INTERACTIVE FASHION: CREATION & OPTIMIZATION OF DIGITAL INTERACTIVE MEDIA FOR FASHION CLOTHING

Stefano Padilla, David A. Robb and Mike J. Chantler[1]

ABSTRACT

We present a new media based on stop-motion animation and direct interaction for fashion clothing. This media is twice as helpful, more engaging, smaller in size, and better at communicating characteristics of materials compared to a set of images or video. Furthermore in this paper we discuss new work optimizing the outputs in terms of media size for fashion clothing. Finally we report some case studies of the media in the wild and future applications.

KEY WORDS

Fashion; Interactivity; Media; HCI; Presentation; Communication; Engagement.

INTRODUCTION

In recent years the fashion marketplace has been transformed as a result of new technologies, channels and attitudes. Today's consumers are presented with a variety of options (store, website, mobile, catalogue or a combination of these choices) on their shopping journeys (Grewal 2009; Doherty 2010; Drapers 2012; Mathwick 2002). In addition, the widespread trend of retailers and consumers towards online shopping has diversified the consumers shopping experience; it is no longer the case that consumers are being limited to visit 'bricks and mortar' shops to buy clothes. In this new marketplace environment retailers should aim to constantly improve their presence throughout all channels, using new technology if required, to succeed.

As consumers become more confident with online technologies and the forthcoming Gen Z[2] gains buying power, retailers will be forced to improve their online presence to retain and gain new consumers. Verdict (2010) predicted that advancing and improving consumer experience (online and mobile) would play a key part in maintaining consumer loyalty in a competitive marketplace. In addition, Schifferstein et al (2005) demonstrated that consumers acquire most information about products through vision and touch. As a result, we believe it is imperative that retailers communicate these two pieces of information (vision and touch) from the real to the digital world to improve the online consumer experience.

It is well known that numerous aspects of fashion clothing are difficult to convey in the online domain. Limitations in the medium and the users' end-devices cause the main difficulties. It is also very common to lose characteristics and properties (e.g. gloss, stretchiness, weight) when converting clothing from the real to the digital world. In most cases consumers are only shown one or a collection of static images for a real piece of clothing. However these lack common features humans use to judge clothing, such as:

- **Flow**, where qualities of fabrics (e.g. weight, thickness or drape) are lost to subjects because they can't observe at first hand the interactions between the fabric and its natural flow.
- **Movement**, transitional details such as stretchiness, tightness or comfort normally seen by subjects when the fabrics are in motion are lost in pictures.
- **Motion disparity**, solves material properties like gloss, shininess or speckle.
- **Personality**, of a brand can be restricted on single images and deprive the presentation of attitude, charisma or charm.

[1] School of mathematical and computer sciences. Heriot-Watt University, Edinburgh, UK.

[2] Generation Z or 'digital natives' is the group of people born from the early 2000s to the present day. Most members of this generation are highly connected as a result of using media technology throughout their life (Schmidt 2008).

Figure 1: It is difficult to imagine the flow and motion of fabrics-only images as media. At the same time material properties and personality are lost compared to seeing the real dress.

Lee et al (2010) also reports negative effects in consumers' enjoyment when online presentations do not fully match the actual items. Therefore, we believe a new kind of media is required that can overcome all the deficiencies of images as previously discussed and shown on *figure 1*.

Although there has been an increase in the use of video to demonstrate clothes and fashion, video is still complex and costly to produce. Furthermore, the size of these media is not well suited for mobile devices. Therefore, our aim was to build some new media which could be accessible to individuals without the need of expensive equipment (Padilla, 2011). To further bridge the perceptual gap between the real and online world we decided to also incorporate further advances in touch gestures by incorporating interaction into our media.

Our method consists of filming a very short action (5 - 15 second), followed by the transformation of it into stop-motion animation. A gesture is then linked to the action to allow for user's interaction with the presentation. Finally, the media is compressed and the final product is encapsulated for general distribution.

