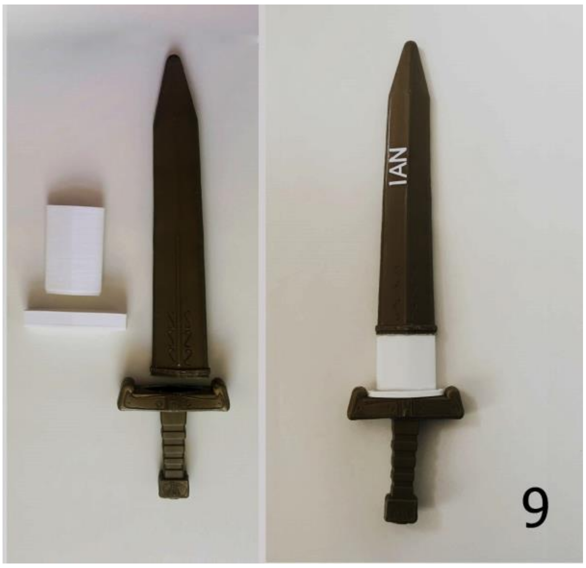

Figure 3: Toy Sword

The Victorian glass lustre was sitting on a shelf of an antique shop, broken. After living approximately 150 years as a whole piece, it was accidently dropped on the floor by the antique shop owner. Unfortunately, he threw away the broken parts and, he had no idea what to do with it. Initially, I designed parts that fitted the missing sections. The 3D printed parts are made out of different material than the lustre, and this would stand out. I designed the pieces in a way that they *emphasize* this aesthetic difference harmoniously. The parts in Figure 4 were designed considering the form and the curves of the lustre. Finally, all the parts were 3D printed and put together resulting in a synthesis of traditional manufacturing methods and new technologies.

Figure 4: Victorian glass lustre repaired and augmented using 3DP

Printing on Demand

3D printers are suitable for making one-off products contrary to mass production because previous investments such as unique moulds for each product or different manufacturing machines are not required for 3DP. One of the most significant potentials of 3DP is its ability to create unique things that are exactly suited to their purpose.

Fixing a shoe heel is one of the easiest repair processes (Figure 5). However, if one wants to create a unique shoe heel it could be very expensive or impossible with conventional methods depending on the design. It is possible to produce a variety of designs according to the needs and wants of the user with 3DP, and the cost would be lower in comparison to conventional one-off manufacturing methods.

Figure 5: 3D printed shoe heel

Sustainability Implications

3DP contributes to the three main principles of sustainability (ecology, economy, and ethics). However, product design, manufacturing processes and post-use opportunities must be reconsidered and restructured fundamentally. Current literature about sustainability implications of 3DP mainly focuses on energy costs and CO2 emissions (Baumers, 2012; Lindemann, Jahnke, Moi, & Koch, 2012). Particularly, Gebler, Uiterkamp and Visser (2014) provides a comprehensive and global assessment of this topic.

The sustainability implications of 3DP on the environment encompass the decrease of resource and energy demands along with the CO2 emissions as 3DP employs additive means of production (Gebler et al., 2014). 3DP enables extending the product lifespan through repair and upgrade. In addition, the end-of-life products could be recycled with a ‘recyclebot’ that uses household polymer waste and turns it into 3D printer filament (Kreiger, Anzalone, Mulder, Glover, & Pearce, 2013). Thus combining the 3D printer with a ‘recyclebot’ would enable closing the loop and positively affect environmental dimension of sustainability. The 3D printed parts could also be reused several times if they are designed considering this option like the 3D printed patches in Figure 6. Conventional methods of textile repair such as darning and patching were the inspiration of this project. The process started by trying different shapes of 3D printed patches that could be pinned or sewn on holes in the fabric. Then final patches are developed which are made out of small 3D printed parts to enable some degree of flexibility to make it suitable for mending textiles.

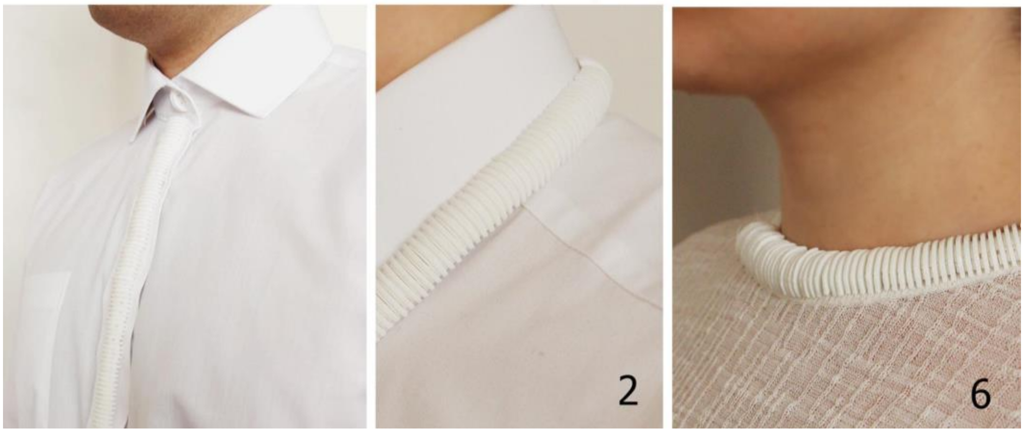

Figure 6: 3D printed patches

3DP holds the potential to increase the accessibility of objects together with online open-source platforms. Thus this could improve the living conditions in rural areas affecting the socio-economic conditions positively.

