UNIVERSITY OF MUNICH
Department "Institute for Informatics"
Education and Research Units Media Informatics
Prof. Dr. Heinrich Hußmann

Master Thesis

Web-Based Creator for Activity Sculptures

Walter Rempening-Diaz
me@walterrempening.com

Working Time:	1. 12. 2014 to 1. 6. 2015
Supervisor:	Simon Stusak
Responsible Professor:	Prof. Dr. Andreas Butz

Acknowledgements

Abstract

The recollection of personal activity data has been greatly facilitated by the increasing amount of applications and devices that encourage users to measure their activity with the primary goal of health improvement. These devices range from mobile applications taking advantage of smartphone sensors to dedicated fitness trackers presented as modern watches and bracelets. Apart from the analytical insights about the data obtained through classic data visualizations, it is also possible to visualize the information through physical objects also known as activity sculptures. It has been shown that activity sculptures have a positive influence in users making them feel rewarded for their active lifestyle. To further study the process of visualizing activity information into sculptures an web-based activity sculpture creator was developed. This tool takes advantage of modern web technologies and offers a platform in which users can export their data and allows them to experiment creating variations of an activity sculpture which can also be exported for 3D printing. For the development of the configurator current product customization platforms where analyzed for gathering best practices in user interface and interaction design. In order for users to have a sculpture with a high degree of variability for the data to be mapped on 4 different sculpture prototypes were developed. For the validation of the configurator an online version was released and a user study was performed. User feedback showed that our prototype was easy to operate and that the obtained sculptures were appealing and meaningful them.

Zusammenfassung

Die Sammlung persönlicher Aktivitätsdaten wurde durch die zahlreiche Anzahl an Anwendungen und Geräte enorm vereinfacht. Diese Anwendungen und Gerätschaften, die hauptsächlich das Ziel haben, Nutzer zu einem aktiven Lebensstil ermutigen, können in Smartphones, wo sie die Vielfalt an Sensoren ausnutzen oder als tragbare Accessoires wie moderne Uhren oder Armbänder gefunden werden. Abgesehen davon, dass klassische Datenvisualisierungen Einblicke in den Aktivitätsdaten verschaffen können, ist es auch möglich den Datensatz durch physikalische Objekte, auch als Aktivitätsskulpturen bekannt, zu visualisieren. Es wurde bewiesen, dass Aktivitätsskulpturen Nutzer positiv beeinflussen, da die Nutzer sich für ihren aktiven Lebensstil belohnt fühlen. Um den Prozess der Visualisierung von Information in Skulpturen weiter zu forschen wurde ein Web-Konfigurator für Aktivitätsskulpturen entwickelt. Durch die Nutzung moderner Web-Technologien erhält der Nutzer eine Platform die ihm es erlaubt seine Daten unkompliziert zu exportieren und ermöglicht ihn die Gestaltung einer 3D druckbaren Skulptur. Für die Entwicklung des Konfigurators, wurden aktuelle Konfiguratoren analysiert mit dem Ziel Best-Practices im Bereich des Interface- und Interaktionsdesigns zu erkennen. Um den Nutzer eine breite Vielfalt an möglichen Anpassungen für die Skulptur, wurden 4 verschiedene Skulptur-Prototypen entwickelt. Letztendlich wurden für die Validierung des Prototyps eine online Demoversion veröffentlicht und eine Nutzerstudie durchgeführt. Die Resonanz der Nutzer zeigte, dass unser Prototyp einfach zu bedienen war und, dass die entstandene Skulptur ästhetisch und sinnvoll rüberkam.

Task Definition

Activity Sculptures are physical (3D printed) representations of personal tracking data (e.g. step count) that dwell between the artistic and the abstract. For this master's thesis the student will develop a web configurator that will allow to individually create said activity sculptures (a similar example can be seen in www.shapeways.com/creator/statement_vase).

The focus of the thesis will be the development of interaction concepts and their implementation in the configurator. The concepts will be examined and improved in smaller iterative user studies. Another important aspect is a seamless and easy import of external tracking data (e.g. export data from tracking apps). The result should be a stable working prototype that can be used for follow-up works.