In this paper, we present the evaluation of this new media in terms of engagement; followed by experiments optimizing the media, using real designs from three different fashion shows. In addition, we present examples of the media being used as case studies and finally we discuss further uses of our new media.

We believe our interactive media will increase engagement in users, help reduce returns of clothing in online shopping and reduce the perceptual gap between the real and the digital world.

This paper is organized as follows. In section '*new interactive media*' we first describe the design decisions behind the media. A simple description of how the media can be created forms section '*creating shoogles*'. The next section '*evaluation*' tests the efficacy and engagement of the new media compared to a set of images. The section in '*optimization*' describes how the media can be compressed for faster delivery. In section '*feedback and market research*' we discuss further uses of the media as a medium to gather consumers' feedback. Section '*case studies*' describes various applications of the new media. In the final section we discuss '*conclusions and future work*'.

NEW INTERACTIVE MEDIA

Presenting a garment using single static images allow users to get a good understanding of the object's essence. The interpretation of these static images; however, can be ambiguous due to the impoverishment in the communication channel compared to experiencing the real garment in a shop.

The bas-relief ambiguity on images is one of the disadvantages of using images. This ambiguity is caused by light sources producing identical shape shading and shadowed regions from different light locations as described by Belhumeur et al (1999). Therefore, shape of cloths or materials can sometimes be unclear to observers when looking only at images of a garment. Light discrepancies as noted by Chantler (1995) can also change how materials are perceived. For example, a material illuminated from a shallow (almost parallel) angle will look completely different to the same material shown with a perpendicular light. Furthermore, many of the material properties can also be difficult to discern from a single view angle. Wendt et al (2010) reports the discrepancies in perception of gloss in materials seen using single images.

Most of these disadvantages can be resolved by adding a small amount of motion or a shoogle[3] to the object as described by Wendt et al (2010), Sakano et al (2010) and Gibson et al (1959). Furthermore, Padilla (2008a; 2008b) discovered that in free environment subjects prefer to handle 3D objects at only around a 60-degree angle between the light position and the main surface normal as seen on *figure 2*. Also, the preferred prototypical movement over time resembles a wobble of just a few degrees around the preferred slope as shown on the second part of *figure 2*.

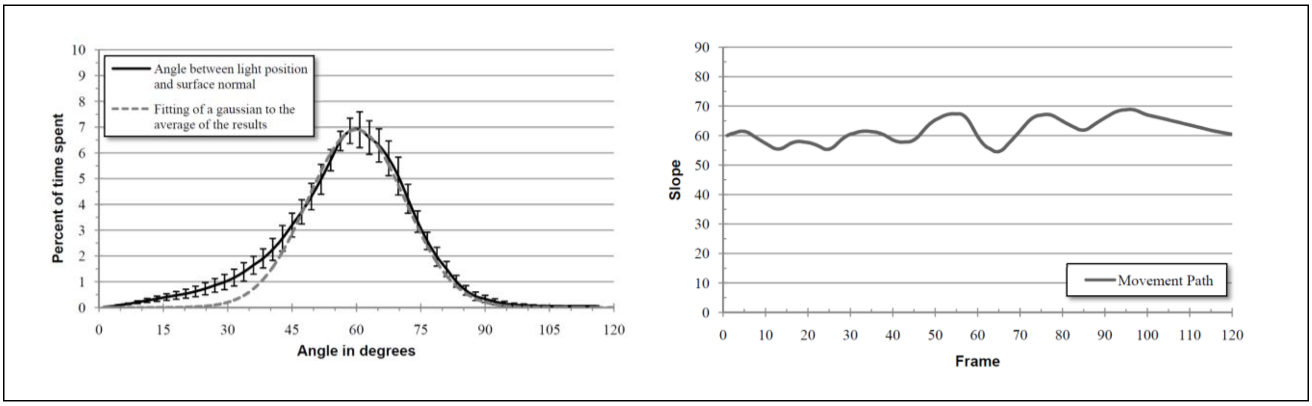


Figure 2: On the left, the aggregated preferred viewing angle in relationship to the light angle from various observers. On the right, the prototypical movement over time resembles a shoogle movement.

