Chapter 1

Success factors for Augmented Reality Business Models

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Abstract

Augmented reality has been a research area for decades. However, there has not been a real breakthrough for commercial applications. Augmented reality still seems like the technology of the near feature. A research carried out to investigate success factors for Augmented reality business models. The reseach is divided into three parts, the business aspect, user aspect, and technology aspect.

1.1 Introduction to Augmented Reality

Augmented reality (AR) is a technique that combines a live view in real-time with virtual computer-generated images, creating a real-time 'augmented' experience of reality.

Augmented reality has been around since the 1990s. It is a term more closely related to the term 'reality' than to the term 'virtual reality', as it takes 'reality' as a starting point, then adding to it (making it a subset of 'mediated reality'). Augmented reality can be thought of as the "middle ground" between Virtual Environments (completely synthetic) and Telepresence (completely real) [Azuma, 1997]. Other terms used could have been 'enhanced reality' or 'amplified reality'.

For the last three years, augmented reality applications have become popular on mobile phones, as these devices have gotten the hardware to facilitate augmented reality applications. An example of augmented reality is Layar, which adds content to the images of the camera of a mobile phone, e.g. nearby restaurants or additional museum information. [Layar, 2010a] Older applications use Head Mounted Displays to display extra information on small display in front of a person.

1.1.1 Definition of Augmented Reality

More formally, augmented reality is considered to include the following three characteristics [Azuma, 1997]:

- Combines real and virtual

- Is interactive in real time

- Registers in 3-D

However, the above definition is not the single accepted definition. Especially since the increased interest of the general public in augmented reality, the definition has blurred a lot. A lot of Businesses make use of the hype surrounding the term as to include the term in any product that adds something to any view of reality. A fine line has to be drawn between applications that are augmented reality and applications that are not augmented reality. Is an application on a mobile phone that gives information based on a user's location augmented reality? It combines real and virtual, but might not interactive and might not register in 3D. Even in games the term augmented reality is being used to describe real-time information additions to an in-game environment.

1.1.2 Applications of Augmented Reality

Devices used for Augmented Reality are commonly [Hayes, G., 2009]:

- Mobile devices with inbuilt cameras such as iPhone, DS Lite, PSP or Android.

- A head mounted display HMDs (eg: glasses or futuristic contact lenses) attached to a wearable networked computer.

- A PC or Mac with webcam.

- A games console with camera accessory.

- A large TV screen with advanced Set Top box and Web cam.

1.1.3 Current Applications

Augmented reality is applied a lot in non-commercial applications. Pilots of aircrafts use augmented reality in their helmets to increase their available information with important additions. It is also often used for other training purposes, making a real like simulation of e.g. combat missions available in locations such as a gym. Surgeons use augmented reality in complex surgery situations. Soldiers in the field use augmented reality in their helmets to get more information on e.g. terrain and locations of enemies. A business application includes marking player and ball movements in games such as soccer in The Netherlands in (slow-motion) replays.

Mobile phone applications include adding information to Google's 3D StreetView on a mobile phone, such as businesses nearby. In this example, the user sees the environment he or she is standing in, 'augmented' with arrows or some other indicator telling him or her which business are where in relation to where the user is standing. Previous to mobile phones being used for AR purposes, the main way AR could be perceived was through helmets with build-in screens. Besides add-ons to Google's StreetView, there are multiple other open-source tools that bring AR to the mobile phone. Another succesful application is 'Layar' (detailed below).

Layar

Today's most succesful commercial application (which is also largely responsible for the buzz surround the term among general public) is the Layar Reality Browser (commonly refered to as 'Layar'). Layar is a mobile phone application (developed by a Dutch company based in Amsterdam) that shows you what is around you by displaying information on what is around you on top of reality [Layar, 2010a]. It uses a phone's GPS connection to check the user's location, and its compass and accelerometer to check in what direction the user is looking. The phone retrieves information via a mobile internet connection. Developers can add different kinds of layers to the application, which determine the information the user is getting (e.g. Wikipedia information, information on restaurants).

As of september 2010, Layar added 3D-capabilities to its platform, giving developers the ability to add 3D-text and 3D-objects to layers [Layar, 2010b].

1.1.4 Possible Future Applications

Augmented Reality is used in a number of ways, especially outside of business applications. However, it is interesting to see in which ways the technology will develop in commercial ways.

