Virtual Fitting Rooms

by

Carlos Alfredo Becerra Rodriguez

A thesis submitted in full fulfillment for the degree of Master in Software and Systems in the Intelligent Virtual Environments Escuela Técnica Superior de Ingenieros Informáticos

June 2016
Declaration of Authorship

I, Carlos Alfredo Becerra Rodriguez, declare that this thesis titled, ‘Virtual Fitting Rooms’ and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.

- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.

- Where I have consulted the published work of others, this is always clearly attributed.

- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.

- I have acknowledged all main sources of help.

- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: Carlos Alfredo Becerra Rodriguez

Date: June 2016
“In theory there is no difference between theory and practice; but in practice, there is.”

Jan L. A. van de Snepscheut
UNIVERSIDAD POLITÉCNICA DE MADRID

Abstract

Intelligent Virtual Environments
Escuela Técnica Superior de Ingenieros Informáticos

Master in Software and Systems

by Carlos Alfredo Becerra Rodriguez

In the last decade a considerable number of efforts have been devoted into developing Virtual Fitting Rooms (VFR) due to the great popularity of Virtual Reality (VR) and Augmented Reality (AR) in the fashion design industry. The existence of new technologies such as Kinect, powerful web cameras and smartphones permit us to examine new ways to try on clothes without doing it physically in a store center. This research is primarily dedicated to review some important aspects about VFR. Thereby, web browser based and augmented reality based VFR projects are described in terms of their main characteristics, architectures, techniques and algorithms. A comparison table and a classification of existing approaches that have been done in the academia are presented for categorising the studies on VFR in a comprehensive way. Additionally, several technological variants of VFR are described according to the analysed attributes in order to explore what has been done in the market. Furthermore, two research activities were conducted: online and experimental evaluation. The first one basically explores through a survey the user acceptance towards online and in-store VFR based on the Technology Acceptance Model (TAM). The second one essentially explores the user satisfaction based on the System Usability Scale (SUS) and the user experience based on the User Experience Questionnaire (UEQ), regarding two different VFR prototypes. Concluding, interesting aspects for VFRs are explored by means of the classification, the prototypes and the surveys.
En la última década un número considerable de esfuerzos han sido realizados en el desarrollo de probadores virtuales debido a la gran popularidad de la realidad virtual y la realidad aumentada en la industria del diseño de modas. La existencia de nuevas tecnologías como la Kinect, potentes cámaras web y celulares inteligentes nos permiten examinar nuevas formas de probar ropa sin necesidad de hacerlo físicamente en un centro comercial. Este trabajo se centra en revisar algunos aspectos importantes acerca de los probadores virtuales. De este modo, proyectos de probadores virtuales basados en navegadores web y basados en realidad virtual son descritos en términos de sus principales características, arquitecturas, técnicas y algoritmos. Una tabla comparativa y una clasificación de los enfoques existentes realizados en el ámbito académico son presentados para categorizar los estudios sobre probadores virtuales de una manera comprensiva. Adicionalmente, diversas variantes tecnológicas de probadores virtuales son descritas de acuerdo a los atributos analizados para explorar lo que ha sido desarrollado en el mercado. Además, dos tipos de investigaciones fueron realizadas: una investigación online y una investigación experimental. La primera explora por medio de una encuesta basada en el modelo TAM (Technology Acceptance Model) la aceptación de los usuarios para los dos tipos de probadores virtuales: online y en tienda. La segunda explora la satisfacción de los usuarios mediante el cuestionario SUS (System Usability Scale) y la experiencia de usuario mediante el cuestionario UEQ (User Experience Questionnaire), respecto a dos diferentes prototipos de probadores virtuales. Finalmente, aspectos interesantes sobre los probadores virtuales son analizados en términos de la clasificación, los prototipos y las encuestas.
Acknowledgements

Foremost, I would like to express my sincere gratitude to my advisor Dra. Angelica de Antonio for the continuous support of my MSc study and research, for her patience, motivation, enthusiasm, and immense knowledge. Her guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my MSc study.

Besides my advisor, I would like to thank the Polytechnic University of Madrid, its directors, its heads of faculty, for the quality of professors and the content of the Master.

Last but not the least, I would like to thank my family: my parents Alfredo and Consuelo and my siblings Luis and Andrea, for supporting me spiritually throughout my life . . .
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# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>VFR</td>
<td>Virtual Fitting Rooms</td>
</tr>
<tr>
<td>VR</td>
<td>Virtual Reality</td>
</tr>
<tr>
<td>AR</td>
<td>Augmented Reality</td>
</tr>
<tr>
<td>TAM</td>
<td>Technology Acceptance Model</td>
</tr>
<tr>
<td>SUS</td>
<td>System Usability Scale</td>
</tr>
<tr>
<td>UEQ</td>
<td>User Experience Questionnaire</td>
</tr>
<tr>
<td>UTAUT</td>
<td>Unified Theory of Acceptance and Use of Technology</td>
</tr>
</tbody>
</table>
I dedicate this thesis first of all to God and then to my beloved parents Alfredo and Consuelo. I hope that this achievement complete the dream they had for me all those many years ago when they chose to give me the best education they could ...
Chapter 1

Introduction

Technology is improving at a rapid pace, as many things are possible today that were not possible fifteen years ago. Nowadays, some of the impossible things are rising to the occasion in the form of Augmented Reality (AR) and Virtual Reality (VR). Virtual fitting rooms are not the exception of this evolutionary process. Virtual Fitting Room, also frequently referred to as virtual dressing room, virtual changing room or virtual try-on room, is the online or in-store equivalent of a real retailer dressing room. Basically, it enables buyers to try on clothes to check different cloth features like size, fit or style, but virtually rather than physically. The main objective of a VFR is giving the user the idea of how an item of clothes will look on him/her without actually trying it on.

Scope of this research

This research focuses primarily on VFR aspects in the context of the academia and market efforts. A broad coverage of existing work in the area of VFR projects using VR and AR is provided. An online and experimental research were developed through different surveys, models and prototypes to explore the user acceptance, the user satisfaction and the user experience.

Aim of this research

This research aims to serve as a useful guidebook of VFR projects, as well as a point of reference of future work in improving the VFR experience. Furthermore, the objective is to answer the following questions: What is a VFR? What are the requirements to establish a VFR? What are the most relevant VFR benefits and concerns for the user? What research projects and commercial initiatives exist? What is the future for the VFR?
Chapter 1. Introduction

Related work

Probably the most relevant work to this research regarding VR are [1–3]. Regarding AR, [4, 5] and regarding user satisfaction, [6, 7]. However, they just focused in their main project solution without showing an overall review. Furthermore, this research provides a more in-depth analysis of VFR and classifies existing approaches in a comprehensive way.
Chapter 2

Background Information

2.1 General Concepts

The main difference between VR and AR is that VR is all about the creation of a virtual world that users can interact with and should be designed in such a way that users would find it difficult to recognise the difference from what is real and what is not. However, AR is the blending of virtual reality and real life where the users are able to interact with virtual contents in the real world, and are able to distinguish between the two [8].

Some other concepts such as computer cluster and grid computing need to be clarified in order to have a better understanding of the main Virtual Fitting Room projects, as we will see later. A computer cluster consists of a set of connected computers that work together so that they can be viewed as a single system. Unlike grid computers, computer clusters have each node set to perform the same task, controlled and scheduled by software. On the other hand, grid computing is the collection of computer resources from multiple locations to reach a common goal. Grid computing is distinguished from computer clusters because grid computers have each node set to perform a different task or application [9].

2.2 Historical Approach

As we can observe in Figure 2.1 virtual try-on systems have been evolving through the time. Some studies started from 2005 with the simple idea of using the clothes as a two-dimensional plane model because the goal was just to get the clothes’ shape. Then researches faced the problem with computation speedup and scalability so they found other alternatives to achieve that with the use of clusters and grid computing. In the
last five years, due to the fast improvement of web browsers, the computation time has been reducing so that 3D processing and rendering is done with good quality.

As it becomes evident in 2.2 virtual dressing rooms in augmented reality have been studied lately and mostly using the Microsoft Kinect Sensor. Although there is one study (2014-III) using a generic web camera. In any case, researchers are working diligently to improve algorithms regarding the data extraction process, the computation process and the display procedures in order to reach good display effects and real-time performance results.

Succinctly, projects that use an avatar are included into VR whereas projects that capture the image of the person using any kind of scanning device or camera are included.
into AR.

2.3 Comercial Products

The table below (2.1) explains what has been done in regard to commercial virtual fitting rooms from a provider’s perspective.

<table>
<thead>
<tr>
<th>Company</th>
<th>URL</th>
<th>Web</th>
<th>In-Store</th>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zugara</td>
<td><a href="http://www.zugara.com">www.zugara.com</a></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Metal</td>
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<td>Fits</td>
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<td>Trimirror</td>
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</tr>
<tr>
<td>Swivel</td>
<td><a href="http://www.facecake.com/swivel">www.facecake.com/swivel</a></td>
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<td>X</td>
<td></td>
</tr>
<tr>
<td>Fitnect</td>
<td><a href="http://www.fitnect.hu">www.fitnect.hu</a></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Try live</td>
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<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Styliff</td>
<td>-</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Virtual Dressing Room</td>
<td>-</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table 2.1: Table of VFR Comercial Products

A few additional cases for web online retailers are companies like Pretty Green, Dafiti and Barbie, for in-store retailers, companies like Nike, Adidas, Puma and Topshop, and finally for mobile retailers, companies like Styliff and Virtual Dressing Room.

2.4 Characteristics of VFR

According to [1, 2] a successful online VFR should have the following features:

1. Accurate, fast and stable computational models.
2. Fast 3D body modelling.
3. High performance computing infrastructures to provide massive computational resources.
4. Interactive 3D Web browser based display capability.

These characteristics are thoroughly valid for VFR with a VR approach. Although the point number two is not valid for VFR with an AR approach. In general, VFR systems can be roughly divided into 3 major modules. The first one for the data input (body measures), the second one for the processing and the last one for the rendering and simulation ([1, 2, 10, 11]):
1. The body-shape module.
2. The computation module.
3. The exhibition module.

