ARDressCode: Augmented Dressing Room with Tag-based Motion Tracking and Real-Time Clothes Simulation

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Abstract

This paper introduces a new augmented reality concept for dressing rooms enabling a customer to combine a tactile experience of the fabrics with easy simulated try-on. The dressing room has a camera and a projection surface instead of a mirror. The customers stick a few visual tags to their normal clothes. Then the ARDressCode application features motion capture and provides an AR video stream on the AR "mirror" with the selected piece of clothes mixed in and fitted to the customer body. Design issues and technical implementation as well as the prospects of further development of the techniques are discussed.

Categories and Subject Descriptors: Augmented Reality, Motion tracking, DART, Virtual try-on

1. Introduction

Augmented Reality (AR) technology [ABB*1, BKP01] integrating digital and physical materials have developed over the recent decade. We see prospects for AR in many aspects of our everyday lives. We have explored one such example of a potential new application domain for AR namely try on in clothes shops. ARDressCode attempt to change the shopping experience in clothing stores by means of AR.

Using AR for clothes try on reveals at least two challenges: 1) we need to develop a light-weight multi-point motion tracking technique 2) we need to develop coherent clothes models that can be dynamically fitted to a moving body in real-time.

ARDressCode was inspired by the FingARtips [BVBC04] work for providing tag-based multi-point motion tracking. For the real time fitting of coherent clothes models, we have used features of the new DART system [MGBD04]. In the following we present the problem domain and discuss the technical solutions chosen for AR-DressCode.

2. Dressing room try on qualities and problems

Some find it tiresome and time consuming to try clothes in clothing stores. It could be easier if one could see whether or not the clothes would fit without having to take off one's own clothes to try out the new ones, and without having to wait in a long queue outside the fitting rooms. It is possible to order clothes on the internet but you never know whether the selected garments fit until you try them on at home. A size medium e.g. can differ from one brand to another and it is difficult to judge the quality of the textile by seeing it in picture on the computer. A better scenario is to see the clothes on one's own body, but in order to save time this may now be done without having to actually put them on. The alternative to a fully virtual try on is a mixed reality where the body is real but the clothes are digital models shaped to fit the individual body. The vision of ARDressCode is to provide these qualities.

ARDressCode could improve the shopping experience by avoiding to spend a lot of time changing clothes and waiting in line. Instead focus is on selecting the clothes and seeing how it fits. This makes ARDressCode an experience based AR application. Trying clothes becomes more immediate and spontaneous.
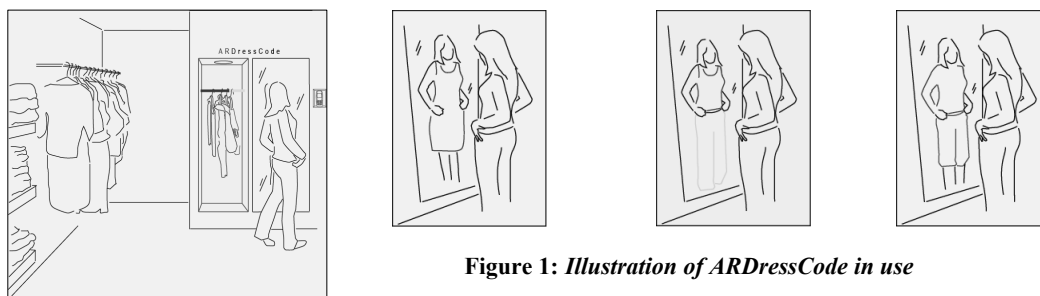
Figure 1: *Illustration of ARDressCode in use*

ARDressCode does not eliminate the physical presence of the customer in the store. This decision about not making a substitute for selecting the clothes is made due to the fact that we find it important that the customer is able to touch, see and smell the real garment in order to make the best judgement. When the customer has selected some garments it is easy to walk up to an ARDressCode and see if the clothes fit. You do not have to bring several sizes of the same clothes. At ARDressCode you can see the differrent sizes and colours of the garment and it is also possible to get suggestions for which t-shirts, shirts or blouses that would go with the selected trousers. This way the customer is not dependent on the sales associate finding other sizes etc., moreover there is less clothes to put back on the hangers when the customer has left the fitting room.

A potential problem of ARDressCode is if the 3D models of the clothes fails to give the user a reliable impression of how it would fit. Every piece of clothes must be modelled with a high amount of polygons in the 3D programme. Unfortunately such models render slowly in real time and this could hamper the illusion of seeing oneself in a mirror. The 3D objects must also be dynamically coherent to fit the movements in real time. Empirical observations have revealed typical movements customers make when trying out new clothes. It is important that the 3D clothes models are able to stretch and fold in a natural way when the customer moves.