Some interesting possible future applications include [Gurd, J., 2010]:

- A store item-finder app overlay on a store's map.

- Advertisements on mobile phones based on a person's location (which also raises the question of whether this is Augmented Reality or not, see the question raised above).

- Customer reviews on shop items shown in stores.

- Getting reviews on shop items by scanning a barcode in-store with a mobile phone.

- Modeling of clothes by people at home, making internet purchasing of clothes easier.

- Generation of 3D models of rooms and furniture enabling a.o. stylists to style the room.

- Creation of mobile maps of a region by local tourist boards.

- Addition of information to exhibitions by museums.

1.1.5 Document structure

This document starts with a research question. This research question breaks up the subject into three parts: the business aspect, the user (or technology acceptance) aspect, and the technology aspect. For each aspect, the research methdology will be discussed, a literature will be done, results will be presented and conclusions will be drwan. The document ends with a gernal conclusion and answer to the research question.

1.2 Problem Statement

Augmented reality has been researched since the 1990s, which has lead to a lot of possible applications of this technique. The types of applications mentioned above have made AR available to the general public, as the PDA, or smartphone has become more and more popular, its most famous example being the iPhone. Despite the great amount of possibilities with AR applications, there are only a few business models successfully exploiting augmented reality technology. This can be caused by businesses not knowing it being unclear how a business can make money with AR. It seems there are some hindering factors, delaying the broad implementation of augmented reality, making it continually to be the technology of the near future. [Sviokla, 2009] In a desirable situation there will be many more succesful AR applications. Possible hindering factors may be e.g. the amount of hardware needed, costs of implementation or social acceptance.

This research will attempt to find out how AR could be made commercially viable, by trying to find the elements an AR business model needs. This could then also be used to see whether newer AR applications will become succesful in the future.

1.2.1 Goal

A Business model breaks up into different parts. This article is aimed at finding the elements of a business model that apply to the applications of AR, and in doing so, giving an idea of how a AR business model functions.

1.3 Research Questions

The problem stated in the previous question leads to several aspects of business models and augmented reality that need investigating. To find out what makes an AR application commercially successful, we need to look at what success is for an AR application. We assume success factors for a technical product such as an AR application fall into three categories:

Business factors such as value creation and distribution of an AR application.

Technology acceptance or user factors such as the usability of an AR application.

Technological factors such as the technical functionality of an AR application.

The aim of this research is to link these success factors to elements from the business model framework proposed by Osterwalder, so we can estimate the success of an application based on the business model the application has. This leads to the main research question:

What are success and failure factors from a business, user and technological perspective for an implementation of a business model framework for Augmented Reality applications?
The main research question breaks down into the following sub questions:

What are the elements and internal structure of the nine parts of an implementation of the Osterwalder business framework for AR applications?
What are technological acceptance factors for AR applications?
What are technological success factors for AR applications?

1.4 Business aspect

This section will describe the business aspects of Augmented Reality applications.

1.4.1 Methodology

The business aspect of augmented reality applications will be researched through an application of the Osterwalder business model framework to the domain. This means that for all elements of the framework, such as value proposition, partner network and financial aspects, we'll search specific AR implementations. As it is not feasible to find all possible implementations of the Osterwalder framework for AR, we will limit the research to a few cases.

1.4.2 Business Model Frameworks

So far, we've mentioned one business model framework that is to be part of this research:the Osterwalder business model framework. This section will delve deeper into the subject of business model frameworks. The aim of this investigation is to clarify what a business model framework is, what its applications are and which model is most suitable for our use. To reach this goal, the start is taking a look at what a business model framework is.

Business Model

Joan Magretta describes a business model as a story that is some variation on existing value chains [Magretta, 2002]. Alex Osterwalder uses a more elaborate definition:
"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams."[Osterwalder, 2004].

At first glance, these definitions seam to differ extensively, as Osterwalder uses terms such as *tool*, *architecture* and *network*. However, the definitions are similar in the sense that they both state that a business model is some way of capturing value and distributing it, the value chain. Both authors agree that a business model is a variation on a theme, each is made up of elements from other business models.

Before we go further with our discussion of business model frameworks, we'll take a closer look at the definition of a business model. This is the main theoretical concept in our study of the business aspect of succesful augmented reality applications, so it is important to have a complete grasp of the subject. Below, the Osterwalder definition of a business model is broken down into its elements.