Possible research questions

- What interaction concepts are possible? What are their advantages and disadvantages?
- What degree of freedom is possible and meaningful while designing a visualization?
- What is a possible design space for said activity sculptures?

Tasks

- Research and related works (e.g. data visualization, configurators)
- Development of interaction concepts
- Concept implementation
- Planing and executing several small user studies
- Written thesis and presentation of work

Requirements

- Programming skills in web development and computer graphics

I confirm that I independently prepared the thesis and that I used only the references and auxiliary means indicated in the thesis.

Munich, May 21, 2015

. . . .

Contents

1 Introduction

The presented work deals with two major topics: web customization platforms and activity sculptures. For the former topic interaction processes and usability aspects applied in current projects are of great interest as they provide a foundation on which the author's prototype will be built upon. The latter will help the user explore and engage with their activity data in a meaningful way, first in virtual and later in physical 3D space. The following sections offer an background information to the topic and a define the problem addressed in this work. To conclude this chapter a general overview of each chapter will be provided.

1.1 Background & Problem Definition

At its core, the problem to solve in this work is a data visualization problem. The field of data visualization is tightly interlaced with other fields such as statistics, psychology, design, human-computer interaction, computer and cognitive sciences to name a few. This makes it a science that requires a broad set of skills to master. Due to its multidisciplinary nature it is also difficult to define. A definition of data visualization suitable for this work would be the one described by Card et al.[2]:"The use of computer-supported, interactive, visual representations of abstract data to amplify cognition". In other words this definition states that the existent knowledge about a specific dataset can be increased by mapping the data to a visual space and by interacting with it through a computer system

The interrogatives and curiosities about a dataset are the start point of every visualization. This work aims to answer some questions about activity data and the possible forms of representing it in a physical sculpture. But why activity data? We are living in a time where there is more data flowing every second through the internet than all the data stored in the internet 20 years ago[9]. It is estimated that the measure of digital created data will grow by a factor of 300 from 130 exabytes in 2005 to 40,000 exabytes in 2020[5]. This forecast shows how the analysis of big data is playing an important role in the way how decisions are made in the industry. The large scale nature of big data observing how millions of users behave can also be put into a much smaller scale namely the quantified self. Big data and the quantified self could be compared to a telescope and a microscope. Both use the same principles to amplify the ability of humans to observe but on totally different magnitudes. The quantified self is a movement of people that make use of self-tracking tools to measure physical performance or vital signs for self improvement and was first described by Wired editor Gary Wolf[19]. Noticing the great momentum the movement was having Gary Wolf founded together with his fellow editor Kevin Kelly the Quantified Self Labs[20]. Even though people have been tracking themselves through the centuries and the improvement of performance by solely knowing one is being observed has been also been studied[10], the technological improvements in sensor development has made the process of gathering activity data much easier. So much that anybody with a smartphone can start tracking his own activity. Advocates of the quantified self movement see in this practice a tremendous potential for solving health challenges through big data[15].

It is therefore of great interest to develop new visual representations for the increasing amount of personal data available. The challenge for these visualizations is that they can engage people in a more deeper level as the data treated is a reflect of their own behavior. For this purpose designers and engineers have been taking advantage of digital fabrication systems, in particular 3D printing, to translate their visualizations from the screen to physical space. Activity sculptures have shown to be a suitable visualization for communicating abstract data into a tangible object. While it can be discussed about the usefulness of such an object is mainly determined by the information it can convey[21], activity sculptures have shown to influence people's behavior positively[8]. Other valuable characteristics of activity sculptures is the interaction possibilities and their physical properties[21]. Simply by being physically constructed they can approach the natural instinct of interacting with objects through touch, by feeling its material and exploring its surface and structure.