2.5 User Acceptance and Satisfaction

There are some theories regarding user acceptance such as the Unified Theory of Acceptance Use of Technology (UTAUT). It tries to explain the degree of acceptance of the use of information technology. It assesses whether the user will be able to accept the new technology and the user’s ability to deal with it. UTAUT has been used and applied by many educational institutions and research centres to answer one of the most critical questions: What are the user’s attitudes towards accepting a technological solution? UTAUT (Figure 2.3) was formulated by Venkatesh [12], which consists of four main concepts: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC). These four main concepts are independent variables which influence dependent variables, behavioural and usage. Gender, age, experience, and voluntariness of system use have indirectly influenced the dependent variables via the four main concepts. Behavioural intention is seen as a critical predictor of technology use [12].

![UTAUT model](image)

**Figure 2.3: UTAUT model ([12])**

User acceptance and satisfaction related to VFR are key issues requiring benchmarks to measure whether virtual try-on systems meet or surpass user expectation. The work in [7] integrated the UTAUT model and perceived risk into a comprehensive model to assess user acceptance and satisfaction. Therefore they needed to empirically test the
model through a survey. Specifically, that study combined the UTAUT factors and perceived risk to explain users’ intention to use an online VFR in China. In Figure 2.4, it can be seen the factors (initially proposed as hypotheses) that directly influence the user adoption and usage of information technology (in this case, for VFR).

![Figure 2.4: UTAUT model and perceived risk ([7])](image)

Performance expectancy is equivalent to the perceived usefulness. Effort expectancy is comparable to the perceived ease-of-use and complexity. Social influence is equivalent to subjective norm and reflects the effect of environmental factors such as the opinions of a user’s relatives or friends. Finally, facilitating conditions is similar to perceived behavioural control and was measured by the perception of being able to access required resources. Meanwhile, the perceived risk is determined as the degree to which a user believes that he/she will incur a loss while using a VFR because risk perceptions have a significant impact on use intentions. Therefore privacy concerns and security concerns might have a significant influence on perceived risk [7].

In conclusion, the results indicated that performance expectancy, effort expectancy, social influence and perceived risk all have a significant impact on intention to use online VFR. Thereby, security concerns and privacy concerns have a significant influence on perceived risk. The authors concluded that once safe environment is lost, achieving online VFR adoption would be impossible because the entire online VFR process of trying garments online would have lost their credibility from the eyes of the user.
Chapter 3

Virtual Fitting Rooms Projects

3.1 Classification of VFR

As mentioned before in Chapter 1, there is not an explicit classification of existing VFR approaches due to the fact that almost all of the studies focused on showing their main project solution. Our proposal for the VFR classification can be observed in the Table 3.1. It is a comparison table regarding VFR projects that shows an overall review. The classification attributes that are proposed for the analysis will be explained in the next section.

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miracle</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>GOViR</td>
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<td>Footwear</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3.1: Comparison table about existing VFR projects (our proposal)

3.2 Attributes for the classification of VFR Projects

- **Dimension**
  
  It is about whether the VFR garments are in 2D or 3D. A shape would be two dimensional as we would need just two dimensions to describe it, such as the height and width. Three dimensional geometries add the dimension of depth so that they describe objects with volume.
• Person
It is about whether the person who tries on the garments in the VFR is the user or the graphical representation of him/her (avatar). It is closely related with the perceived realism of the VFR.

• Body Measurement
It is about the method employed to input the user’s body measurements, whether it is predefined, provided by the user or gathered by scanning the user itself.

• External Hardware
It is about the type of external hardware used to gather the user input data (movement, body measures). It could be using a simple web camera or the Microsoft Kinect.

• Architecture
Due to the fact some VFR projects employed different types of system architectures (Grid Computing and Local Cluster), the current options are one server, grid and cluster.

• Display
It is about whether the VFR display and simulation are done in a web browser or an external display device.

3.3 Virtual Reality Projects

3.3.1 The MIRACLE System

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miracle</td>
<td>2D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2: The MIRACLE system summary table

In this study [13], they propose a system that obtains the more presence by using clothes as a two-dimensional plane model and capturing the movement of the clothes. They go back to the basic fact that the goal is trying on clothing and the purpose that they need is only clothes’ shape.

The idea behind this system is like we were in front of the mirror looking whether a garment looks well on us. We can observe in the Figure 3.1 the concept image of the MIRACLE system. MIRACLE stands for ”Virtual MIRror and Advanced CLothing Environment”. It basically needs basic image processing to fit the cloth model on the
human body. After the model of clothes is made, the model is changed according to the movement of the person. But the "MIRACLE" system does not need to calculate an enormous computational complexity like three dimension simulation of cloth and accurate human body measurement because it can actually acquire shape from the image as the observational data. Therefore this system can be utilised for achieving real-time image processing.

Finally, they achieved good results in the shape recognition on the surface of two dimensions by measuring three dimensions shape of flexible things.

![Figure 3.1: Concept image of the MIRACLE system ([13])](image)

3.3.2 Grid Computing

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOVFiR</td>
<td>2D</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3.3: The GOVFiR system summary table

In this research [11], the key techniques for Grid computing based Online VFR and its hierarchical architecture are discussed. The grid infrastructure provides massive computing powers in order to obtain real-time and high fidelity simulation.

As we see in the Figure 3.2, the proposed framework contains three major modules: body modelling module, computing module, and 3D garment module. Among the body-modelling module, a 3D geometric body model is transformed through grid discretization. Then the body motion algorithms and body deformation algorithms are applied to generate the static and dynamic postures of a body. Finally, the static and dynamic postures, as well as the 3D garment module become a complete online VFR.
A body shape can approximately be reconstructed through its key geometric parameters, such as stature, arm length and others. These key parameters make it possible to reconstruct a 3D body in a high-level abstraction with satisfactory precision. With the key parameters of bodies, the user only needs to modify some parameters to change a body shape. After the completion of parameters acquisition, a 3D body using mesh data will be constructed in real time and the 3D model will also be stored in a database server for later use. The main steps for its body modelling are the following:

- **Step 1:** Separate a body anatomy into some key parts (neck, should, chest, waist, abdomen, hip, thigh and arms). A complete database including templates of various kinds of body shapes is constructed in advance with geometric shapes and no specific sizes.

- **Step 2:** Select all parts of body shapes which are most related to the user’s real parameters through a 3D query interface linking to the body shape database.

- **Step 3:** The user modifies his body measure parameters by giving some key parameters or through picture matching (with a video camera).

- **Step 4:** The system connects all the individual parts automatically and a 3D virtual model is created comprising to the user’s real body shape and surfaces.

The system architecture for this system (called GOVFiR) is depicted in the Figure 3.3. A grid computing platform consisting of eight heterogeneous nodes with different OS and hardware configurations were used. So when a user request is processed, the computing data (garments) is decomposed by domains and the contact computations
are decomposed by tasks. In this way, all the tasks and sub-tasks are distributed among servers.

Thus, they proposed a real time VFR based on this grid computing platform to reconstruct a 3D virtual model. Furthermore, the system has obtained good performance such as computation speedup, strong robustness and scalability.

3.3.3 Local Cluster

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Cluster</td>
<td>2D</td>
<td>3D</td>
<td>Avatar</td>
<td>Real Predefined</td>
<td>Input Scanning</td>
<td>Camera</td>
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<tr>
<td></td>
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<td>X</td>
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<td>X</td>
</tr>
</tbody>
</table>

Table 3.4: The local cluster system summary table

In this research [2], some key techniques for cluster computing based online VFR are discussed. The same author of the grid computing VFR proposed this approach, so it is basically the same system infrastructure with parallel processing instead of grid computing and some algorithm enhancements. In this case the system consists in three modules: the body-shape module, the computation and simulation module, and the interactive exhibition module.

Here is the main difference: when the customer’s cloth selection requests is being processed, the computational domain or the garments mesh is partitioned into subdomains. Then the sub-tasks will be processed in parallel by individual cluster node. The parallel tasks and applications can be managed and executed over local or widespread heterogeneous platforms. The experiment result showed that the proposed architecture can achieve real-time, high-fidelity cloth simulation and provide encouraging online virtual fitting experiences. An screenshot of the system can be seen in the Figure 3.4.
3.3.4 Web Environment Based

Two studies cover this approach. In the research [1], several key techniques for 3D VFR systems on web environment including 3D modelling, collision dictation, real-time rendering are discussed; and in the research [10] a web browser based garment and mannequin 3D display system for online cloth virtual fitting room is described including its architecture and related techniques.

The architecture of the research [10] can be divided in three major modules: the geometry description module, the data loading module and the drawing and rendering module. The architecture involves many parts. For geometry description they used a text language for describing 3D shapes called VRML. Regarding the data structure they used a simpler format for fast parsing called HD3. For real-time drawing they used OpenGL. In regard to the organisation of scenes and graphics they employed key frames. Finally for the client side they established a communication between ActiveX Control and Javascript. The experiment result had good display effects and showed that the proposed architecture can be the basis for online virtual fitting rooms. A screenshot of this system can be seen in Figure 3.5.

We can observe in Figure 3.6 that the proposed framework for the research [1] is divided into three main modules: body building module, garments module and interaction module.
For modelling the human body they defined measurements as parameters and hairstyle and color appearance. Measurements such as height, weight, chest waist and hips were used to create a 3D mannequin. To minimise the user’s workload, a pre-defined mannequin template closest to the user’s body shape was selected on the basis of his/her gender and BMI (Body Mass Index). To manage the hairstyle and color of the skin the system provides several samples. Regarding to the garment module it is required to apply accurate physical properties of the cloth to the simulated cloth to model a cloth realistically. The key idea is understand the physical behaviour of the cloth. In regard to the interaction module, the system should manage human motion, cloth animation, collision handling and garment matching. Therefore in order to obtain realistic simulation results the collision handling needs to be performed between garments and the
skin layer of the human body including self-collision detection for cloth’s wrinkle and crumple situations. Finally the garment matching process occurs when the enquiry of the user is matched with the garments database. A screenshot of this system can be seen in Figure 3.7.

![3D VFR system on web environment](image)

**Figure 3.7:** 3D VFR system on web environment ([1])

### 3.4 Augmented Reality Projects

Virtual Fitting Rooms in augmented reality have been mostly studied using a Kinect sensor despite the fact that different vendors created their own complex devices. Nowadays, we can see the use of this cutting-edge approach in apparel stores to enhance the shopping experience. Additionally, as we mentioned before, this is a new field of study because the earlier research with a Kinect was done in 2013. Nevertheless, a study in the 2014 proposed a VFR based on the human pose using a generic web camera.