...the value a company offers... Value is the key concept of a business model. it is what a business trades with its customers. Value can be financial, but more likely with AR applications, it is non financial, in the form some sort of service offered to customers.

...to one or several segments of customers... The type of customers the business wants to focus on.

...the architecture of the firm... How the business is set up, in other words, what the internal structure is.

...its network of partners... The partners making the business possible, such as, in case of AR applications, technology providers.

...creating, marketing and delivering this value... The actual "business", what the business does.

...generate profitable and sustainable revenue streams. The bottom line of a business: making sure money not only comes in at some point, but keeps coming in.

The discussion above brings us to what a business model framework is: a description of elements that can be found in a business model, the building blocks for a business model, or, in the words of Magretta, the possible variations of the "story". In that sense, the business model framework is an ontology, a description of the elements and constructs needed to model a certain domain, in this case business models. As the term ontology is often used in connection to the Bunge-Wand-Weber models, some more elaboration is in place. Mario Bunge developed a basic ontology from a philosophical perspective, giving a description of the elements needed to describe "the world", or in Bunge's own terms, "the furniture of the world" [Bunge, 1977]. Yair Wand and Ron Weber created an adaptation of this model, making it more applicable to the field of information

technology [Wand and Weber, 1990]. The model has since then been a frequently used way to describe information systems and processes. However, as our definition of a business model is not focused on processes, we explicitly do not use the BWW model. As any ontology is related to Bunge original work in metaphysics, an ontology of business models does conform to the elements Bunge proposed. A further discussion of ontologies goes beyond the scope of this paper, it suffices to state that for our purposes, we consider an ontology to be a set of constructs needed to describe a domain.

Other terms used for such a set of constructs and elements is a *reference model* and of course, business model framework. As the latter is the term most often used, at least in the two main ontologies/reference models/frameworks considered here (STOF and Osterwalder), we'll use *business model framework* from here onwards. A little more formally, we'll use the following definition of a business model framework:

An ontology describing the elements that make up a business model[1].

1.4.3 Applications of Business Model Frameworks

With the definition of a business model and business model framework clear, it's time look at how business model frameworks can be used. Osterwalder and Pigneur give the following reasons for using such a framework [Osterwalder et al., 2002]:

- Increase understanding of the domain of the business, through dividing the business model in smaller "portions".

- Making it more easy to share the business model with other stakeholders, as a framework is a fixed point that can be used to compare businesses and business models.

- Increased understanding of the business model, in other words, knowing the mechanics of the business, makes it easier to adapt it.

- A framework makes it possible to simulate businesses, enabling one to learn about them without putting an organization at risk.

Comparison of Business Model Frameworks

Above, we have described what we consider to be a business model framework, mentioning the Osterwalder business framework. As choosing a suitable framework is central to answering the research question, this section looks into what framework best fits this research and the Augmented Reality domain in general. The framework chosen plays the role of "glue" in this research, binding together the technological, user and business elements. That already limits the choices available for a framework, as it must allow for a broad field of elements. Besides a general framework encompassing the research as a whole, this section also looks into a business model framework that gives more detail on the value from a business perspective.

We choose to assess the business value aspect of augmented reality using a business model framework based on the premise that a *business case* is an instantiation of a *business model framework*: it is a concrete implementation of the elements of the business model framework. A business case is either a success or not, giving information on what implementation of elements of the framework is a success. The use of the framework is needed, as this gives a common ground on which every business case and its succesful elements can be mapped.

What this means, is that we need two candidate business model frameworks, one general, one specific to business value. An obvious candidate would be the Osterwalder business model framework, being one of the more well known business model frameworks. Another candidate is the STOF model, developed by [Bouwman et al., 2008]. This model combines a business model ontology with information on the technological side of business. To limit the scope, these are the two models we'll compare below.

Osterwalder Business Model Framework

One of the more well-known business model frameworks, specifically to technological businesses, is the Osterwalder business model framework, or in his own words: The business model ontology [Osterwalder, 2004]. The ontology for business he proposes contains of nine elements, grouped into Alex Osterwalder proposed a nine-element business model framework in his dissertation, divided into four pillars: *Product, Customer Interface, Infrastructure Management* and *Financial Aspects*.

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[1]Note: we consider a business model to be as Osterwalder defined

The pillars show the four main elements of business, which are subdivided into a total of nine elements. The subdivision allows for more detailed modelling of business.