As discussed before, one key aspect in the process of modern data visualization is that the interaction with the visual representation of the data occurs on a computer-aided system. One approach that has proved to be efficient in aiding users to manipulate objects to their specific need is the configurator. This tool supports the product configuration process satisfying every design and configuration constrain set by the manufacturer[7]. The development of configuration systems originated from the mass customization paradigm, that establishes a business model in which companies massively manufacture individually customized goods[3]. This paradigm is divided in different methods that offer each different degrees of freedom to customers. Out of this method the collaborative customization or the co-creation method uses of software tools that allow the customer to transfer their preferences directly to the product[13, 12]. Most of the configurators are deployed as web applications, in large due to the scalability and accessibility of web systems. Advancements in web technologies allow manufacturers to build more complex configuration systems. Because the configurator's degree of user friendliness can have a positive or negative impact on the completion of a sale, it is important to companies to understand how to guide the customer in a meaningful way to complete the sale[14, 1]. The work-flow proposed in research is usable to ensuring the successful guidance of the user throughout the process of developing a product suited to his needs. This same knowledge could be applied to the development of a visualization system.

To summarize this section, the motivation of this work could be resumed as follows. The increasing desire to quantify every aspect of the self and the advancements in digital fabrication open the field for a new kind of visualizations residing in physical space out of the constrains of the screen. This is a challenge for the data visualization field that can be addressed through co-creation production techniques and best practices to develop a software tool that includes the user in the process of achieving a visualization that is aesthetically and functionally meaningful.

1.2 Goals

The main goal of this work is to develop a system that can guides intuitively the user in each process of the visualization of his activity data. This all includes importing the activity data of the user and processing it in order to be visualized in a sculpture which will be further manipulated to users preferences and exporting it for 3D print. The aim of the web configurator is to perform all these tasks providing the user the best experience possible. For this the development of interaction concepts, that guide users through each step of the configuration process, plays an important role in the achievement of an enjoyable platform. Another goal is to ensure the interaction concepts in the prototype are understandable and easy to grasp. In order to achieve this goal users feedback was taken into account through user studies and questionnaires. The diversity of users chosen for the studies was made possible through local testers and through an online demo of the prototype. Furthermore the design of an activity sculpture that shows high variability in the configuration possibilities was an objective kept in mind throughout the prototyping phase. In order for the system to respond fast to user input a special set of technologies was needed. This work aims to take advantage of current edge technologies by implementing them in the prototype.

1.3 Content overview

The presented work takes the following structure. Chapter 2 presents current configurators in different fields of the industry and academic research. Further on current projects related to activity sculptures will be discussed. The final section of the chapter presents an analysis of activity data sources and current implementation of available fitness tracker APIs. In Chapter 3 the prototype design process will be presented. For this sketches and concepts for both sculptures and the configurator will be explained concluding with final thoughts about the final decision making. Chapter

4 deals with the development and implementation of the prototype. In this chapter the prototype's architecture and special features will be discussed. Chapter 5 is focused on the design and execution of the user study concluding with a discussion about the results and findings of the study. Chapter 6 concludes this work and chapter 7 states the ways on which this work can be further developed.

2 Related Work

In this chapter projects related to product configurators and activity sculptures will be presented. Each work presents a unique solution to the addressed problem, the approach each author took will be discussed and the adaptation of useful knowledge to this work will be explored. To conclude the chapter an overview of available vendor API for data import will be presented.

2.1 Web-based Interactive Product Visualization

This work has a particular interest in product configurators that make use of 3D computer graphics to visualize the product. The majority of modern web configurators are image based and make use of well designed backgrounds to place the product in well perceived environment. For example the UNU© GmbH electric scooter configurator puts the scooter on a street background that changes as the user moves to the next step of the configuration (fig.2.1). Other systems may opt for a more minimalistic look, and will try to isolate the product and place it in a white background as seen on figure 2.2. Although this might work for some products the user still misses some of the benefits of interacting with a spatial representation the products[18]. One of the main challenges of developing configurator systems is the modeling of the relation between the product configuration and its visual representation and the correct rendering of the visual representation in real time[4]. The advantage of a 3D visualization system over an image based one, is that the different configurations can be generated on the fly instead of using complex logic systems to retrieve the correct image combination from an image database. On the following section, three product configurators will be presented that use novel 3D visualization technologies to offer users a robust interactive tools for designing unique products.