#### 3.4.1 Kinect Based

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footwear [14]</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*Table 3.6: Kinect based systems summary table*

All the encountered studies used Kinect sensor to create a VFR. The principal difference was in the way they utilised the sensor and the precise goal they wanted to achieve. The research [5] may be considered as one of the first studies that have been done with this approach using the Kinect sensor. Its estimation method for cloth sizes is clearly explained. Due to its high technical content, the algorithms will not be described in detail. The aim of all the researches is to develop new VFR with Kinect sensors such
that 3D model of a cloth track user’s body on a real time. The key idea behind is to first extract the characteristic point (using the contour of the user), then to get the size estimate of the body site and finally verify the precision of the estimated value and its reliability.

In the research [14], they developed a system for design evaluation of footwear using Kinect sensor. Fundamentally, the system allows users to virtually try on 3D shoe models in a live video stream. Here, the Kinect was used to track human foot motion based on color and depth images. They performed two methods. The first one using marker detection (fluorescent markers and RGB spaces) and rough positioning. However, they realised it was not a precise tracking procedure but it was a good initial estimate for foot position and an adequate basis for the second method. The second procedure was markerless tracking. In this approach they overcome the problem of foot location with foot segmentation (foot region is separated from the background). Besides, they used a reference 3D foot model, ICP algorithm (Iterative Closest Point) and model trimming to get over the limited view angle of Kinect. The results were really good because there was a more correct alignment between the foot and the shoe and also a higher computational efficiency due to the ICP exhibited superior positional accuracy. In Figure 3.8 we can see the result of the experiment.

In the research [4], they presented a virtual fitting room framework using a depth sensor, which provides a realistic fitting experience with customised motion filters, size adjustments and physical simulation. The proposed scaling method adjusts the avatar and determines a standardised apparel size according to the user’s measurements, prepares the collision mesh and the physics simulation. In addition, they applied bone splitting
to realistically render the body parts near the joints. All components were integrated ef-
ficiently to keep the frame rate higher than previous works while not sacrificing realism. A screenshot of the system can be observed in Figure 3.9.

![Figure 3.9: Depth map data and the corresponding posture of the user with a virtual cloth on it ([4])](image)

An embedded physics engine within the framework depicts its architecture. The cloth simulation framework utilises the proprietary PhysX engine by Nvidia, specifically these two principal components: the cloth deformation and collision detection modules. The deformation algorithm is based on the position-based dynamics approach, calculating the position of the particles from their previous positions and applying constraints on mutual distance and angle. On the other hand, collision detection between the body and the cloth is based using collision spheres and capsules co-located with body joints and bones, respectively. A human body with the default radii can be seen in Figure 3.10. The user’s body measurements are used to estimate the locations of joints and bones, for collision sphere placement, whereas the radii are used directly for determining the sphere sizes.

![Figure 3.10: A human body with the default radii ([4])](image)
3.4.2 Pose Estimation

<table>
<thead>
<tr>
<th>System</th>
<th>Dimension</th>
<th>Person</th>
<th>Body Measurement</th>
<th>External Hardware</th>
<th>Architecture</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Pose</td>
<td>2D</td>
<td>X</td>
<td>Real</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>3D</td>
<td></td>
<td>Predefined</td>
<td>Scanning Camera</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avatar</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Web</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Kinect</td>
<td>Server</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>Grid Cluster</td>
<td>Web Device</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3.7: Pose Estimation system summary table

In this study [3], a real-time solution to set up an online virtual fitting room using a generic web camera is discussed. The functionality is basically achieved in two steps: the user selects an image of a cloth and then the system captures his/her own video to display the cloth on it. In Figure 3.11 we can observe the user with the virtually fitted cloth.

Their research is very technical but its algorithm can be divided into three main sections: data acquisition, pose estimation and apparel fitting. The data acquisition is gathered by using a generic web camera. The camera first records the background without the moving of the user. Then the user is allowed to be in the field of view of the web camera. Hence using a frame difference, background registration and subtraction methodology and the identification of the high curvature points the human body can be segmented out from the video. The pose estimation is calculated by the identification of the head, end of feet and hands, neck and elbows. Finally the cloth fitting is achieved superimposing the cloth on a human template model (T pose as the initial posture) with some apparel post processing enhancements.

Figure 3.11: The user with a virtual fitted cloth ([3])

3.5 Discussion

It is evident that as long as time was going many new complex techniques were developed and others were improving their predecessors as well. For instance, in the MIRACLE
system, when simulating the model, the authors noticed that the computational complexity of the wrinkles were enormous so they decided to implement a VFR in 2D due to the simplicity, fastness and cheapness. In the grid computing approach they realised that resource management mechanisms, including job scheduling, load balancing and fault-tolerance should have been addressed in order to meet the high-fidelity, fault-tolerant, and real time requirements of virtual try on systems and the performance requirements. Then, they tried the cluster approach due to the fact that the above-mentioned problems were time-consuming and demanded massive computational resources. Therefore they utilised parallel and distributed computing technologies to overcome those problems. Afterwards, with regard to the web based approaches, they achieved that users can view the clothing animation from various angles and even change user’s hairstyle and accessories. Nevertheless, they stated that there is still a long way to go to make the system satisfactory in terms of interactive 3D exhibition and that the user is not necessarily familiar with all of the measurements and not able to measure himself/herself correctly. Authors of the pose estimation research started with the idea that most users do not have any access to a Kinect as a household device so they used a generic web camera to build a virtual try-on system. Then, finally, the Microsoft’s Kinect appeared to be a subject of study and was not used just for scanning complete bodies but also for specific parts such as the design evaluation of footwear research. Kinect based systems showed good stability and efficiency for real time applications.

The conclusion is that through the time many techniques and approaches have been tried to develop virtual try-on systems and somehow they were the basis for the next ones. As technology is evolving new techniques are being discovered and researches are making huge efforts to apply them to enhance VFR experiences.
Chapter 4

Technological Variants

In this chapter six technological variants that have been identified will be shown and described. They are based on the previously analysed attributes for VFR projects. The first two technological variants belong to AR because the user can see himself/herself through the display device and the remaining variants to VR due to usage of avatars (scanned, with the user measures or predefined).

4.1 Variant 1: Real Person + Kinect + Superimpose Clothing

In this variant the user just stands in front of the interactive external display device (it uses Kinect to keep tracking the user movements), then selects his/her favourite clothes and they will appear superimposed on the screen according to his/her body shape. Moreover, the superimposed clothes follow the user movements in real time. We can observe an example of this variant in the Figure 4.1.

4.2 Variant 2: Real Person + Web Camera + Superimpose Clothing

This version differs from the previous variant in the external input and display devices used. In this case, instead of having a big display screen it employs a window in a web browser, and instead of using kinect it is based on the user’s web camera. Obviously, there is a loss of precision and reality due to precarious generic web cameras. We can observe an example of this variant in the Figure 4.2.
4.3 Variant 3: Avatar + Kinect + 3D Clothing

This variant utilises an avatar of the user previously scanned using the Kinect device. Therefore, there is no need to superimpose clothes but show the 3D clothing on the avatar. We can observe an example of this variant in the Figure 4.3.

4.4 Variant 4: Avatar + Input Body Measures + 3D Clothing

This version is completely different from the previous ones due to the usage of input parameters. In this case, the user needs to provide his/her own body measures such
Figure 4.3: TriMirror [triMirrorTV]. (2016, Feb 28). Kinect Virtual Mirror and Fitting Room at Fashion Show [Video file]. Retrieved from https://www.youtube.com/watch?v=YIDT-PpENkY

as height, weight, bust and waist to the system, in order to configure the avatar’s dimensions. We can see an screenshot of this kind of variant in the Figure 4.4.

Figure 4.4: "Metail - Your online fitting room." http://trymetail.com/collections/metail. Metail. Screenshot. 28 Feb 2016.

4.5 Variant 5: Predefined Avatar + 3D Clothing

Regarding the web-based variants this is the simplest one. It just uses predefined avatars and 3D clothes to simulate the virtual rooms. The user can select among different avatars
to choose the one that fits better to her/his appearance. We can observe an screenshot of this kind of variant in the Figure 4.5.

![Figure 4.5: “Try clothes in online dressing room.”](http://glamstorm.com/en/fittingroom/clothes. Glamstorm. Screenshot. 28 Feb 2016.)

### 4.6 Variant 6: Photo + Superimpose Clothing

All the previous variants can be utilised either for online or in-store based virtual fitting rooms but this variant is an attempt to reach a virtual fitting room experience using mobile phones. The user takes a photo of herself/himself and then adjusts the cloth according his/her body shape. We can observe an example of this variant in the Figure 4.6.

Chapter 5

Prototypes

In this chapter the two prototypes that were developed, based on the previous VFR variants, are described.

5.1 Prototype 1: Real Person + Web Camera + Superimpose Clothing

For this prototype we employed the Webcam Social Shopper’s product demo, a VFR application of Zugara. The product URL is the following: http://webcamsocialshopper.com/demos. It basically employs the user’s web camera and superimpose the clothes on the user’s body image. The prototype features according to the classification of VFR are:

- **Dimension:** 2D
- **Person:** Real
- **Body Measurement:** Scanning
- **External Hardware:** Camera
- **Architecture:** Server
- **Display:** Web

An example of a user using the prototype can be seen in the Figure 5.1.
Figure 5.1: A user using the Webcam Social Shopper

5.2 Prototype 2: Avatar + Kinect + 3D Clothing

The goal of this prototype is to show the process to scan a user body with the Kinect, then use the avatar to put on clothes. For this purpose, we employed four different technologies:

- **Kinect**: As the external hardware to perform the body scanning. Kinect V1. The Figure 5.2 depicts the initial user position in front of the Kinect.

- **Kscan3d**: As the software to capture and export 3D scan data. It supports Kinect for Windows. Free 2016 version. An screenshot can be seen in the Figure 5.3. Moreover, the Figure 5.4 represents the scanning process using the Kscan3d and the Kinect.

- **OpenSim**: As the open source virtual world server. Version 0.2.8.1.

- **Firestorm Viewer**: As the virtual world viewer. It has an enormous number of features, options and interface customisation choices. Version 4.7.7.48706. The Figure 5.5 shows the avatar that will be dressed up.

The complete process to scan a human body using Kscan3d will be described. First, the Kinect sensors gather color and depth data. Kscan3d converts Kinect data into a 3D mesh. Then, the user captures data from all angles to create a complete mesh. Then, the software captures and aligns 3D data automatically. The user can delete points and smooth data. Finally, the user exports meshes to common files formats and use them for visual effects, games, 3D printing or web visualisation.
In this case, an academic prototype was developed. A Kinect body scanning simulation was performed making each user be in different positions to gather the meshes from different angles. Moreover, the complete process was explained in details to make students understand but in the final stage a predefined avatar (using OpenSim) was used to change clothes instead. The process to build the full featured VFR take some more development time and additional equipment that we did not count on.