Another contribution 3DP offers to the social dimension of sustainability is the localisation of manufacturing and supply chains. Supply chains are expected to shorten and become less transport intensive (Birtchnell, Urry, Cook, C., Curry). Localisation enables product diversity for various user needs and effective user feedback (Dogan, 2007). Accordingly, it has significant implications for developing more creative, ethically responsible product end-of-life solutions. In conclusion, 3DP represents a manufacturing technology which is strongly associated with a large sustainability potential considering economic, social and environmental dimensions.

The Interest in 3DP

3DP can also be used as an effective way to draw people’s attention to repair activity. Possible groups could include ‘technology geeks’ who are not specifically interested in repair, or children as it is easier to gather their attention with the help of interesting products.

A 3DP pen is included in this research work significantly because it draws people's attention and encourages them to easily engage in the repair activity. The working mechanism of a 3DP pen is similar to a glue gun. It heats up in one minute after it is plugged in. Then a PLA or ABS plastic string inside the pen melts with the heat and comes through the nozzle. The product is easy to operate but it is very hard to create neat shapes with it.

A damaged lace doily was repaired with the 3DP pen as it can be seen in Figure 7. I drew the pattern on paper and followed the lines with the 3DP pen. Although the pattern was two dimensional, it was hard to create the exact shapes. The final result was both aesthetically pleasing and interesting. It is not necessary to buy the 3DP pen for repairing textiles or other products, but it could be available in repair cafes and makerspaces. People could lease or use it when they need to.

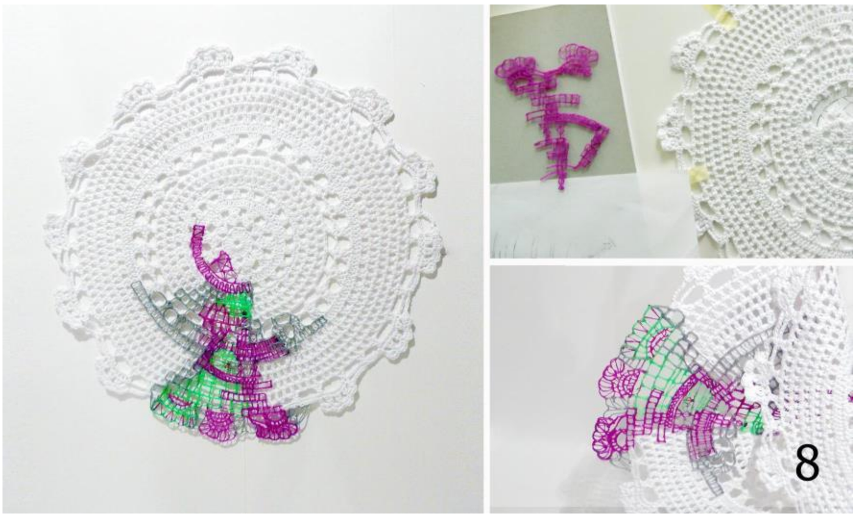

Figure 7: Lace Doily repaired using 3DP pen

Possible Future Developments

A myriad of innovations in manufacturing technology is taking place at the moment. People will 3D print food, living tissue and fully assembled electronic products when these innovations will be widespread (Lipson & Kurman 2013). As the opportunities of 3DP improve each day rapidly. It is conceivable for manufacturers to provide ‘official’ downloadable 3D models of spare parts of products which they produce, in the near future. Moreover, it will be possible to print active systems like a working mobile phone instead of passive parts (Lipson & Kurman 2013). Possible future developments will alter the way we conceive products and our relationship with them.

Barriers

Although 3DP is an effective method with endless possibilities of designs it enables, there are some difficulties with employing it in repair that should be addressed.

Knowledge, Skills, and Time Required

Developing 3D CAD models requires skills, knowledge, and precision. Besides getting the 3D modelling service is very expensive. However, there are open source websites such as Thingiverse[1] where one can find CAD models of various product parts and instructions for repairing products with 3D printed parts; currently the variety of these means is not sufficient enough to answer the need.

Precision needed in CAD Modelling

Digital precision is one of the advantages that 3DP provides. However, it could be difficult to create a precise CAD model especially for the products with organic shapes. For example, it was not easy to create a spare part that fits the damaged spout of the teapot in Figure 8.

[1]http://www.thingeverse.com/

Figure 8: Teapot with a damaged spout

Accessibility of Facilities

Creating the CAD model and finding a 3D printer are some difficulties which could be faced when fixing products with 3DP. However, these issues could be addressed when 3DP technology gets more widespread in the future.

Technology develops fast, and current interest in 3DP indicates that it could penetrate more into our everyday life. If CAD models of various product parts and the 3DP service become more widespread in the future, it would become easier to download, and 3D print damaged product parts according to our needs and wants with desktop 3D printers or in local stores. Hence repairing our products would be more convenient than buying a new product and would change the typical user disposal behaviour. Eventually, it would affect the manufacturing system and businesses. One can also conclude that the user demand for spare parts would eventually make companies reconsider their business models and include repair as a part of their system.

Conclusion

This article focuses on the opportunities and barriers of 3DP for extending the lifespan of products through repair. The researcher repaired twenty damaged products in order to explore the potential of the 3DP for each unique repair activity. The results obtained by this study were useful to comprehend the potential of 3DP for repairing physically damaged products. Employing 3DP for creating spare part has a great potential for repairing products. Moreover, these parts could be designed to personalize the product or improve its design. Some difficulties were found in the research process including the knowledge, skills and time required and the precision needed to develop the CAD models. The potential of 3DP and other technologies could be used for encouraging people to repair their products and experience profound relationships with things through repair activity.

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