Figure 1.1 shows the pillars and the nine elements comprising the pillars[2]. This figure is an adaptation of the business model canvas, a tool developed by Osterwalder to visualize the business model [Osterwalder, 2010]. The left side (Infrastructure management) shows value capturing and creation through using resources from partners for activities, the middle (Product) shows what value is created and the right side (Customer interface) shows how the value is distributed to customers through different channels. Finally, the lower part (Financial aspects) of the figure displays the financial "bottom line" associated with the value above.
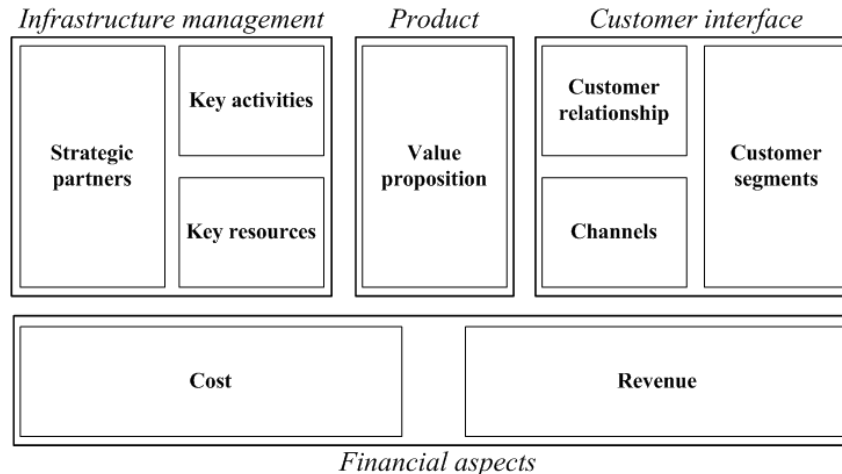

Figure 1.1: The Osterwalder Business Model Ontology

The table (table 1.1) below shows a more detailed description, including a possible value for the AR domain [3] of the elements of the Osterwalder business model framework.

1.5   Business Model Scenarios

The previous section discussed the theoretical aspect of business modelling and what a business model framework is. This provides a starting point to finding an answer to the business aspect of our research question: *"What are the elements and internal structure of the nine parts of an implementation of the Osterwalder business framework for AR applications?"* As this question suggests, the answer should consist of a description of possibile implementations for every element of the Osterwalder framework. Seen from the perspective of finding success and failure factors, we need to add to that which of these business model element implementations contribute to business success or failure. To provide these answer, this section will start with a discussion of element implementations. After that, the focus will shift to success and failure, by looking at actual successful AR applications and their business model.

1.5.1   Ontology of Augmented Reality business model implementations

This section looks at different implementations for each of the nine elements of the Osterwalder business model framework, with the aim of providing a complete as possible view of the AR domain. At the end, any AR business model should be built up from variations of the implementations of the nine elements. As this is in essence a description of the elements in the domain, this is in fact an ontology, and thereby a specialization of the Osterwalder business model ontology to the AR domain. Of course, the challenge in devicing this ontology is the level of abstraction, or being specific enough to be useful and abstract enough to be applicable to the entire domain.

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[2]Note: the original titles and descriptions for the elements customer segments, key activities and key resources in Osterwalder's dissertation were somewhat different from what is shown above. In his later work, he uses the titles mentioned in the figure. Therefore, we chose to use the newer titles.

[3]As mentioned above, the descriptions of key partners, activities and resources are different from Osterwalder's dissertation. However, this is just a different distribution of what a resource, activity and partner are, altogether the infrastructure management would have the same description in both the older and newer model.

Element	Description
Value proposition	The bundle of services and product the company offers that have value to it's customers. For AR, this is something like "Integrating virtual information into the real world"
Key partners	Those organizations partnering with the company to create value for the customer. Partners for AR applications are technology and infrastructure providers, such as AR device manufacturers.
Key activities	The activities and processes within the company that create value for the customer. AR activities include developing new software.
Key resources	The resources the company requires to create value for the customer. A required resource for AR is a device through which AR can be perceived.
Customer segments	The segments of customers the company wants to deliver value to. As the possible applications of AR are broad, any customer segment could possibly apply.
Distribution channels	The means of getting in touch with customers the company has. Since AR applications are likely to be distributed through the internet, this will be the most importantt distribution channel.
Customer relationship	The type of relation the company has established with the customer. As AR software is likely to be distributed online, the relation to the customer will be indirect and not very intensive.