One could use video to represent small motion; however, non-interactive videos of motion do not work as well as it is known that people get very anxious when they can’t control things on an internet browser, as noted in the Nielsen et al (2009) studies. Our media improves on video by allowing users to interact with an animation replicating natural short motions and naïve interactions. Moreover, Park et al (2008) reported an increase in cognitive and affective responses from rotational product presentations in an online environment.

To encapsulate the concept of our media, shoogles[4] can be described as interactive objects produced from short videos (or a sequence of images) of an object in motion. In shoogles, users can control an action of the object using simple view-control gestures (see *figure 3*). In the next section we clarify the steps for creating media and the design considerations of our creation tool.

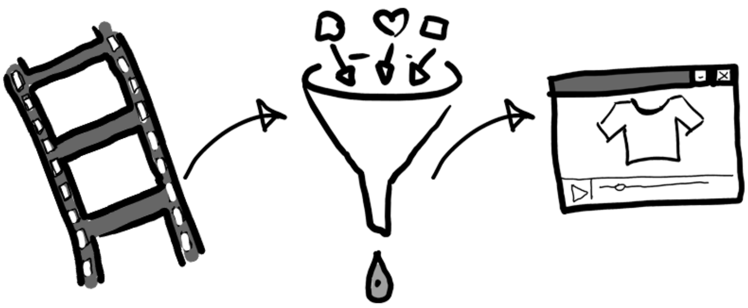


Figure 3: Simple diagram encapsulating the media concept. We start with a short video, add interaction and output the compressed media.

CREATING SHOOGLES

Our aim was to produce a tool that would enable anyone to create our new media (shoogles) with ease. We named our tool Shoogleit (Padilla 2011); the main aim was to build a web-based tool for use on desktop and multi-modal devices, which could be accessible to individuals and small business without the need for purchasing expensive and specialized

[3] Shoogle (verb), dialect chiefly Scot: to shake, sway or rock back and forth.
[4] We use the term shoogles to describe the output media from our tools.

equipment. *Table 1* below describes some of the criterion we adhered during the development process to achieve our aims.

Development criterion	Explanation
Simplicity	The interface had to be as simple as possible for individual. To achieve this criterion we developed a creation interface that mimics a filmstrip. Users can add, cut or reorganize frames in an analogous process to the real physical technique.
Web tool	Our creation tool (Shoogleit) runs online as a web tool using Adobe's Flash technologies, as it is most common on desktop computers (96% compared to around 60% of HTML5 browsers). A fully compliable HTML5 interface is currently under development partly due to the high adoption of this new standard from various browsers.
Multiple devices	We separated the media's data from the player to enable viewing in multiple devices. At the moment, shoogles run on all Flash enabled devices including mobiles (Android 2.2), in all Apple iOS devices using HTML5 or as an app running in native code (Orzechowski 2012; Padilla 2012).
Share and embed	Search engines around the world index Shoogles daily. Moreover, anyone can share and embed them on their Facebook, Twitter, website, e-shop or on eBay.
Quick	Optimizations to the media (as described in the next section of this paper) allow us to produce media that is better suited for mobile devices and users with reduced internet bandwidth (e.g. rural areas).

Table 1: Design considerations when developing the Shoogleit tool.

Figure 4: On the left, link to the main tool website (http://www.shoogleit.com). On the centre, QR code links to some examples of interactive fashion (http://bit.ly/interactive_fashion). On the right, the link points to our free iOS app (http://www.shoogleit.com/app).

Our interactive media creation tool is currently available online and it is free to use for everyone. Users can also download our free iOS app to store and play media in Apple devices. Furthermore, the media can be shared on most social media and be embedded into blogs, websites or eBay. Below is a short description about creating fashion shoogles; however, there is no experience like learning something hands on, hence *figure 4* links to the various tools.

Figure 5: Photographs of our simple camera and light setup that was used to capture the Heriot-Watt University 'Representation: Presentation' fashion show.