The prototype features according to the classification of VFR are:

- **Dimension:** 3D
- **Person:** Avatar
- **Body Measurement:** Scanning
- **External Hardware:** Kinect
- **Architecture:** Server
- **Display:** Web

![Initial user position in front of the Kinect](image)
Chapter 5. Prototypes

Figure 5.3: Kscan3d application

Figure 5.4: The scanning process using Kscan3d and Kinect
Figure 5.5: The Firestorm viewer showing an avatar that will be dressed up
Chapter 6

Survey

6.1 Technology Acceptance Model - TAM

The technology acceptance model (TAM) is an information system theory that models how users come to accept and use an specific technology. In other words, it is a model that tries to explain why people would choose to use that particular technology in one context. This model suggests that when the users are presented with a new technology, a number of factors influence their decision about how and when they will use it. We can observe in the Figures 6.1, 6.2 and 6.3 the evolution of this technological model. TAM2 includes social influence process such subjective norm, and cognitive instrumental process such as job relevance, output quality and result demonstrability. TAM3 is mostly based on the TAM2 and includes other measures such as perception of external control and perceived enjoyment ([15–18]). A version based on the TAM 3 has also been proposed in the context of e-commerce with an inclusion of the effects of trust and perceived risk on system use ([19]).

Figure 6.1: TAM

Most studies use the TAM in order to evaluate applications by two main measures: perceived usefulness and perceived ease of use. We used the TAM3 as the foundation
Figure 6.2: TAM2

Figure 6.3: TAM3
model of this research. However, we did not use all the measures and selected carefully those ones that were more important for our research instead. Anticipated use was taken from the research [18]. The questions regarding each measure were taken and adapted from [18] and [20]. Finally, the measures we employed are the following:

- **Perceived Usefulness**: The degree to which a person believes that using a particular system would enhance his or her task performance.

- **Perceived Enjoyment**: The extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use.

- **Perceived Risk**: The degree to which a user believes that he/she will incur a loss while using a VFR because risk perceptions have a significant impact on use intentions.

- **Anticipated Use**: The degree to which a person feels beforehand the usage of a particular system.

## 6.2 System Usability Scale - SUS

The System Usability Scale (SUS) provides a reliable tool for measuring the user’s satisfaction. It includes 10 items using a five-point response scale from strongly disagree to strongly agree. SUS has become an industry standard with lots of references. The main benefits are: easy scale to administer to participants, can be used on small sample sizes with reliable results and it is valid (helps to differentiate between usable and unusable systems). SUS has generally been seen as providing this type of high-level subjective view of usability and is thus often used in carrying out comparisons of usability between systems [21].

We should keep the following in mind:

- The scoring system is somewhat complex.

- The best way to interpret your results involves normalising the scores to produce a percentile ranking.

- The SUS model is not diagnostic. Its use is in classifying the ease of use of the web page, application or environment being tested.
The principal difficulty of this model is the complex scoring system but it can be normalised to produce a percentile ranking ([22]). We tried to make it simpler. We calculated the mean value of the participant’s scores for each question. If the rounded value is greater than 3 it is positive, if it is 3 is neutral and if it is less than 3 is negative.

6.3 User Experience Questionnaire - UEQ

The UEQ allows a quick, easy and flexible assessment of the user experience for any interactive product. The scales of the questionnaire are designed to cover a comprehensive impression of the user experience. The questionnaire format supports the users response to immediately express feelings, impressions, and attitudes that arise when they use a product ([23–25]).

The user experience questionnaire contains 6 scales with 26 items in total that measure several usability aspects:

1. **Attractiveness**: General impression towards the product. Do users like or dislike the product? Items: annoying / enjoyable, good / bad, unlikable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.

2. **Efficiency**: Can users solve their tasks with the product without unnecessary effort? Does the user interface look organised? Items: fast / slow, inefficient / efficient, impractical / practical, organised / cluttered.

3. **Perspicuity**: Is it easy to understand how to use the product? Is it easy to get familiar with the product? Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing.

4. **Dependability**: Does the user feel in control of the interaction? Is the interaction with the product secure and predictable? Items: unpredictable / predictable, obstructive / supportive, secure / not secure, meets expectations / does not meet expectations.

5. **Stimulation**: Is it motivating and exciting to use the product? Items: valuable / inferior, boring / exciting, not interesting / interesting, motivating / demotivating.

Basically, we used the 26 items of the UEQ questionnaire to survey the participants and then put the results into the analytical template provided by [23] to get the statistics, charts and benchmarks.

6.4 Research Studies

In this study, two research study types were developed. The first one is an online research that basically explores the user acceptance based on the TAM model. It was designed to evaluate two approaches: online and in-store VFR. The second study is an experimental research that essentially explores the satisfaction based on the SUS model and the user experience based on the UEQ model regarding different VFRs. It was evaluated for the two prototypes previously described.

6.4.1 Online Research

This research is based on the TAM model and was applied in order to explore online and in-store VFR potential adoption. The online survey was done using Google Forms and was structured in the following 4 sections:

- General Information
- Online VFR
- In-store VFR
- Final Questions

It was administered to 64 people from different ages and varied professional backgrounds. The online form is attached in the Appendix A.

6.4.2 Experimental Research

This research also involved administering a questionnaire to explore different VFR technological variants. This online survey was done also using Google Forms and was structured in 4 sections:

- General Information
- Satisfaction Test (SUS)
• User Experience Test (UEQ)

• Final Questions

This questionnaire was applied for the two prototypes previously explained in the chapter 5.

• Prototype 1: Real Person + Web Camera + Superimpose Clothing

• Prototype 2: Avatar + Kinect + 3D Clothing

It was administered to 9 students from different age, gender and career. The prototypes were presented in different order to avoid bias caused by the order effect. The experimental questionnaire is attached in the Appendix B and the experiment design in the Appendix C. The experiment design shows the activities that the participants needed to complete step by step. Finally, additional variables were measured manually during the experiment in the laboratory such as: execution time, task completeness, number of errors and task with more difficulties.

6.5 Results

In this section the main results will be presented following the structure previously proposed for each research. The full survey results for the online research are attached in the Appendix D and for the experimental one, in the Appendix E.

6.5.1 Results for the Online Research

Here the results show the people’s answers presented in percentages regarding the different topics and questions. The complete distribution of responses for each question can be found in the in the Appendix D.

A. GENERAL INFORMATION

Age

• 43.8% are between 18 and 24 years old

• 43.8% are between 25 and 34 years old

• 9.4% are between 35 and 44 years old
Which one do you prefer the most?

- 21.9% prefer Online Shopping
- 78.1% prefer Shopping at Physical Stores

Have you ever tried an online VFR or in-store VFR?

- 15.6% have tried a VFR before
- 84.4% have never tried a VFR before

B. ONLINE VFR

Perceived Usefulness

- 65% agree that using this type of VFR will reduce their time when shopping
- 56.2% agree that using this type of VFR will facilitate their decision to buy clothes
- 59.4% agree that this type of VFR will improve their shopping experience in general
- Cloth combination and how it looks like are the most advantageous factors of this technology compared with not having it

Perceived Enjoyment

- 75% agree that this type of VFR is interesting
- 70.3% agree that this type of VFR is enjoyable
- 59.4% agree that this type of VFR is a good way to spend their leisure time

Perceived Risk

- Security issues and how it looks like are their main concerns in online shopping when it comes to clothing goods
- 50% agree that using this type of VFR will decrease their perceived risk when buying in comparison with the traditional method (using images of clothes)

Anticipated Use
• 57.8% agree that they will use it on a regular basis in the future assuming that this type of VFR exists

• 54.7% agree that this will make them buy more clothes in the future assuming that this type of VFR is available in their favourite e-commerce web page

C. IN-STORE VFR

Perceived Usefulness

• 71.8% agree that using this type of VFR will reduce their time when shopping

• 61% agree that using this type of VFR will facilitate their decision to buy clothes

• 67.3% agree that this type of VFR will improve their shopping experience in general

• Convenience of no undressing, speed when buying and how it looks like are the most advantageous factors of this technology compared with not having it

Perceived Enjoyment

• 78% agree that this type of VFR is interesting

• 71.9% agree that this type of VFR is enjoyable

• 53.1% agree that this type of VFR is a good way to spend their leisure time

Perceived Risk

• Whether it fits and privacy issues are their main concerns having this type of VFR in physical stores

• 40.7% agree that using this type of VFR will decrease their perceived risk when buying in comparison with a real dressing room

• 42.2% agree that using this type of VFR will decrease their perceived risk when buying in comparison with the online VFR

Anticipated Use

• 57.8% agree that they will use it on a regular basis in the future assuming that this type of VFR exists
• 53.1% agree that this will make them buy more clothes in the future assuming that this type of VFR is available in their favourite shopping center

D. FINAL QUESTIONS

Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime?

• 18.8% prefer an avatar of themselves
• 81.3% prefer themselves in realtime

How would you like to do the scanning to get the avatar?

• 57.8% prefer scanning by themselves at home
• 42.2% prefer going to the nearest mall where there is a scanning booth and follow the instructions

6.5.2 Results for the Experimental Research

Here the average value of each item will be shown for the SUS results and statistical charts and benchmarking graphs for the UEQ results. Either way, for the SUS and UEQ surveys, the complete distribution of responses are in the Appendix E.

A. GENERAL INFORMATION

Age

• 11.1% are between 18 and 24 years old
• 44.4% are between 25 and 34 years old
• 33.3% are between 35 and 44 years old

Which one do you prefer the most?

• 33.3% prefer Online Shopping
• 66.7% prefer Shopping at Physical Stores

Have you ever tried an online VFR or in-store VFR?
• 100% have never tried a VFR before

B. REAL PERSON + WEB CAMERA + SUPERIMPOSE CLOTHING

B1. USABILITY TEST (SUS) [Points in average in the scale of 1 to 5 being 1 = Strongly Disagree and 5 = Strongly Agree]

- I would like to use this VFR frequently [3.55 = Agree]
- I found this VFR unnecessarily complex [2.11 = Disagree]
- I thought the VFR was easy to use [3.66 = Agree]
- I would need the support of a technical person to be able to use this VFR [2.11 = Disagree]
- I found the various functions in this system were well integrated [4.00 = Agree]
- I thought there was too much inconsistency in this VFR [2.22 = Disagree]
- I would imagine that most people would learn to use this VFR very quickly [3.80 = Agree]
- I found the VFR very cumbersome to use [2.33 = Disagree]
- I felt very confident using the VFR [3.88 = Agree]
- I needed to learn a lot of things before I could get going with this VFR [2.00 = Disagree]

B2. USER EXPERIENCE TEST (UEQ)

In the Figure 6.4 we can find the results per item for the real person prototype. In the Figure 6.5, the mean values per item. In the Figure 6.6, the UEQ scales. In the Figure 6.7, the distribution of the scales. Finally, in the Figure 6.8, the benchmark graph.