Finally it is a problem that the customer in our current prototype needs to attach fiducial markers in order to try out the clothes. If applying the markers is as troublesome and time consuming as trying the clothes itself, the point is lost.

3. The ARDressCode Concept

The concept of ARDressCode is to allow users to try on clothing items virtually in front of an augmented mirror, which displays the user wearing a 3D model of the chosen clothing. This way the customers can try multiple clothing items virtually and see how they fit physically and aesthetically without having to try them on.

When customers have selected their items they hang them on the bar in the closet to the left of the mirror and place their mobile phone in the box to the right (fig. 1).

To try a new item, the users just need to put the item at the yellow side of the bar.

3.1. Dressing Room Setting

Figure 2 shows a hardware setup for ARDressCode. The clothes in the store need to be equipped with RFID tags. When the customer places the selected piece of clothing on the ARDressCode bar, the application receives data about the piece.
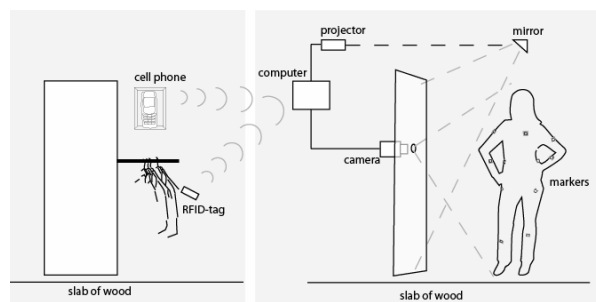

Figure 2: *Drawing of the technical setup*

The customers' BlueTooth mobile phone may also allow the application to receive the customers' profile with precise body measurements., This profile is for privacy reasons kept solely on the phone. When the mobile phone is placed in the ARDressCode box, the information is loaded to the application.

The augmented mirror consists of a slab of wood with a small hole in the middle, where a small video camera is able to record the customers' position and movements. A live image of the customer is projected on the front side of the slab simulating a mirror. The image is based on the input from the camera, the data of body measurements from the mobile phone and the information about the clothes given by the RFID chips. The reflection seen by the customer is similar to a reflection in a mirror except with ARDressCode the reflection includes the customer wearing the selected clothes. This augmented experience is encountered without the use of head worn or handheld displays as described in [ABB*01].

The optimal scenario would be, if the camera was hidden so that the customer would not be aware of the fact that

(s)he was being filmed. In order to make a realistic showing of the clothes on the customer, it is necessary to attach a few ARToolKit [BKP01, BVBC04] markers to the person. Thereby the movements of the markers can be tracked in real time in the augmented mirror.

3.2. Architecture of the application

The ARDressCode prototype utilizes vision based tracking as well as context-awareness techniques [Dey01]. The current implementation focuses on the key features: the visual representation of a digital mirror, dynamically showing the user wearing and manipulating one or more virtual models of selected physical garment.

Practically, this is realized by attaching a small set of fiducial markers on the user's body at physiological "trigger points", i.e. spots that are central to basic human motions [RL05].

Until now, we have concentrated on identifying such trigger points primarily on the torso. We have found that no matter how people use their arms, they always affect the corresponding elbow as well. This encouraged us to attach a marker (using a slapwrap device) on each arm, facing the video capture camera, in an angle of approximately 35°-45°. The marker should be placed at the top part of the radius bone, near the ulna joint. Further we placed a marker at the centre area of the torso to track the overall body movement.
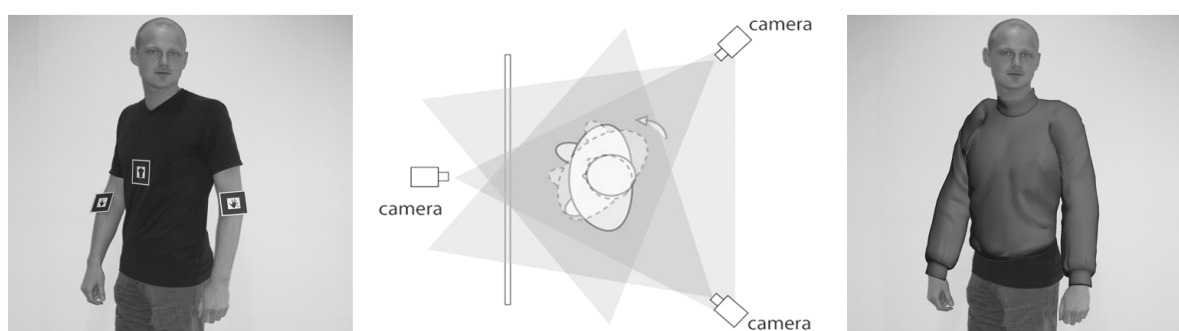