We decided to first experiment with simple rotations as interactivity for fashion garments. We use a single Canon 5D mark II camera, a HiLite lighted background, and a set of Elinchrom constant lights for our setup (see *Figure 5*). The lighted background was used to create the pristine white background feel to our media. The lights positions resemble three-point lighting (key, fill and back light) and our camera was in the centre of the scene but tilted 90 degrees to improve the fit of the models to the camera frame. Our setup is very simple and standard; however, we encourage users to develop their own style.

The steps to create a simple media are described in depth in our tool's website (including video tutorials); however, the steps are enumerated below for comprehensiveness:

1. **Upload** short video or sequence of images.
2. Wait for the video to be automatically **split** into frames.
3. **Add**, **crop**, **edit** or **fix** frames to smooth out the animation.
4. **Link** interaction to motion of the frames.
5. Tune direction and speed of the **interaction**.
6. **Publish** and share the new media.

We defined the behaviour of the interaction in the media using the combination of two fundamental formulas (linear motion and friction) as described on *formula 1*. Users can edit the constant of speed (*K*) to match their animation. The friction constant is set to a low decay but increases drastically to simulate natural friction when users hold their finger (or mouse pointer) on the animation.

$$M_f = K\,.\,(\,V_i + \frac{1}{2}at^2\,)\,.\,(\,\mu_f\,.\,N\,)$$

Formula 1: Interaction linked to animation formula, where M_f=the distance as frames, K=speed of interaction, V_i=initial velocity, a=acceleration, t=time in frames per second, μ_f=friction coefficient and N=normal force.

EVALUATION

The efficacy on the media was evaluated using eye-tracking techniques to measure the engagement time when observers gaze at some interactive fashion design. A simple questionnaire was used to quantify the helpfulness of the media presentation. Ten volunteers from Heriot-Watt University (mostly students) took part in our experiment in exchange for Amazon vouchers. The group consisted of 4 female and 6 male volunteers from ages 25 to 35 years. This group represents a similar group to one of the top spending groups online according to Verdict (2010).

In our experiment, each subject was exposed to various objects including prototypical fashion clothing, art and toys. The stimuli was presented either as a set of pictures (taken from different angles) or as an interactive media. Subjects were then asked to complete a questionnaire for each presentation. In the questionnaire, subjects were asked to rate the helpfulness of the presentation for 10 independent scales (weight, size, material, flexibility, texture, durability, softness, build quality, details and purchasing decision). Gaze information for each presentation was also collected using a Tobii TX300 remote eye tracker (Tobii, 2013). Subjects were allowed to take as long as desired to observe the stimuli and complete each questionnaire.

Five-point Likert scales were used to capture each of the ten judgements from the volunteers. Our main aim was to discover whether (or whether not) subjects perceived the media to be more helpful than a set of static pictures. Engagement was measured as time-spend looking at each presentation. The areas of interest matched the actual stimuli size shown in each presentation. The Tobii I-VT fixation filter (Olsen, 2012) was used to discern between saccades and fixations.

We tested the results from our subjects using a two-sided chi-square test, whilst engagement time was analysed using a two-sided t-test. From the analysis we were able to demonstrate that:

- **Helpfulness**, there is a significant association between the type of media and whether the subjects found it helpful $X^2(4) = 35.08$, $p < 0.001$. Based on odds ration between the two presentations (images and interactive media), the odds of subjects finding the presentation more helpful was 2.15 times higher if they were presented with the interactive media than if they were shown pictures. For clothing the subjects found the interactive media 2.65 times more helpful than the set of pictures.
- **Engagement,** on average the subjects spent significant more time paying attention to the interactive objects ($M = 71.65$, $SE = 6.01$) than looking at the set of pictures ($M = 51.46$, $SE = 3.92$), $t(98) = -2.812$, $p < 0.01$, $r = 0.3$. This shows subjects spend a third more time engaged with the interactive media than with the set of images. Furthermore for clothing, the subjects spend on average of 60 seconds judging at each interactive presentation.