C. AVATAR + KINECT + 3D CLOTHING

C1. USABILITY TEST (SUS) [Points in average in the scale of 1 to 5 being 1 = Strongly Disagree and 5 = Strongly Agree]

- I would like to use this VFR frequently [3.33 = Neutral]
- I found this VFR unnecessarily complex [2.44 = Disagree]
- I thought the VFR was easy to use [3.88 = Agree]
Chapter 6. Survey

Figure 6.4: UEQ results per item for the real person prototype

Figure 6.5: UEQ mean values per item for the real person prototype

Figure 6.6: UEQ scales for the real person prototype
• I would need the support of a technical person to be able to use this VFR [2.77 = Neutral]
• I found the various functions in this system were well integrated [3.11 = Neutral]
• I thought there was too much inconsistency in this VFR [2.33 = Disagree]
• I would imagine that most people would learn to use this VFR very quickly [3.44 = Neutral]
• I found the VFR very cumbersome to use [2.33 = Disagree]
• I felt very confident using the VFR [3.55 = Agree]
• I needed to learn a lot of things before I could get going with this VFR [2.55 = Neutral]

C2. USER EXPERIENCE TEST (UEQ)

In the Figure 6.9 we can find the results per item for the avatar prototype. In the Figure 6.10, the mean values per item. In the Figure 6.11, the UEQ scales. In the Figure 6.12, the distribution of the scales. Finally, in the Figure 6.13, the benchmark graph.

D. FINAL QUESTIONS
Chapter 6. Survey

Figure 6.9: UEQ results per item for the avatar prototype

Figure 6.10: UEQ mean values per item for the avatar prototype

Figure 6.11: UEQ scales for the avatar prototype
Which one did you like the most?

- 66.7% prefer the prototype: Real Person + Web Camera + Superimpose Clothing
- 33.3% prefer the prototype: Avatar + Kinect + 3D Clothing

Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime?

- 100.0% prefer themselves in realtime

As mentioned before, some other variables were measured manually in order to analyse the users’ behaviour during the experiment. All the tasks were expected to be done in an interval of 25 minutes and the participants in average finished 2 minutes earlier. The tasks were clear and easy to do so all of them completed all the tasks step by step. Other important variable in a usability test is the number of errors, but in this experiment we cannot talk about this measure because no errors were committed. Instead, we observed that they encountered more inconveniences in some specific tasks that delayed their overall time. For instance, regarding the prototype using a real person, users had delays manipulating the VFR options with their hands, and regarding the prototype using an avatar, users had delays looking for the best position during the scanning process with the Kinect.
6.6 Discussion

6.6.1 Online Research

Regarding the profile of the survey respondents, most of them were young people in their 20s that prefer shopping at physical stores rather than online shopping and have not had the chance to experience a VFR before.

It can be seen that almost three quarters of those surveyed agreed that using online VFR will reduce their time when shopping, and, in general, it will improve their shopping experience. The most important advantages compared with not having the VFR are the possibility to visualise cloth combinations and checking how the clothes look like on them. More than 70% agreed that online VFRs are interesting and enjoyable. With respect to the risks when trying on clothes online, security issues and differences with how the clothes will look like in reality are the main concerns. Moreover, only half agreed that this VFR will decrease their perceived risk when buying in comparison with the traditional method which uses images of clothes. However, a considerable group of respondents were neutral regarding their level of agreement for this statement. Then, more than a half agreed that online VFR will make them buy more clothes and that they will use it on a regular basis.

The same way as with online VFR, almost three quarters of the respondents agreed that in-store VFR will reduce their time when shopping and facilitate their decision to buy clothes improving their shopping experience. The most important advantages compared with not having the VFR are the convenience of not undressing and checking how the clothes look like on them. More than 80% agreed that in-store VFR are interesting and enjoyable. With respect to the risks when trying on clothes with VFR in physical stores, privacy issues and whether it fits are the main concerns. Less than a half agreed that this type of VFR will decrease their perceived risk when buying in comparison with a real dressing room, as expected. Despite 20% of respondents being neutral, it shows that in-store VFR are far away to replace real dressing rooms in terms of realism. However, more than a half agreed that in-store VFR will make them buy more clothes and that they will use it on a regular basis.

And now, comparing both alternatives according to the same questions, the results are quite balanced. The in-store VFR will reduce the time when shopping a little bit more than the online VFR. The in-store VFR is much more interesting than the online VFR. However, both of them face the problem of how the cloth will fit or look like on the users. In spite of adversity online VFR will be used in regular basis more than in-store VFR.
Finally, regarding VFR alternatives, respondents prefer to see themselves in realtime rather than having an avatar of themselves with their measures and they want the scanning to be done by themselves rather than going to the nearest mall.

### 6.6.2 Experimental Research

Regarding the profile of the participants surveyed, most of them were young people in their 20s that mostly prefer shopping at physical stores rather than online shopping and had never had the chance to experience a VFR before.

In regard to the prototype that displays the real person captured with the web camera, both the usability test and the user experience test show positive results. For the usability test, users found it not complex, easy to use and easy to learn so they would like to use it frequently. Regarding the user experience test the results for the 6 aspects are good. The best one is the perspicuity expressing that users found it easy to understand. The result for the attractiveness aspect is that this VFR is mostly enjoyable, attractive and friendly. According to the efficiency aspect it is mostly efficient and organised. According to the perspicuity aspect it is mostly understandable, easy and clear. According to the dependability aspect it is mostly supportive and predictable. According to the stimulation aspect it is mostly interesting and motivating. According to the novelty aspect it is mostly leading edge and innovative.

With respect to the prototype that uses an avatar of the person and the Kinect, both the usability test and the user experience test show positive results although with slightly less points compared with the previous prototype. For the usability test, users found it also not complex and easy to use. However, they may need the support of a technical person to be able to use it. It must be due to the previous scanning process that need to be done to get the avatar. By some manner they are not convinced to use it frequently. Regarding the user experience test the overall result is quite similar to the preceding prototype with slightly less points in some items again. According to the attractiveness aspect this VFR is mostly good and pleasing. According to the efficiency aspect it is mostly organised. According to the perspicuity aspect it is mostly understandable, clear and easy to learn. According to the dependability aspect it is mostly predictable. According to the stimulation aspect it is mostly valuable and interesting. According to the novelty aspect it is mostly creative and leading edge.

One important aspect about the UEQ test is that people tend to be positive in their answers and also try to avoid extreme answer categories. In that case, there are some adjustments in the calculations to make them more realistic. The benchmark graph can give us conclusions about the relative quality of the evaluated product compared to
other products (benchmark data until 2016). For the real person prototype, the aspects above the average are attractiveness, perspicuity, stimulation and novelty. It means that this prototype is basically enjoyable, easy to understand, interesting and innovative. Meanwhile, for the avatar prototype, the aspects above the average are perspicuity and novelty. It means that this prototype is basically easy to understand and innovative. Despite both results are good, the results of the avatar prototype might be influenced by the fact that the generated avatar did not truly represent the participants.

Finally, after the separate analysis of the two research types (online and experimental), we can conclude that they agree with each other in several aspects in a positive way. There is no better product because the statistics and results were close enough. Although, trying to make a comparison, respondents liked the real person prototype more than the avatar one and definitely prefer to see themselves in realtime rather than having an avatar of themselves with their measures.
Chapter 7

Research Results

7.1 Research Questions

• What is a VFR?
  It is the online or in-store equivalent of a real retailer dressing room where the user tries on clothes to check different cloth features (size, fit or style) virtually rather than physically. The main objective of a VFR is giving the user the idea of how an item of clothes will look on him/her without actually trying it on.

• What are the requirements to establish a VFR?
  Since there are two flavours for VFR (VR and AR) the requirements might change depending on the business objective. For an online VFR at least three modules should be developed: body-shape, computation and exhibition. Meanwhile, for an in-store VFR a body scanning device, the computation module and the display device should be considered.

• What are the most relevant VFR benefits and concerns for the user?
  How the clothes will look like is the main benefit for both types of VFR. Moreover, cloth combination and the convenience of not undressing are the secondary benefits regarding online VFR and in-store VFR correspondingly. Whether the cloth fits and security issues are the main concerns in both cases.

• What research projects and commercial initiatives exist?
  VFR companies like Zugara [26] are working with technological organisations in multiple ways. For instance, they are part of early technological programs before releases, have distribution relationships regarding to the hardware or establish partner agreements. In this case Zugara is working with: Microsoft (Kinect), Samsung (display and tablets), SoftKinetic (depth-sensing cameras) and NemesisTech (partner).
• **What is the future for the VFR?**
   As technology is continuously evolving new state-of-the-art techniques (simple or complex) will appear and researches will spread the knowledge among the academic community and make huge efforts to apply them to enhance VFR experiences. Based on the results of this study we can state that users prefer to see themselves as they were in front of a mirror. Regarding the AR perspective there is a technological challenge in how to adapt the clothes to an image of a body in movement that has two dimensions. Regarding the VR perspective the challenge rely on building an avatar that represents the user accurately and that it should be fast and does not require a lot of computational resources.

### 7.2 Conclusions

• Since online fitting rooms still cannot replace the manual garment try-on room for a matter of accuracy, it nevertheless allows online virtual fitting experiences and speeding up the shopping cycle of garments.

• Still a large part of the users agree that VFR will reduce their time when shopping and facilitate their decision to buy clothes therefore improving their shopping experience in general.

• The most important benefits of VFR are cloth combination, the convenience of not undressing and how the clothes will look like on users.

• There are risks that need to be treated with caution such as security and privacy issues and whether the clothes will fit correctly the user’s body.

• Either way, online or in-store, still have a long way to make VFR satisfactory in terms of accuracy, realism and computation time.

• Despite a VFR cannot fully replace a real dressing room, it will make users buy more clothes and make them use it on a regular basis.

• Both the satisfaction test and the user experience test show positive results regarding VFR. Succinctly, they are perceived as useful, easy to use, interesting, innovative and enjoyable, and also people like them.