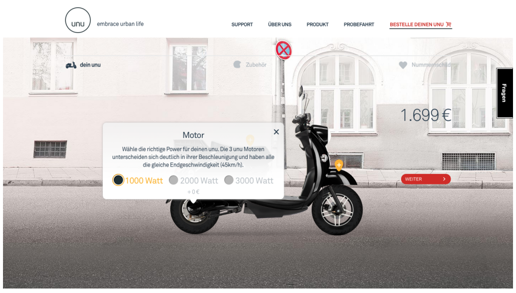

Figure 2.1: UNU GmbH© electric scooter web configurator[6]

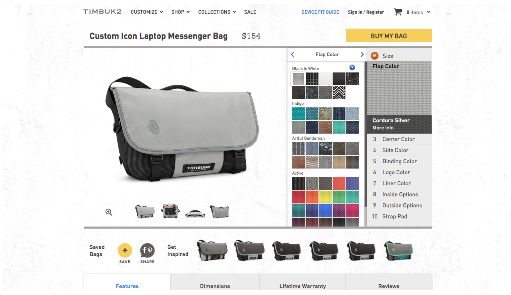

Figure 2.2: Timbuk2© bag web configurator[17]

2.1.1 Gates 3D Configurator

As part of an action-research project from Living Lab[11] Rolland et al.[14] developed a gate configurator for the French company Groupe Maine's gates. The objective of the authors was to showcase the possibilities of 3D Web technologies in e-commerce applications. The developed tool was build with the Unitiy3D[16] game engine, a flexible tool principally build for game development but it has proved to be also useful for architectural visualization and graphic intense web applications. After a user has logged in to the configurator, the platform allows customers to select from a variety of gate styles visualized as 3D models placed on the right side controls (see fig.2.3). The user has also the option of setting the environment in which the gate is being placed (left side controls). This can happen by either selecting a predefined environment of by uploading a picture of the user's home or place where the gate shall be installed later. Customers can position the gates in the uploaded photograph by operating dedicated slider controls. The main advantage of allowing customers to upload their own images is that this allows them to have a better idea of how the selected gates will look in the final environment making them feel more comfortable about their decision. The authors state that they preferred the superimposition of a custom image rather than letting the user customize the environment with threes or buildings to make it look as close as possible because of the possible frame rate drop produced of handling many models and generating and because it is quite rare that somebody has a 3D model of his home.

One of the main aspects of the gates configurator in respect to the research purposes the authors had, was that of developing a tool that improved the visualization of products with the end of encouraging the purchasing of the product in an online medium. To validate the design ideas behind the gate configurator and analyze the impact it had on customers, the authors performed an empirical evaluation. The results of the 27 evaluated participants showed that the manipulation of objects in 3D space seem naturally and was also confirmed to be important to the participants to have this option. This shows that having a realistic view of the product improves the chances of sale. now working again

Figure 2.3: Groupe Maine's configurator[14]

2.1.2 Makervis

2.1.3 Twikit

2.2 Activity Sculptures

2.2.1 Sweet Atoms

2.2.2 Mental Fabrications

2.3 Activity Data Sources

2.3.1 Fitness Tracker APIs

3 Prototype Design

3.1 Requirements

3.2 Sculpture Design

3.2.1 3D Graph

3.2.2 Activity Landscape

3.2.3 Activity Flora

3.2.4 Activity Vase

3.2.5 Prototype Validation

3.3 Configurator Design

3.3.1 Ideation Process

3.3.2 Prototype Validation

4 Implementation

4.1 Requirements

4.2 Technology

4.3 Architecture

4.4 Configurator

4.4.1 Sculpture Manipulation

4.4.2 Sculpture Generation & Rendering

4.5 Backend

4.5.1 Withings API Integration

4.5.2 Data Processing

5 User Study

5.1 Study Design

5.2 Questionnaire

5.3 Participants

5.4 Procedure

5.5 Limitations

5.6 Results

6 Conclusion

7 Future Work

List of Figures

LIST OF FIGURES

References

[1] E. Abbasi, A. Hubaux, M. Acher, Q. Boucher, and P. Heymans. What's in a web configurator? empirical results from 111 cases. University of Belgium, 2013.

[2] S. K. Card, J. D. Mackinlay, and B. Shneiderman, editors. *Readings in Information Visualization: Using Vision to Think*. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1999.