Figure 3: *Conceptual motion capture and occluding virtual objects in ARDressCode.*

We use the Designer's Augmented Reality Toolkit (DART) [MGB*03], which is a set of software tools supporting rapid prototyping and development of AR applications. The core feature of DART is the DART Xtra, an extension/plug-in for Macromedia Director, the de-facto standard in multimedia software application development [MGB*03]. The Xtra is programmed in C++ and includes ARToolkit [BKP01], enabling real-time capture of live video-streams from DirectShow cameras, followed by image analysis to facilitate tracking of spatial cues, such as fiducial markers [GDM04]. When tracking is successful the marker's corresponding virtual objects are superimposed on the video stream in real-time. The resulting video stream is shown on a display, e.g. HMD [ABB*01] or projected on a surface. Besides the basic ARToolKit, DART utilises the potentials of VPRN functionality to support a wide range of sensors and trackers, thereby facilitating communications with external devices [MGBD04], such as mobile phones.

In ARDressCode, we use the features of DART's integrated ARToolKit in combination with physical markers to obtain a seamless and natural interaction between the user and the application domain. Such interaction is achieved by engaging the human body as the user's physical control interface to the virtual 3D objects, which means that transformations and deformations of virtual objects are synchronized in real-time with the user's motions in the real world.

To enable a 360° tracking of the markers, two cameras should be placed behind the user, one on each side. The only task of the back cameras is to track information about markers that are no longer observable by the front camera. Consequently, the user can turn the side to the front camera and still obtain the intended digital mirror-effect. It is only when all markers are recognised that the virtual objects are displayed. If just one of the markers gets out of sync with the overall tracking for more than one second, the corresponding virtual model is disabled and fades out until all markers are visible to the cameras once again.

With a focus on usability, we chose to design the markers in ARDressCode with a visual semantics, relevant to the application context. Thus, each marker represents its associated body-part, making it easy for the end-user to decode the markers actual functionality and where they are supposed to be attached to the body.

4. Clothes simulation in DART

We have seen many examples showing the use of animations in ARToolKit or the use of a "tool tag" to influence an object coupled with another tag (e.g. BattleBoard3D [AKNG04]). However, to our knowledge no one has demonstrated an ARToolKit based real-time motion tracking coupled to surfaces in a dynamic coherent 3D model.

4.1. Bone-driven biped structure model

With DART using the integrated ShockWave3D plug-in in Macromedia Director, it is possible to produce highly advanced and interactive 3D models for Director-based AR environments. Director's 3D Xtra provides advanced technologies that normally are included in modelling software such as 3D Studio Max (3DS) and Alias Maya. These features include Multiresolution Mesh and Hierarchical Subdivision Surface Technology, which combined enables Director to increase and decrease the polygon count of the active 3D models "on-the-fly" [Mac05]. This way, the designer rarely has to worry about whether the quality of the virtual object will influence the application's overall performance. As a result we exported high-poly models from 3DS to Director and maintained both surface (shader in W3D) and texture quality on the W3D formatted models.

With our current implementation of ARDressCode we are facing some problems with the coherent clothes model. Presently, we are only able to dynamically move small groups of vertices in the 3D model, and not influence the motions of the entire model. Thus, we are working on an optimization of our prototype where the model is divided into separate 3D objects, representing the torso as well as the upper and lower arms. Further we are looking into a stabile implementation of ARDressCode, using a Havok physics plug-in for Director, and thereby focus on making it simpler to simulate dynamic and natural looking motion in real-time.

Our motivation for choosing DART as the software framework for ARDressCode, derives from the W3D format's support for bone-driven and biped structure model resources. According to the Director documentation, W3D should, in contrast to the VRML, enables the developer to create virtual 3D objects with natural looking motions and work with these motions in DART.

joints in the biped structure with corresponding joints in the 3D model (fig. 4). The goal is to affect and move these joints relative to the position and orientation of the fiducial markers tracked by DART. With the final implementation of ARDressCode, we expect that the result would be a model that twist and bend in a natural looking way, as proposed in Figure. 3.

4.2. Towards coherent clothes simulation

The main obstacle in solving our current implementation problems lies within the immediate limitations in Director's plug-ins. Since the 3D plug-in in Director is mainly constructed for interactive software genres such as computer games on the internet, it does not directly address the possibility of creating dynamic animations. Rather it focuses on moving the models, based on key-framed motions exported from 3D modelling software or based on animation scripts written in Lingo. Thus, Director mainly seeks to apply an animation modifier to models to play back animations created in 3D modelling software.