To further explore consumers' engagement in an online environment, we measured the average time various subjects spent looking at interactive products on websites. The subjects were from random backgrounds and we capture 100 measurements per category. The average time looking at shoogles was almost 2 minutes (117.94 seconds, SD=83) and for fashion clothing the average time spent was more than a minute and a half (94.16 seconds, SD=42).

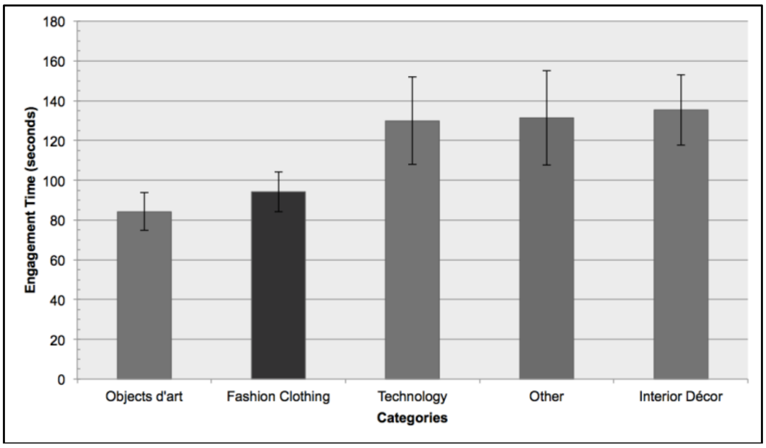


Figure 6: Average time spent looking at certain categories of interactive media.

Our experiments, therefore, confirms that subjects encountered the interactive media more helpful than a set of images. The subjects were also more engaged when interacting with the presentations in an online environment. We would like to note that even though interactive media was perceived as more helpful and engaging, we believe our media should not replace images but instead complement them.

OPTIMIZATION

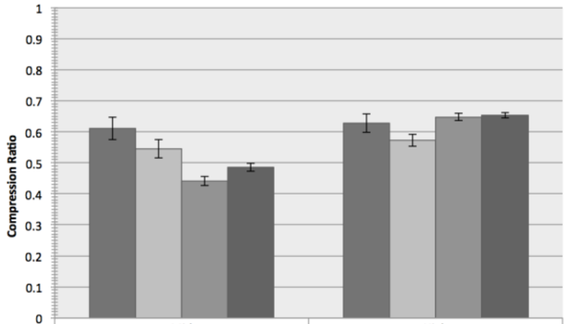
Our main aim to investigate optimization was to reduce the file size of the media. Smaller files are better suited for mobile devices and low bandwidth areas (e.g. rural or remote areas), as they load faster reducing user wait times and irritation. For our optimization experiments we analysed prototypical presentations of fashion designs. The stimuli included common characteristics from fashion shots like solid backgrounds and models spinning around, characteristics commonly seen on fashion catwalks.

The experiment analysed two compression methods that use only ready-available software components. We purposely avoided writing our own proprietary codecs, as they will never be hardware optimized and as so diminishing any gains by taking longer to decode our media. Our two methods consist of:

- **Simple compression**, entails compressing the frame images using JPEG lossy compression (Borenstein, 1992) to reduce the image sizes. Then a Deflate loss compression algorithm (Deutsch, 1996) is applied to the data to reduce structure repetition.
- **Between frame compression,** consists on grouping similar individual lines of the frame sequence before it is compressed into JPEG with the aim to improve compression on repetition and co-occurrence in the data. Finally we will apply the Deflate compression algorithm to reduce on structure repetition.

For our experiment we used stimuli 120 interactive designs from 3 different fashion shows. Each design was compressed using our two methods for two resolutions (1080 and 600 pixels tall). In addition, we tested two compression qualities (Q=50 and Q=80) for the JPEG algorithm. To evaluate our compression methods, we compared each of our 960 combinations (120 designs x 2 methods x 2 resolutions x 2 qualities = 960) to a video compressed using H.264/MPEG-4 (Sullivan, 2005) of around 3 to 5 seconds of each design with normal comparable quality (e.g. YouTube 1080p bandwidth is 8Mbs).