Table 1.1: Description of the elements of the Osterwalder business model framework, including an application to the AR domain

Value proposition

Since a business model revolves around value, this ontology will start with the value proposition. The value proposition states what bundle of services and products the application provides. For augmented reality, we consider 16 different types of value propositions[Hayes, 2009]. This means that any application of AR conforms to some variation of these types. Of course, there can be no certainty that this list of types is exhausting, as AR is an evolving technology. A factor contributing to this list changing with time is that business model innovation is a key driver for business success. This will be discussed in more detail in the section on succes and failure factors. Tabel 1.2 shows the 16 different types of value propositions for Augmented Reality applications.

Value proposition type	Description
In situ	*Making it possible to see a product in its environment before it's completed.* This value proposition is for instance applicable to furniture manufacturers, who could show their product in a potential customers living room. Another example is the virtual fitting room, which is discussed in more detail in the section on the user aspect of AR.
	Continued on next page

Value proposition type	Description
Utility	*Enhancing life by making things easier.* Practically any application that provides information to its users fits this value proposition, such as an application that shows where mail boxes nearby are located. Many of the Layar-applications have this value proposition.
Training	*Improving training by practising real life situations.* AR can be used to create a situation that may be difficult to create in real life, on which people can practise their skills. Examples of applications that fit this proposition include surgery and bomb disposal
Social Gaming	*Providing gaming as part of the real word.* This proposition is about combining virtual and real world for gaming. Examples include paint ball like competition with virtual bullets, but also betting applications fall under this category. The latter would be something like a customer watching a horse race and seeing in real time what the odds are per horse.
Location layers	*Location based guides and routes.* This is applicable to applications that give information on the most interesting sites in a city or a guide around a museum. This proposition is closely related to utility, but is specifically focused on the value offered by a travel guide.
Virtual demo	*Seeing and manipulating a product before it's available.* This applies to customers being able to see a product in a store or catalogue that isn't released, or being able to see the product before it's assembled (for instance used for LEGO products). This proposition is related to the in situ-proposition, but differs in the sense that in situ is about seeing the product in it's eventual location, whereas virtual demo is just about the product.
Experiential education	*Adding a new experience to education.* This value proposition covers all applications that add a new virtual dimension to education. Examples would be a trip to an archaeological site, where the site "comes to life" in AR.
Enhanced classifieds	*Seeing a localized directory of products offered.* This proposition is about seeing what products are offered in a consumers neighbourhood, or guiding a consumer to the product they want.
3D virals	*Virtual advertising as part of the environment.* This proposition covers advertising in augmented reality with some form of interaction, so-called virals.
Personalized shopping	*Adding suggestions while shopping.* This proposition is another form of advertising, where shops can give customers suggestions on what to buy in augmented reality, based on their personal preferences.
	Continued on next page

Value proposition type	Description
Cooperation	*Improving remote cooperation with virtual services.* This proposition applies to working together by using Augmented Reality. An example is meetings where external participants are present through AR.
Blended branding	*Providing virtual advertising space.* This applies to adding advertisements to the virtual domain, so that someone using AR would see the advertisement.
Augmented events	*Relevant content added to events.* This value proposition is about enhancing the experience at for example a pop concert. A user would see the event, plus relevant information, such as how to buy the album.
Intertainment	*Enhancing entertainment experience.* This proposition is applicable to bringing TV and movies to the spectators through AR. For example, the movie scenes would be playing in the spectators living room.
Understanding systems	*Increase understanding of complex systems.* This proposition is about using AR to have different views of an object or system, and being able to virtually "take it apart".
Recognition & targeting	*Recognizing customers and knowing their backgrounds.* This proposition applies to applications that identify customers and display their habits or shopping history.

As mentioned above, value is central in Osterwalder's business model framework. In the business model canvas (a graphical tool for analyzing and developing business models, made up of the nine elements of Osterwalder's business model framework) [Osterwalder, 2010] , this is emphasized by the value proposition being the center point of the canvas. Since this ontology of AR business model implementations is a specialization of Osterwalder's framework, the value propositions therefore naturally are central as well.