One reason why an entire model may react to motions in the ulna joint is due to the biped structure's use of hierarchical subdivision of the 3D model's geometry in W3D. With a biped structure, sets of vertices from the mesh are grouped into a parent-child hierarchy, thus simplifying rotation and translation of the model by letting all members of a group move together with a single command. Thus, the parent-child relationship ensures that, affecting the joints in the biped structure will affect the rest of the model in the correct manner.

In our search for a method to implement a stable version of a coherent model in ARDressCode we have been presented with demos of rag dolls effects in Director, created with Havok [Hav05]. By applying force to an associated biped structure it appears that Havok is able to simulate dynamic and very natural looking motion in real-time.
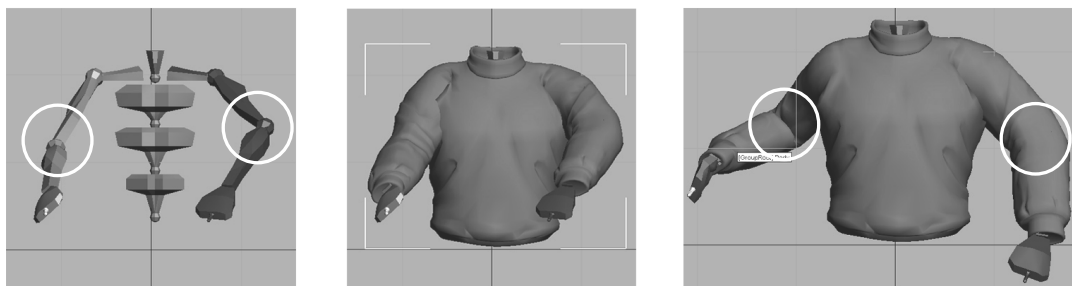

Figure 4: *Motion of ulna joint affecting the model's overall shader in 3DS.*

In the development of our 3D model we used 3DS 7.0 which integrates Discrete Character Studio and thereby makes it easy to create a working biped structure for the 3D model. We coupled the biped structure with a 3D model of a dressed human upper body, exported to 3DS format from Curious Labs Poser 5. In 3DS, we have associated the ulna

As a consequence we are currently looking into the possibilities of coupling tracking data of the fiducial markers with force-vectors used by Havok to affect the 3D model, and thereby create dynamic motions in ARDressCode. To fully understand such aspects we are presently exploring the relations between the reactor tool in 3DS and Havok in Director.

5. Related Work

Technically, ARDressCode can be compared with several other ARToolKit applications, e.g. FingARtips [BVBC04]. Compared to FingARtips we have added support for real-time animation of coherent dynamic 3D models with only a few markers.

Another tracking method used in blue studios, is to use several IR cameras to flash IR light onto a set of small lightweight markers that reflect the light back to the cameras. Like in ARDressCode, these markers are attached to the tracked body. When the cameras receive reflected light, it is possible to calculate a 3D position, based on merged 2D-data from all the cameras [Qua05].

A variant to this approach might be for the user to wear a thin suit equipped with hidden markers, traceable by the IR cameras. Thus the user avoids attaching fiducial markers since these are integrated in the suit. Such a supplementary garment would however, reduce the advantages of AR-DressCode of not having to put on clothes.

Conceptually, the wish is to give the customers in a clothing store enhanced shopping experiences compared to e.g. the Prada shop in New York [Ide05]. Here they have already experimented with interactive dressing rooms, wireless handheld staff devices and RFID tags attached to all of the garments. When a tag is scanned information about the particular garment is transmitted to the staff device allowing the sales associate to provide better service for the customers. The customers can also place the clothing items in a RFID Closet and the information is provided on a touch screen. . The user may also see a video clip of the close being shown on a catwalk. But ARDressCode goes beyond the Prada system by providing the customer with a virtually display of him/her self wearing the clothes.

A closing example is Virtual Try-On [Hum05] that uses a body scan to make a complete 3D model of the customer. This way the users can dress the virtual model using their personal computers, excluding the annoying aspects of trying clothes.

6. Conclusion and Future Work

This paper introduced a new AR concept for clothes try-on. The ARDressCode prototype addresses the challenges of developing a light weight multipoint motion tracking coupled to real-time animation of a coherent 3D clothes overlay in AR.

Real use of ARDressCode requires implementation of additional virtual objects including jeans, jerseys etc. Further an optimization of the coherent clothes model is needed. Finally, the VRPN communication to mobile phones has to be developed. As mentioned, ARDressCode is an alternative to a fully virtual try on. But if the customer is not able to go to a physical store, ARDressCode can also add value for customers preferring e-commerce at home. This would require print out of the necessary fiducial markers and a web cam enabling the user to try on the clothes in front of the computer. The user only needs to attach the markers and open a browser.

7. Acknowledgements

8. Author information

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