• There is no sense to compare which approach is the best. Both cases, online or in-store VFR, turn out to be good options in different situations. User preferences cannot be generalised at all although they prefer a little bit more observing themselves in realtime instead of an avatar.
• Nowadays it is possible to test various measurements and postures (such sitting and walking) before a user really buys the garments in a web or in-store based VFR.

• The use of Augmented Reality in the field of virtual fitting rooms is growing by leaps and bounds thus far and the evidence of this is the latest researches done and the presence of several commercial vendors in the market.

7.3 Research Opportunities

The main objective is to enhance the VFR experience. Regarding this, some research opportunities will be listed below:

• **Integrate VFR with payment methods**
  To enable the fast integration of online payment gateways with the VFR or through the usage of QR codes.

• **Share virtual shopping experience**
  The fact of sharing with friends or other people at the same time the VFR experience.

• **Mobile integration**
  Mobile devices and potentials have not been deeply explored or analysed to provide VFR solutions.

• **Enhance the accuracy of body scanners**
  Enhancements in body scanners would make the VFR process much more faster to the normal user.

• **Advanced shading modules**
  Until now, there are no studies that analyses the shade in clothes in order to make VFR more realistic solutions.

• **Simulation and deformation of cloth models subjected to body motions**
  Showing wrinkles and crumples of the clothes when the user moves to improve the realism of VFR.

• **Deliver fit and sizing solutions when carrying multiple brands**
  Analyse VFR not just from the user perspective but the provider also because there is also a pre-process task involved to include new clothes of different brands.
Bibliography


Appendix A

Online Research Survey
Virtual Fitting Room - Online Research

Thank you for participating in this survey. My main objective is to explore user acceptance of the Virtual Fitting Room (VFR) technology. The survey is structured in 4 sections: general information, online VFR, in-store VFR and final questions.

I hope you answer these questions with an appropriate level of confidence in order to get better accurate results for my Master's Thesis research.

* Required

A. GENERAL INFORMATION

1. Age *
   
   Mark only one oval.
   
   [ ] Under 18
   [ ] 18 - 24
   [ ] 25 - 34
   [ ] 35 - 44
   [ ] 45 - 54
   [ ] 55 - 64
   [ ] Above 65

2. Which one do you prefer the most? *
   
   Mark only one oval.
   
   [ ] Online shopping
   [ ] Shopping at physical stores

3. Have you ever tried an online VFR or in-store VFR? *
   
   Mark only one oval.
   
   [ ] Yes
   [ ] No

B. ONLINE VFR

Is the online equivalent of a real retailer dressing room. It uses a webcam to try-on clothes virtually. You can find below some pictures if you do not know it.
PERCEIVED USEFULNESS

4. Using this type of VFR will reduce my time when shopping *
   Mark only one oval.

   1 2 3 4 5 6 7
   Strongly Disagree       Strongly Agree

5. Using this type of VFR will facilitate my decision to buy clothes *
   Mark only one oval.

   1 2 3 4 5 6 7
   Strongly Disagree       Strongly Agree
6. *This type of VFR will improve my shopping experience in general*  
*Mark only one oval.*

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7. *What is the most advantageous factor of this technology compared with not having it?*  
*Check all that apply.*

- [ ] Fit
- [ ] Look like
- [ ] Cloth combination
- [ ] Other: ...

PERCEIVED ENJOYMENT

8. *This type of VFR is interesting*  
*Mark only one oval.*

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9. *This type of VFR is enjoyable*  
*Mark only one oval.*

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10. *This type of VFR could be a good way to spend my leisure time*  
*Mark only one oval.*

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PERCEIVED RISK
11. When it comes to clothing goods, what would be your main concern when shopping online? *
   Check all that apply.
   - Fit
   - Look like
   - Privacy concerns
   - Security concerns
   - Other: ......................................................................................................

12. Using this type of VFR will decrease my perceived risk when buying in comparison with the traditional method (using images of clothes) *
   Mark only one oval.
   1 2 3 4 5 6 7
   Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

ANTICIPATED USE

13. Assuming that this type of VFR exists, you predict that you will use it on a regular basis in the future *
   Mark only one oval.
   1 2 3 4 5 6 7
   Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

14. Assuming that this type of VFR would be available in your favourite e-commerce web page, you predict that this will make you buy more clothes in the future *
   Mark only one oval.
   1 2 3 4 5 6 7
   Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

C. IN-STORE VFR

Is the in-store equivalent of a real retailer dressing room. It uses an external device to try-on clothes virtually. You can find below a picture if you do not know it.
PERCEIVED USEFULNESS

15. Using this type of VFR will reduce my time when shopping *

Mark only one oval.

1 2 3 4 5 6 7

| Strongly Disagree |  |  |  |  |  |  | Strongly Agree |

16. Using this type of VFR will facilitate my decision to buy clothes *

Mark only one oval.

1 2 3 4 5 6 7

| Strongly Disagree |  |  |  |  |  |  | Strongly Agree |

17. This type of VFR will improve my shopping experience in general *

Mark only one oval.

1 2 3 4 5 6 7

| Strongly Disagree |  |  |  |  |  |  | Strongly Agree |
18. What is the most advantageous factor of this technology compared with not having it? *
   Check all that apply.
   
   - [ ] Fit
   - [ ] Look like
   - [ ] Convenience of no undressing
   - [ ] Speed when buying
   - [ ] Other:

   ........................................................................................................

PERCEIVED ENJOYMENT

19. This type of VFR is interesting *
   Mark only one oval.

   1 2 3 4 5 6 7
   Strongly
   Disagree
   Strongly
   Agree

20. This type of VFR is enjoyable *
   Mark only one oval.

   1 2 3 4 5 6 7
   Strongly
   Disagree
   Strongly
   Agree

21. This type of VFR could be a good way to spend my leisure time *
   Mark only one oval.

   1 2 3 4 5 6 7
   Strongly
   Disagree
   Strongly
   Agree

PERCEIVED RISK

22. Having this type of VFR in physical stores, what would be your main concern? *
   Check all that apply.

   - [ ] Fit
   - [ ] Look like
   - [ ] Privacy concerns
   - [ ] Security concerns
   - [ ] Other:

   ........................................................................................................
23. Using this type of VFR will decrease my perceived risk when buying in comparison with a real dressing room *

Mark only one oval.

1 2 3 4 5 6 7

Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

24. Using this type of VFR will decrease my perceived risk when buying in comparison with the online VFR *

Mark only one oval.

1 2 3 4 5 6 7

Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

ANTICIPATED USE

25. Assuming that this type of VFR exists, you predict that you will use it on a regular basis in the future *

Mark only one oval.

1 2 3 4 5 6 7

Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

26. Assuming that this type of VFR would be available in your favourite shopping center, you predict that this will make you buy more clothes in the future *

Mark only one oval.

1 2 3 4 5 6 7

Strongly Disagree ☐ ☐ ☐ ☐ ☐ ☐ ☐ Strongly Agree

D. FINAL QUESTIONS

27. Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime? *

Mark only one oval.

☐ Avatar of myself
☐ Myself in realtime
28. **How would you like to do the scanning to get the avatar?** *
   
   *Mark only one oval.*

   - [ ] By yourself at home. You prefer to figure out how it works by yourself.
   - [ ] Go to the nearest mall where there is a scanning booth and follow the instruction.
   
   The whole scanning process takes aprox. 3 minutes.

29. **Optionally, leave your email address in case we need to contact you for further clarifications**

   ..............................................................................................................
Appendix B

Experimental Research Survey
Virtual Fitting Room - Experimental Research

Thank you for participating in this survey. My main objective is to explore the adoption of different Virtual Fitting Rooms (VFR) through a usability test (SUS) and a user experience test (UEQ). In this case 2 prototypes will be evaluated.

*Required

General Information

1. Age *

Mark only one oval.

- Under 18
- 18 - 24
- 25 - 34
- 35 - 44
- Above 45

2. Which one do you prefer the most? *

Mark only one oval.

- Online shopping
- Shopping at physical stores

3. Have you ever tried an online VFR or in-store VFR? *

Mark only one oval.

- Yes
- No

Tests for the prototype: Real Person + Web Camera + Superimpose Clothing

1. USABILITY TEST (SUS)
4. 1 = Strongly Disagree and 5 Strongly Agree
*Mark only one oval per row.*

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<td>I would like to use this VFR frequently</td>
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<td>I found this VFR unnecessarily complex</td>
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<td>I thought the VFR was easy to use</td>
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<td>I would need the support of a technical person to be able to use this VFR</td>
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<td>I found the various functions in this system were well integrated</td>
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<tr>
<td>I thought there was too much inconsistency in this VFR</td>
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<tr>
<td>I would imagine that most people would learn to use this VFR very quickly</td>
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<tr>
<td>I found the VFR very cumbersome to use</td>
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<tr>
<td>I felt very confident using the VFR</td>
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<td>I needed to learn a lot of things before I could get going with this VFR</td>
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**2. USER EXPERIENCE TEST (UEQ)**

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<td>Annoying</td>
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6. *Mark only one oval.*

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14. Mark only one oval.