The remaining ontologies of the other eight elements that are to be discussed for this ontology are grouped by value propositions. That means that the discussion of the eight remaining element is made from the perspective of the value proposition. The next element to be discussed is the *Key partner* element, as part of the value creation substructure (*pillar*) of Osterwalder's framework.

Key Partners

General

The Key Partners are, per Osterwalder's definition *those organizations partnering with the company to create value for the customer*. Their role is supporting the company in creating value and helping created value to be delivered. The two major types of key partner are mentioned in this last sentence: *technology providers* and *infrastructure providers*.

Technology providers give the company the tools they need to create value. For augmented realiity, these tools are either for creating the application (software) or form a platform for the AR application. The latter can be hardware (an Augmented Reality device) and software (more precisely *middleware*, an abstraction layer between the application and the hardware).

Infrastructure providers facilitate the company in bringing the value it creates to their customers. For augmented reality, this is all about bringing the application to the customer. The most likely way of bringing the value to the customer for software applications is the Internet, making Internet service providers the most important among the infrastructure providers. Other providers are organizations that supply the AR application as part of their own value proposition, such as Google's Android Market and Apple's App Store. This role can be called application broker.

Schematically, the key partner element is divided into subelements as seen in figure 1.2. Note that actual key partners are in italics.
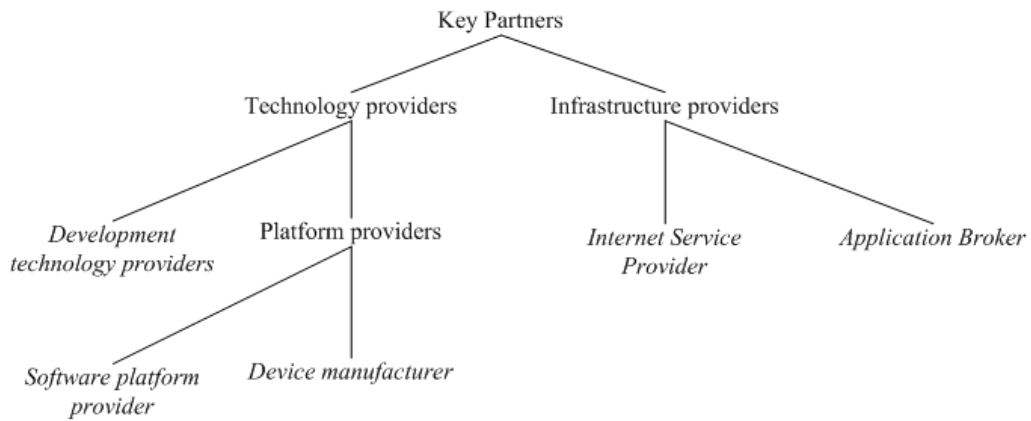
Figure 1.2: Structure of Key Partners for AR applications

Development Technology Provider	Software Platform Provider	Device manufacturer	Internet Service Provider	Application broker
All	All	Training Social gaming Virtual demo Experiential education Intertainment	All	All

Table 1.3: Key partners per value proposition

Value proposition specific

The five key partners mentioned above do not necessarily apply to every value proposition. Specifically the device manufacturer does not apply to every proposition, as not every proposition needs specific hardware. Table 1.3 below shows the five key partner types, and to which value propositions they could apply.

Key Activities

General

Key activities are the processes a company performs on its resources in order to create value. As companies that create AR applications are software developers, the most important processes involve the creation of software. Software development is broken down into two types of processes, that create value for customers. The first is *Creating new software*, which creates value by offering completely new functionality to customers. The second type is *Resolving software problems*, which is about adding value through removing bugs and problems with existing software. Figure 1.3 shows the sub elements of the Key Activities element.
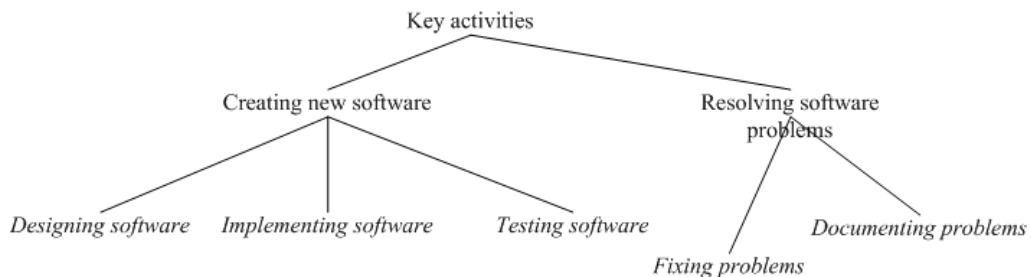

Figure 1.3: Structure of Key Activities for AR applications

Value proposition specific

As both key activities type apply to any software development company, there are no differences in key activity types for the different value propositions.