From our evaluation we can demonstrate that, for fashion clothing, our compression algorithms produce file sizes about half the size compared to video (see *figure 7*). From the proposed two methods, our between frame compression produces better results; however, the small difference between file sizes can be negated by the extra processing time required. As a result, we recommend our method of simple compression as it reduces complexity whilst still producing good compression ratios.



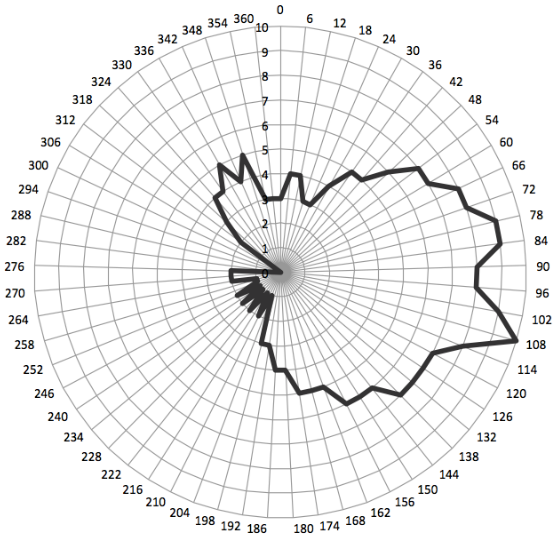
	Mid	High
Simple Compression (1080)	0.61057352	0.627621435
Between Frame Compression (1080)	0.54477465	0.572130481
Simple Compression (600)	0.44140987	0.647467311
Between Frame Compression (600)	0.485779363	0.653073998

Figure 7: Average ratio values for our different compression algorithms and qualities.

It is worth mentioning new technologies in video including HEVC H.265 will half video file sizes as reported by Ohm et al (2012). However, we can also apply new image compression algorithms to our methods like WebP (Google, 2012) to also reduce our file sizes. Furthermore, the interaction element from our media will still be present compared to normal video files.

FEEDBACK AND MARKET RESEARCH

A different advantage of interactive animations is the ability to record and track extra information from users. On the evaluation section of this paper we described using interaction time to measure engagement. It is also possible to record frame angle in rotations to capture market research. Moreover, using eye-tracking technologies and ray-casting techniques we can create a 3D heat cloud showing interest areas for a design.



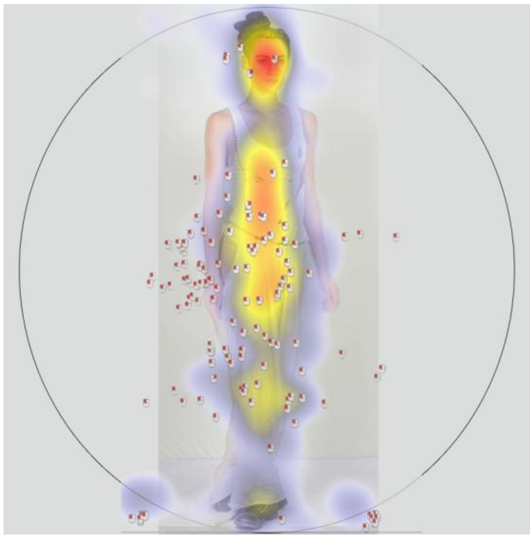


Figure 8: On the right, an example of view angle recording. On the right, an example of one angle from a 3D heat cloud using eye-tracking recordings.

CASE STUDIES

There are hundreds of examples of interactive fashion designs on our website. Below we describe three example case studies of our media used in the wild (graduate fashion show, archives and exhibitions).

Heriot-Watt University's Graduate Fashion Shows, every year Design and Fashion graduates get the opportunity to display their work in public (see *figure 8*). Pictures and videos are generally available after the fashion show; however, it is often the case that these do not have the desired impact or exposure. We were asked to create interactive presentations for all the students' designs with the aim of engaging future students, form an archive base for future reference, and a as learning tool.