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<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
15. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Obstructive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supportive</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

16. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Complicated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unlikable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Usual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leading edge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Unpleasant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleasant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21. *Mark only one oval.*

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Secure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not secure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
22. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demotivating</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

23. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meet expectations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does not meet expectations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inefficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confusing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

26. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impractical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

27. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organised</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluttered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

28. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unattractive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tests for the prototype: Avatar + Kinect + 3D Clothing

1. USABILITY TEST (SUS)

31. 1 = Strongly Disagree and 5 Strongly Agree
Mark only one oval per row.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like to use this VFR frequently</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I found this VFR unnecessarily complex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I thought the VFR was easy to use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would need the support of a technical person to be able to use this VFR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I found the various functions in this system were well integrated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I thought there was too much inconsistency in this VFR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would imagine that most people would learn to use this VFR very quickly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I found the VFR very cumbersome to use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I felt very confident using the VFR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I needed to learn a lot of things before I could get going with this VFR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. USER EXPERIENCE TEST (UEQ)
32. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annoying</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Enjoyable</td>
</tr>
</tbody>
</table>

33. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not understandable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Understandable</td>
</tr>
</tbody>
</table>

34. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dull</td>
</tr>
</tbody>
</table>

35. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to learn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Difficult to learn</td>
</tr>
</tbody>
</table>

36. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valuable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inferior</td>
</tr>
</tbody>
</table>

37. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Exciting</td>
</tr>
</tbody>
</table>

38. *Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not interesting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Interesting</td>
</tr>
</tbody>
</table>
39. Mark only one oval.

```
1 2 3 4 5 6 7
Unpredictable ○ ○ ○ ○ ○ ○ ○ Predictable
```

40. Mark only one oval.

```
1 2 3 4 5 6 7
Fast ○ ○ ○ ○ ○ ○ ○ Slow
```

41. Mark only one oval.

```
1 2 3 4 5 6 7
Inventive ○ ○ ○ ○ ○ ○ ○ Conventional
```

42. Mark only one oval.

```
1 2 3 4 5 6 7
Obstructive ○ ○ ○ ○ ○ ○ ○ Supportive
```

43. Mark only one oval.

```
1 2 3 4 5 6 7
Good ○ ○ ○ ○ ○ ○ ○ Bad
```

44. Mark only one oval.

```
1 2 3 4 5 6 7
Complicated ○ ○ ○ ○ ○ ○ ○ Easy
```

45. Mark only one oval.

```
1 2 3 4 5 6 7
Unlikable ○ ○ ○ ○ ○ ○ ○ Pleasing
```
46. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Usual | | | | | | | | Leading edge

47. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Unpleasant | | | | | | | | Pleasant

48. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Secure | | | | | | | | Not secure

49. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Motivating | | | | | | | | Demotivating

50. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Meet expectations | | | | | | | | Does not meet expectations

51. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Inefficient | | | | | | | | Efficient

52. **Mark only one oval.**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>
| Clear | | | | | | | | Confusing
53. Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impractical</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Practical</th>
</tr>
</thead>
</table>

54. Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Organised</th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th>Cluttered</th>
</tr>
</thead>
</table>

55. Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</table>

<table>
<thead>
<tr>
<th>Attractive</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Unattractive</th>
</tr>
</thead>
</table>

56. Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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</tbody>
</table>

<table>
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<tr>
<th>Friendly</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Unfriendly</th>
</tr>
</thead>
</table>

57. Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
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<th>6</th>
<th>7</th>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Conservative</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Innovative</th>
</tr>
</thead>
</table>

**Final Questions**

58. Which one did you like the most? *

Mark only one oval.

- [ ] Prototype 1: Real Person + Web Camera + Superimpose Clothing
- [ ] Prototype 2: Avatar + Kinect + 3D Clothing

59. Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime? *

Mark only one oval.

- [ ] Avatar of myself
- [ ] Myself in realtime
Appendix C

Experiment Design
VFR - Experiment Design

The steps that need to be done for the two experiments with the prototypes will be described below.

Experiment: Real Person + Web Camera + Superimpose Clothing

Situation

You are busy at home and need to buy a t-shirt. The nearest mall is far away and you decided to use a VFR.

Step1

Go to the online VFR: http://webcamsocialshopper.com/demos

Step2

Select the cloth you like the most from the list of items.

Step3

Take a photo with the selected cloth.

Step4
Watch the first two minutes of a variant of this approach: real person + kinect + superimpose clothing

http://youtube.com/watch?v=Mr71jrkzWq8

**Experiment: Avatar + Kinect + 3D Clothing**

**Situation**

Your favourite e-commerce web site has implemented a new way to buy clothes where you have an avatar of yourself, and in order to use it you need to go the nearest shopping center to perform the scanning process. It takes approximately 3 minutes.

**Step1: Scanning**

Stay 1.5 meters away from the Kinect to scan yourself in different positions (frontal, both sides and back)

**Step2: Joining meshes**
You will see an example of a complete scanned body with all the meshes joined. It takes some time and additional equipment so we will skip this step.

**Step 3: Change clothes**

You need to enter to a virtual environment that simulates in this case the VFR where you can change the avatar’s clothes. The avatar was supposed to be your previous scanned avatar with the Kinect.

**Step 4**

Watch from the minute 1:27 to 2:40 a video of a variant of this VFR.

http://youtube.com/watch?v=pMladTwgHoI
Appendix D

Online Survey Responses
64 responses

Summary

A. GENERAL INFORMATION

Age

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>2</td>
<td>3.1%</td>
</tr>
<tr>
<td>18 - 24</td>
<td>28</td>
<td>43.8%</td>
</tr>
<tr>
<td>25 - 34</td>
<td>28</td>
<td>43.8%</td>
</tr>
<tr>
<td>35 - 44</td>
<td>6</td>
<td>9.4%</td>
</tr>
<tr>
<td>45 - 54</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>55 - 64</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Above 65</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Which one do you prefer the most?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online shopping</td>
<td>14</td>
<td>21.9%</td>
</tr>
<tr>
<td>Shopping at physical stores</td>
<td>50</td>
<td>78.1%</td>
</tr>
</tbody>
</table>

Have you ever tried an online VFR or in-store VFR?

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10</td>
<td>15.6%</td>
</tr>
<tr>
<td>No</td>
<td>54</td>
<td>84.4%</td>
</tr>
</tbody>
</table>

B. ONLINE VFR
PERCEIVED USEFULNESS

Using this type of VFR will reduce my time when shopping

<table>
<thead>
<tr>
<th>Strongly Disagree:</th>
<th>1</th>
<th>2</th>
<th>3.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>6.3%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>6.3%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>14</td>
<td>21.9%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18</td>
<td>28.1%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>14</td>
<td>21.9%</td>
</tr>
</tbody>
</table>

Strongly Agree: 7  8  12.5%

Using this type of VFR will facilitate my decision to buy clothes

<table>
<thead>
<tr>
<th>Strongly Disagree:</th>
<th>1</th>
<th>2</th>
<th>3.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>8</td>
<td>12.5%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>9</td>
<td>14.1%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>9</td>
<td>14.1%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>10</td>
<td>15.6%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>21</td>
<td>32.8%</td>
</tr>
</tbody>
</table>
This type of VFR will improve my shopping experience in general

What is the most advantageous factor of this technology compared with not having it?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit</td>
<td>13</td>
<td>20.3%</td>
</tr>
<tr>
<td>Look like</td>
<td>28</td>
<td>43.8%</td>
</tr>
<tr>
<td>Cloth combination</td>
<td>42</td>
<td>65.6%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>3.1%</td>
</tr>
</tbody>
</table>

PERCEIVED ENJOYMENT

This type of VFR is interesting
Strongly Disagree: 1 1 1.6%
2 1 1.6%
3 4 6.3%
4 10 15.6%
5 13 20.3%
6 26 40.6%

Strongly Agree: 7 9 14.1%

This type of VFR is enjoyable

Strongly Disagree: 1 1 1.6%
2 2 3.1%
3 5 7.8%
4 11 17.2%
5 20 31.3%
6 23 35.9%

Strongly Agree: 7 2 3.1%

This type of VFR could be a good way to spend my leisure time

Strongly Disagree: 1 4 6.3%
PERCEIVED RISK

When it comes to clothing goods, what would be your main concern when shopping online?

![Bar chart showing concerns]

- Fit: 33, 51.6%
- Look like: 25, 39.1%
- Privacy concerns: 14, 21.9%
- Security concerns: 28, 43.8%
- Other: 2, 3.1%

Using this type of VFR will decrease my perceived risk when buying in comparison with the traditional method (using images of clothes)

![Bar chart showing responses]

- Strongly Disagree: 1, 3.1%
- 2, 17.2%
- 3, 10.9%
- 4, 18.8%
- 5, 28.1%
- 6, 14.1%
ANTICIPATED USE

Assuming that this type of VFR exists, you predict that you will use it on a regular basis in the future

Assuming that this type of VFR would be available in your favourite e-commerce web page, you predict that this will make you buy more clothes in the future
C. IN-STORE VFR

PERCEIVED USEFULNESS

Using this type of VFR will reduce my time when shopping

![Bar chart showing responses to the perception of usefulness of reducing time shopping.

Strongly Disagree: 1  2  3.1%
  2  1  1.6%
  3  4  6.3%
  4  11  17.2%
  5  15  23.4%
  6  18  28.1%

Strongly Agree: 7  13  20.3%

Using this type of VFR will facilitate my decision to buy clothes

![Bar chart showing responses to the perception of usefulness of facilitating clothing decisions.

Strongly Disagree: 1  3  4.7%
  2  4  6.3%
  3  7  10.9%
  4  11  17.2%
  5  20  31.3%
  6  8  12.5%]
This type of VFR will improve my shopping experience in general

What is the most advantageous factor of this technology compared with not having it?

PERCEIVED ENJOYMENT

This type of VFR is interesting
This type of VFR is enjoyable

- Strongly Disagree: 1 1 1.6%
- 2 2 3.1%
- 3 1 1.6%
- 4 10 15.6%
- 5 18 28.1%
- 6 18 28.1%
- Strongly Agree: 7 14 21.9%

This type of VFR could be a good way to spend my leisure time

- Strongly Disagree: 1 1 1.6%
- 2 3 4.7%
- 3 3 4.7%
- 4 11 17.2%
- 5 14 21.9%
- 6 25 39.1%
- Strongly Agree: 7 7 10.9%
PERCEIVED RISK

Having this type of VFR in physical stores, what would be your main concern?

- **Fit**: 27 (42.2%)
- **Look like**: 18 (28.1%)
- **Privacy concerns**: 26 (40.6%)
- **Security concerns**: 17 (26.6%)
- **Other**: 0 (0%)

Using this type of VFR will decrease my perceived risk when buying in comparison with a real dressing room.
Using this type of VFR will decrease my perceived risk when buying in comparison with the online VFR

ANTICIPATED USE

Assuming that this type of VFR exists, you predict that you will use it on a regular basis in the future
Assuming that this type of VFR would be available in your favourite shopping center, you predict that this will make you buy more clothes in the future

Strongly Disagree: 1 4 6.3%
2 4 6.3%
3 11 17.2%
4 11 17.2%
5 14 21.9%
6 10 15.6%
Strongly Agree: 7 10 15.6%

D. FINAL QUESTIONS

Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime?

Avatar of myself 12 18.8%
Myself in realtime 52 81.3%

How would you like to do the scanning to get the avatar?

Avatar of myself 42.2%
Myself in realtime 57.8%
By yourself at home. You prefer to figure out how it works by yourself.

Go to the nearest mall where there is a scanning booth and follow the instruction. The whole scanning process takes approximately 3 minutes. Optionally, leave your email address in case we need to contact you for further clarifications.
Appendix E

Experimental Survey Responses
9 responses

Publish analytics

Summary

General Information

Age

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>18 - 24</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>25 - 34</td>
<td>4</td>
<td>44.4%</td>
</tr>
<tr>
<td>35 - 44</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>Above 45</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Which one do you prefer the most?