Key Resources

General

Key resources are the resources the company needs to create value for its customers. Resources are used by the company's processes and activities. AR applications are essentially software, and technology is needed to create software. Since AR needs a device for it to be perceived, devices are also needed in the process of AR application development. Technology is defined as the practical application of knowledge in a specific area, which means that knowledge is also a resource for AR. This knowledge can either be in the form of patents filed, or expertise of the company's staff. This brings us to the structure of key resources as shown in figure 1.10.
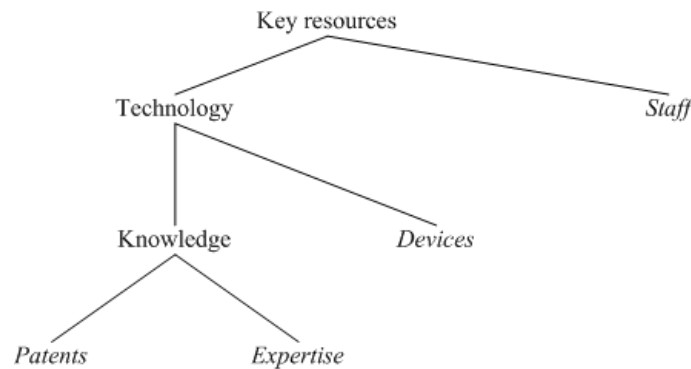

Figure 1.4: Structure of Key Resources for AR applications

Value proposition specific

Every value proposition potentially needs devices, staff, expertise and patents to create the value they deliver to customers. There are therefore no differences in resource types for the sixteen value propositions.

Customer Relationships

The customer relationship element represents the type of relationship the company has with it's customers. The relation can either be focused on customer acquisition (getting more customers), customer retention or increasing sales per customer (add-on relationship). The relationship differs per type of value proposition and can take an abundance of forms. What can be said in general is that a customer relationship for an AR application is not likely to be direct, as the company would have no direct contact with its customers.

Distribution Channels

General

Distribution channels are the ways the company gets in touch with their customers and distributes its value. For software, the most prominent distribution channel is directly through the Internet, allowing customers to download the application from the company's website. An alternative is to distribute the application to some application publisher or broker, which in turn transfers the application to it's customers. The latter is mostly applicable to AR applications for mobile devices, specifically to Google's Android Market and Apples App Store. The final alternative would be to distribute through (electronics) stores. This structure is shown in figure 1.5.

Value proposition specific

As mentioned above, the application broker channel is most applicable to AR for mobile, as seen in the two brokers we mentioned. The value propositions that are likely to be used through mobile
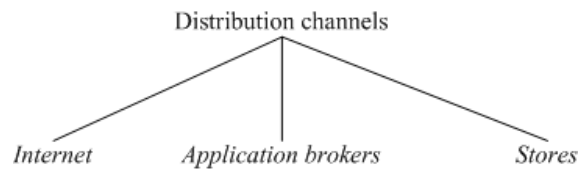
Figure 1.5: Structure of Distribution Channels for AR applications

devices are in situ, utility, location layers, enhanced classifieds, 3D virals, personalized shopping, blended branding and augmented events.

Customer Segments

General

Customer segments are the types of customers the company wants to deliver value to. Since this is different depending on what value the company wants to delivered, no general remarks can be made on this subject.

Value proposition specific

Table 1.4 is an incomplete list of potential customer segments per value proposition.

Value propostion	Customer segments
In situ	Manufacturers, architects
Utility	"Smartphone" users
Training	Students, teachers
Social gaming	Gamers
Location layers	"Smartphone" users
Virtual demo	Shop customers, shopkeepers
Experiential education	Museums, zoos, educational institutions
Enhanced classifieds	"Smartphone" users
3D Virals	"Smartphone" users
Personalized shopping	"Smartphone" users, shopkeepers
Cooperation	Business professionals
Blended branding	"Smartphone users"
Augmented events	"Smartphone users"
Intertainment	Home entertainment users
Understanding systems	Students, teachers, mechanics
Recognition & targeting	Marketers

Table 1.4: Potential customer segments per value proposition

Value & Cost Structure

The value and cost structure describe the financial aspect that is associated with the value captured and delivered by the application, specifying both cost and revenues. The main costs for an AR application are staff, for developing the application itself, and possibly Internet hosting, for delivering the application to the company's customers. The revenues can either be advertisements or fees customers pay for the application.