Figure 8: Some examples of the design from the 2011 graduate fashion show.

Interactive Exhibits, we created an interactive installation for the graduate exhibition run in conjunction with the fashion shows at Dovecot Studios Edinburgh. In the exhibition, visitors were able to interact with designs from the previous year using multi-touch tables (see *figure 9*). This method of delivery proved very popular with visitors from small children to adults.

Figure 9: Visitors interacting with the media in multi-touch tables.

Paisley Shawls Archive, we had the good fortune to collaborate with the Heriot-Watt's Archive, Records Management and Museum Service (ARMMS) to create interactive presentations from their collection of Paisley shawls. These are items of clothing from 1790s o 1860s loosely worn over the shoulders and upper body originally from the Paisley area. Unfortunately, the size of the shawls limits their exposure. For example some shawls measure 2 meters in width and height, making them difficult to handle and returning then to storage can take hours. A normal flat image is taken to show the shawls; however, they do not represent the shawls accurately as they lack drape and flow. We use our interactive presentations to enhance the archives as shown on *figure 10*.

CONCLUSIONS

We believe that our new media is a simple and inexpensive way of reducing common deficiencies of images and video. Using the methods described it is possible to produce interactive clothes presentations in a matter of a couple of minutes. These clothes presentations are more engaging, twice as helpful, and better communicate the properties of materials. Furthermore, our experiment to optimize the media shows that is it possible to create outputs of a smaller size compared to video increasing the usefulness of the media for mobile devices.

Case studies in the wild reassure us that the media can be used to enhance fashion shows, clothes archives and gallery exhibits. The media in the wild was deemed very helpful and more engaging. Furthermore, tracking enhancements in the media can be implemented to produce market research reports. Also, the use of cloud storage and eye-tracker technologies can give us a further insight into preferences in consumers.

Figure 10: On the left, the shawls are shown on a flat table. On the right, a sample is shown of the interactive presentation, which includes drape and flow.

LIMITATIONS AND FUTURE WORK

It is important to acknowledge improvements that can be added into our media to further evolve it. At the moment, the creation of the media is not fully automated. Work by Nguyen (2013) on video interaction can be implemented into our tool to fully automate the creation process. In addition, even though our tool can play media in desktop and mobile devices, it can only create media from the desktop tool. A version capable of creating interactive media from mobile devices would help up-and-coming designers share their design faster and with greater ease.

Further areas of investigation have already been exposed which will benefit our media. This include multi-gesture interactions as described by Orzechowski et al work (2012), design presentation research as demonstrated by Atkinson et al (2013) and multi-modal interfaces including vibration or sound.

Finally, we would also like to acknowledge that industry can be much segmented in terms of online shopping platforms. As a result, we hope the work presented in this paper serves as motivation to them to create their own distinctive implementation, and further innovate their own interactive fashion.

REFERENCES

ATKINSON, D., ORZECHOWSKI, P., PETRECA, B., WATKINS, P., BAURLEY, S., BIANCHI-BERTHOUZE, N., PADILLA, S., CHANTLER M. “Tactile Perceptions of Digital Textiles: A Design Research Approach” SIGACM CHI, Paris, 2013.

BELHUMEUR, P. N., KRIEGMAN, D. J., & YUILLE, A. L. “The Bas-Relief Ambiguity”. International Journal of Computer Vision. 35 (1), 33-44. 1999.

BORENSTEIN, N., BELLCORE, N., INNOSOFT, F. ”MIME (Multipurpose Internet Mail Extensions)”, Standard Network Working Group, 1992.

CHANTLER, M. “Why Illuminant Direction is Fundamental to Texture Analysis”. IEE Proc. Vision, Image and Signal Processing, 142 (4), 199-206, 1995.

DEUTSCH, P. “DEFLATE Compressed Data Format Specification version 1.3”. Network Working Group, http://tools.ietf.org/html/rfc1951. 1996.

DOHERTY, N.F. AND ELLIS-CHADWICK, F. “Internet retailing: the past, the present and the future”. International Journal of Retail and Distribution Management, 38 (11/12), pp. 943-965, 2010.