<table>
<thead>
<tr>
<th>Option</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online shopping</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>Shopping at physical stores</td>
<td>6</td>
<td>66.7%</td>
</tr>
</tbody>
</table>

Have you ever tried an online VFR or in-store VFR?

| Yes | 0 | 0% |
Tests for the prototype: Real Person + Web Camera + Superimpose Clothing

1. USABILITY TEST (SUS)

I would like to use this VFR frequently [null]

1 0 0%
2 1 11.1%
3 3 33.3%
4 4 44.4%
5 1 11.1%

I found this VFR unnecessarily complex [null]

1 1.0
2 2.0
3 3.0
4 4.0
5 5.0
I thought the VFR was easy to use [null]

<table>
<thead>
<tr>
<th>Rating</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>22.2%</td>
</tr>
</tbody>
</table>

I would need the support of a technical person to be able to use this VFR [null]

<table>
<thead>
<tr>
<th>Rating</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0%</td>
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<tr>
<td>2</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>22.2%</td>
</tr>
</tbody>
</table>

I found the various functions in this system were well integrated [null]

<table>
<thead>
<tr>
<th>Rating</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
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<td>22.2%</td>
</tr>
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<td>5</td>
<td>55.6%</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>
I thought there was too much inconsistency in this VFR [null]

I would imagine that most people would learn to use this VFR very quickly [null]
I found the VFR very cumbersome to use [null]

I felt very confident using the VFR [null]
I needed to learn a lot of things before I could get going with this VFR [null]

2. USER EXPERIENCE TEST (UEQ)
Not understandable: 1 0 0%
2 0 0%
3 0 0%
4 1 11.1%
5 0 0%
6 5 55.6%
Understandable: 7 3 33.3%

Creative: 1 1 11.1%
2 2 22.2%
3 1 11.1%
4 3 33.3%
5 0 0%
6 1 11.1%
Dull: 7 1 11.1%
Easy to learn:
1 2 22.2%
2 2 22.2%
3 1 11.1%
4 2 22.2%
5 0 0%
6 1 11.1%

Difficult to learn:
7 1 11.1%

Valuable:
1 1 11.1%
2 2 22.2%
3 2 22.2%
4 3 33.3%
5 1 11.1%
6 0 0%

Inferior:
7 0 0%

Boring:
1 0 0%
2 0 0%
Not interesting: 1 0 0%
    2 0 0%
    3 1 11.1%
    4 1 11.1%
    5 4 44.4%
    6 1 11.1%
Interesting: 7 2 22.2%

Unpredictable: 1 0 0%
    2 0 0%
    3 0 0%
    4 1 11.1%
    5 4 44.4%
    6 3 33.3%
Predictable: 7 1 11.1%
Fast:
- 1 0 0%
- 2 1 11.1%
- 3 4 44.4%
- 4 3 33.3%
- 5 0 0%
- 6 1 11.1%

Slow:
- 7 0 0%

Inventive:
- 1 1 11.1%
- 2 3 33.3%
- 3 1 11.1%
- 4 1 11.1%
- 5 3 33.3%
- 6 0 0%

Conventional:
- 7 0 0%
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<th>7</th>
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<tbody>
<tr>
<td>Count</td>
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<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>
| Percentage  | 0%| 0%| 11.1%| 33.3%| 22.2%| 33.3%| 0%

Supportive:

| 7 | 0 | 0% |

Good:

| 1 | 1 | 11.1% |
| 2 | 5 | 55.6% |
| 3 | 1 | 11.1% |
| 4 | 1 | 11.1% |
| 5 | 1 | 11.1% |
| 6 | 0 | 0% |

Bad:

| 7 | 0 | 0% |
Unlikable:

<p>| | | |</p>
<table>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>22.2%</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>22.2%</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>33.3%</td>
</tr>
</tbody>
</table>

Pleasing:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

Usual:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>
4  1  11.1%
5  3  33.3%
6  3  33.3%
Leading edge: 7  1  11.1%

Unpleasant: 1  0  0%
  2  1  11.1%
  3  0  0%
  4  2  22.2%
  5  1  11.1%
  6  4  44.4%
Pleasant: 7  1  11.1%

Secure: 1  1  11.1%
  2  1  11.1%
  3  3  33.3%
  4  3  33.3%
  5  0  0%
  6  1  11.1%
Not secure: 7  0  0%
Motivating:
1  1  11.1%
2  3  33.3%
3  2  22.2%
4  3  33.3%
5  0  0%
6  0  0%

Demotivating:
7  0  0%

Meet expectations:
1  0  0%
2  4  44.4%
3  1  11.1%
4  1  11.1%
5  3  33.3%
6  0  0%

Does not meet expectations:
7  0  0%
Impractical: 1 0 0%
2 0 0%
3 2 22.2%
4 3 33.3%
5 1 11.1%
6 1 11.1%
Practical: 7 2 22.2%

Organised: 1 2 22.2%
2 3 33.3%
3 2 22.2%
4 2 22.2%
5 0 0%
6 0 0%
Cluttered: 7 0 0%

Attractive: 1 2 22.2%
2 4 44.4%
3 1 11.1%
4 2 22.2%
<table>
<thead>
<tr>
<th></th>
<th>Score</th>
<th>Percentage</th>
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<tbody>
<tr>
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<td>0%</td>
</tr>
<tr>
<td>Friendly</td>
<td>1 2</td>
<td>22.2%</td>
</tr>
<tr>
<td></td>
<td>2 4</td>
<td>44.4%</td>
</tr>
<tr>
<td></td>
<td>3 1</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>4 2</td>
<td>22.2%</td>
</tr>
<tr>
<td></td>
<td>5 0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>6 0</td>
<td>0%</td>
</tr>
<tr>
<td>Unfriendly</td>
<td>7</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Score</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>11.1%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>22.2%</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>33.3%</td>
</tr>
<tr>
<td>Innovative</td>
<td>7</td>
<td>11.1%</td>
</tr>
</tbody>
</table>
Tests for the prototype: Avatar + Kinect + 3D Clothing

1. USABILITY TEST (SUS)

I would like to use this VFR frequently [null]

<table>
<thead>
<tr>
<th>Score</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>22.2%</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>33.3%</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>11.1%</td>
</tr>
</tbody>
</table>

I found this VFR unnecessarily complex [null]

<table>
<thead>
<tr>
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<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>22.2%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>22.2%</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>44.4%</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>11.1%</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

I thought the VFR was easy to use [null]
I would need the support of a technical person to be able to use this VFR [null]

I found the various functions in this system were well integrated [null]
I thought there was too much inconsistency in this VFR [null]

I would imagine that most people would learn to use this VFR very quickly [null]
I found the VFR very cumbersome to use [null]

I felt very confident using the VFR [null]

I needed to learn a lot of things before I could get going with this VFR [null]
2. USER EXPERIENCE TEST (UEQ)

Annoying:
- 1 0 0%
- 2 0 0%
- 3 2 22.2%
- 4 3 33.3%
- 5 0 0%
- 6 2 22.2%

Enjoyable:
- 7 2 22.2%

Not understandable:
- 0 0 0%
Difficult to learn: 7 0 0%

Valuable: 1 1 11.1%
2 5 55.6%
3 2 22.2%
4 1 11.1%
5 0 0%
6 0 0%

Inferior: 7 0 0%

Boring: 1 0 0%
2 0 0%
3 4 44.4%
4 1 11.1%
5 1 11.1%
6 2 22.2%

Exciting: 7 1 11.1%
Not interesting:
1 0 0%
2 2 22.2%
3 0 0%
4 1 11.1%
5 1 11.1%
6 3 33.3%

Interesting:
7 2 22.2%

Unpredictable:
1 0 0%
2 0 0%
3 0 0%
4 1 11.1%
5 5 55.6%
6 3 33.3%

Predictable:
7 0 0%
Fast:
1 0 0%
2 3 33.3%
3 1 11.1%
4 2 22.2%
5 2 22.2%
6 1 11.1%

Slow:
7 0 0%

Inventive:
1 1 11.1%
2 2 22.2%
3 3 33.3%
4 1 11.1%
5 2 22.2%
6 0 0%

Conventional:
7 0 0%

Obstructive:
1 0 0%
2 1 11.1%
3 1 11.1%
4 2 22.2%
5 2 22.2%
6 3 33.3%
Supportive: 7 0 0%

Good: 1 1 11.1%
2 4 44.4%
3 0 0%
4 3 33.3%
5 1 11.1%
6 0 0%
Bad: 7 0 0%

Complicated: 1 0 0%
2 0 0%
3 2 22.2%
4 1 11.1%
5 1 11.1%
6 4 44.4%
Easy: 7 1 11.1%
Unpleasant:
1 0 0%
2 0 0%
3 2 22.2%
4 2 22.2%
5 0 0%
6 4 44.4%

Pleasant:
7 1 11.1%

Secure:
1 1 11.1%
2 2 22.2%
3 3 33.3%
4 1 11.1%
5 1 11.1%
6 1 11.1%

Not secure:
7 0 0%
Motivating:
1 11.1%
2 22.2%
3 22.2%
4 22.2%
5 22.2%
6 0 0%

Demotivating:
7 0 0%

Meet expectations:
1 1 11.1%
2 2 22.2%
3 1 11.1%
4 2 22.2%
5 1 11.1%
6 2 22.2%

Does not meet expectations: 7 0 0%

Inefficient:
1 0 0%
2 0 0%
3 2 22.2%
Efficient: 7 1 11.1%

Clear: 1 1 11.1%
2 4 44.4%
3 1 11.1%
4 3 33.3%
5 0 0%
6 0 0%
Confusing: 7 0 0%

Impractical: 1 0 0%
2 2 22.2%
3 1 11.1%
4 1 11.1%
5 2 22.2%
6 2 22.2%
Practical: 7 1 11.1%
Organised:

1 1 11.1%
2 1 11.1%
3 4 44.4%
4 1 11.1%
5 2 22.2%
6 0 0%

Cluttered:

7 0 0%

Attractive:

1 1 11.1%
2 2 22.2%
3 2 22.2%
4 2 22.2%
5 2 22.2%
6 0 0%

Unattractive:

7 0 0%
Final Questions

Which one did you like the most?
Having any of these VFR, would you prefer an avatar of yourself with your measures or a recording of yourself in realtime?

Number of daily responses

Avatar of myself 0 0%
Myself in realtime 9 100%