[3] A. Felfernig, L. Hotz, C. Bagley, and J. Tiihonen. *Knowledge-based configuration: From research to business cases*. Newnes, 2014.

[4] M. C. Felice, J. B. Ferreira Filho, M. Acher, A. Blouin, and O. Barais. Interactive visualisation of products in online configurators. *17th International Software Product Line Conference co-located workshops*, 2013.

[5] J. Gantz and D. Reinsel. The digital universe in 2020: Big data, bigger digital shadows, and biggest growth in the far east. *IDC iView: IDC Analyze the Future*, 2007:1–16, 2012.

[6] U. GmbH. Unu embrace urban life, 2014. last accessed 20-05-2015, `https://unumotors.com/get-your-unu.html`.

[7] G. Hedin, L. Ohlsson, and J. McKenna. Product configuration using object oriented grammars. In *System Configuration Management*, pages 107–126. Springer, 1998.

[8] R. A. Khot, L. Hjorth, and F. Mueller. Understanding physical activity through 3d printed material artifacts. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, pages 3835–3844. ACM, 2014.

[9] V. Mayer-Schönberger and K. Cukier. *Big data: A revolution that will transform how we live, work, and think*. Houghton Mifflin Harcourt, 2013.

[10] R. McCarney, J. Warner, S. Iliffe, R. van Haselen, M. Griffin, and P. Fisher. The hawthorne effect: a randomised, controlled trial. *BMC medical research methodology*, 7(1):30, 2007.

[11] E. N. of Living Labs. European network of living labs, 2014. last accessed 21-05-2015, `http://www.openlivinglabs.eu/aboutus`.

[12] F. T. Piller. User innovation: Der kunde als initiator und beteiligter im innovationsprozess. *Drossou, O., Krempl, S.(Hg.): Open Innovation. Freier Austausch von Wissen als soziales, politisches und wirtschaftliches Erfolgsmodell. Hannover*, pages 85–97, 2006.

[13] B. J. Pine. *Mass customization: the new frontier in business competition*. Harvard Business Press, 1999.

[14] R. Rolland, E. Yvain, O. Christmann, E. Loup-Escande, and S. Richir. E-commerce and web 3d for involving the customer in the design process: the case of a gates 3d configurator. In *Proceedings of the 2012 Virtual Reality International Conference*, page 25. ACM, 2012.

[15] M. Swan. The quantified self: fundamental disruption in big data science and biological discovery. *Big Data*, 1(2):85–99, 2013.

[16] U. Technologies. Unity game engine, 2015. last accessed 21-05-2015, `http://www.unity3d.com`.

[17] Timbuk2. Timbuk2 custom classic messenger bag, 2014. last accessed 20-05-2015, http://www.timbuk2.com/customizer#/product/18-custom-classic-messenger-bag/size/2/customize.

[18] A. Vande Moere and S. Patel. Analyzing the design approaches of physical data sculptures in a design education context. *Visual Information Communications International (VINCI'09)*, 2009.

[19] G. Wolf. Know thyself: Tracking every facet of life, from sleep to mood to pain. *Wired Magazine*, 24(7):365, 2009. http://archive.wired.com/medtech/health/magazine/17-07/lbnp_knowthyself?currentPage=all.

[20] G. Wolf. The quantified self, self knowledge through numbers, May 2012. last accessed 19-05-2015, http://www.quantifiedself.com/.

[21] J. Zhao and A. V. Moere. Embodiment in data sculpture: a model of the physical visualization of information. In *Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts*, pages 343–350. ACM, 2008.

Appendix

A Online Questionnaire

B User Study Results

B.1 Questionnaire Results

B.2 Heat Map Images

C Prototype Sketches

C.1 Sculpture Prototypes

C.2 Web Configurator Prototypes

Contents of the enclosed CD

Thesis

- LaTeX Document
- PDF File

Presentations

- Initial presentation
- Final presentation

Activity Sculpture Web Configurator

- Prototype sketches
- Source code
- Gitlab and Github mirrors
- Instructions for deployment
- Login Data

Sculptures

- Prototype sketches
- .stl 3D print ready example files

User Study

- Questionnaire
- Results
- Heat map images