DRAPERS. “Drapers E-tail Fashion Report 2012”, Emap, London, 2012.

GIBSON, J. J., SMITH, O. W., & FLOCK, A. “Motion parallax as a determinant of perceived depth”. Journal of Experimental Psychology, 54, 40-51. 1959.

GOOGLE. "Comparative Study of WebP, JPEG and JPEG 2000". Google Code. 2012.

GREWAL, D. AND LEVY, M. “Emerging issues in retailing research”, Journal of Retailing, 85 (4), pp. 522-526, 2009.

LEE, H., KIM, J., Fiore, AM. “Affective and Cognitive Online Shopping Experience”. Clothing and Textile Research Journal, 28, 2, 140-54, 2010.

MATHWICK, C., MALHOTRA, N.K. AND RIGDON, E. “The effect of dynamic retail experiences on experiential perceptions of value: an Internet and catalog comparison”, Journal of Retailing, 78, pp. 51-60. 2002.

NGUYEN, C., NIU, Y., LIU, F. “Direct Manipulation Video Navigation in 3D” SIG ACM CHI, Paris, 2013.

NIELSEN, J. AND PERNICE, K. “Eyetracking Web Usability (Voices That Matter)”. New Riders. 2009.

OLSEN, A. “The Tobii I-VT Fixation Filter”, Tobii Technology, 2012.

OHM, J., TAN, T. “Comparison of the Coding Efficiency of Video Coding Standards – Including High Efficiency Video Coding (HEVC)” IEEE Transactions on Circuit and Systems for Video Technology. Vol 22, 12, 2012.

ORZECHOWSKI, P., PADILLA, S., ATKINSON, D., CHANTLER, M.J., BAURLEY, S., BIAMCHI-BERTHOUZE, N., WATKINS, P., PETRECA, B. “Archiving and Simulation of Fabrics with MultiGesture Interfaces”. HCI2012, People and Computers XXVI, BCS. 2012.

PARK, J., STOEL, L. AND LENNON, S. “Cognitive, affective and conative responses to visual simulation: The effects of rotation in online product presentation”. Journal of Consumer Behaviour. 7, 72-87. 2008.

PADILLA. S. “Mathematical Models for Perceived Roughness of Three-Dimensional Surface Textures”. Ph.D. Thesis, Heriot-Watt University, 2008.

PADILLA, S. DRBOHLAV, O., GREEN, P.R., SPENCE, A.D. AND CHANTLER. M J. “Perceived roughness of 1/f noise surfaces”. Vision Research, 48:1791,1797, 2008.

PADILLA, S., CHANTLER, M. J. “Shoogleit.com: Engaging Online with Interactive Objects”. Digital Engagement 2011, November 15 - 17, 2011, Newcastle, UK, 2011.

PADILLA, S., ORZECHOWSKI, P., CHANTLER, M. J. “Digital tools for the creative industries”. Digital Futures 2012: The Third Annual Digital Economy All Hands Conference. Aberdeen. 2012.

SAKANO, Y. AND ANDO, HIROSHI. “Effects of head motion and stereo viewing on perceived glossiness”. Journal of Vision. 10(9):15, 1-14. 2010.

SCHIFFERSTEIN, HNJ, CLEIREN MP. “Capturing product experiences: a split modality approach” Acta Psychologica 118, 293-318, 2005.

SCHMIDT, L; HAWKINS, P. "Children of the tech revolution". Sydney Morning Herald. 2008.

SULLIVAN, G J.; WIEGAND, T. "Video Compression—From Concepts to the H.264/AVC Standard". Proceedings of the IEEE 93 (1). 2005.

VERDICT. “e-Retail growth set to slow significantly”, press release 24 September 2010.

WENDT, G., FAUL, F., VEBJORN, E. AND MAUSFELD, R. “Disparity, motion, and color information improve gloss constancy performance”. Journal of Vision. 10(9):7, 1-17. 2010.