Overview of the AR Business Model Framework

Appendix B shows an overview of the AR Business Model Framework described above. The appendix shows a specialization of the Osterwalder Business Model Canvas, that can be used for augmented reality applications.

1.5.2 Success and Failure Scenarios

The previous section has discussed an ontology of AR applications. This section looks at what impact specific business model implementations have on the success of an AR application. To start, we look briefly at what success is.

What is *success*?

A well known definition of business success is profit. If a business is profitable, it is deemed successful, and vice versa. As profit is essential to a business' survival, this seems like a valid definition. However, it can be refined. As the business model framework discussed is all about value, value should also be considered in the definition of success. Therefore, we assume a business to be successful if it adds value for its customers. With that *should* also come profit.

Successful AR ventures

An application that implements the framework discussed above is likely to be profitable, as it means it conforms to the standards of the industry. If other companies can be successful with business model that matches the framework, then so can a new venture implementing the framework. Since there are still very few paid AR applications, the field is still open for new entrants. It is however outside the scope of this research to exactly determine what combination and implementation of the nine elements is really successful.

1.6 User aspect

One factor that influences the success of a new technology is the acceptance by users. Various studies have been done to be able to predict the intention of users to actually use a new technology. In this section, a research is carried out to be able to predict factors that influence the acceptance of Augmented Reality. First a literature study will be done to find a relevant method to analyze user behavior. A method will be chosen to be adjusted for the Augmented Reality domain. The results of the research will be discussed, and end with a sub conclusion on the user aspect of this research.

1.6.1 Literature

A technology acceptance model examines how users come to accept and use a technology. According to Venkatesh et al., information systems research has long studied how and why individuals adopt new information technologies, and the explanation of user acceptance of new technology is often described as one of the most mature research areas in the contemporary information systems literature. Within this broad area, there have been several streams of research, and each of these streams makes important contributions to the literature on user acceptance of information technology. One stream of research focuses on individual acceptance of technology by using intention or usage as a dependent variable. Other streams have focused on implementation success at the organizational level and task-technology fit among others. In this section, a number of these users acceptance models will be discussed.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) [Davis, 1989] is a theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it, summarized as:

- Perceived usefulness (PU) - This was defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance".

- Perceived ease-of-use (PEOU) - Davis defined this as "the degree to which a person believes that using a particular system would be free from effort".

  Validation of TAM found it to account for 40% of the variance in usage intention.

Unified Theory of Acceptance and Use of Technology (UTAUT)

Unified Theory of Acceptance and Use of Technology (UTAUT) is a technology acceptance model that aims to explain user intentions to use an information system and usage behavior. The theory holds that four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior. Validation of UTAUT in a longitudinal study found it to account for 70% of the variance in usage intention. [Venkatesh et al., 2003]

UTAUT was developed through a review and consolidation of the constructs of eight models that earlier research had employed to explain information systems usage behavior:

- Theory of Reasoned Action (TRA)

- Technology Acceptance Model (TAM)

- Motivational model (MM)

- Theory of Planned Behavior (TPB)

- Combined TAM and TPB (C-TAM-TPB)

- Model of PC Utilization (MPCU)

- Innovation Diffusion Theory (IDT)

- Social Cognitive Theory (SCT)

The unified theory of acceptance and use of technology comprises four core determinants of intention and usage, and up to four moderates of key relations. Four constructs play a significant role as direct determinants of user acceptance and usage behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. The four key moderators in UTAUT are gender, age, experience, and voluntariness of use.

The authors of UTAUT argue that in terms of explained variance the unified model is a substantial improvement over any of the original eight models and their extensions. They posed that ATAUT provides a useful tool to asses the likelihood of success for new technology introductions and helps to understand the drivers of acceptance in order to proactively design interventions targeted at populations of users that may be less inclined to adopt and use new systems.

1.6.2   Methodology

To identify the success and failing factors for Augmented Reality technology, a survey will be held. The result of this survey should be an overview of factor that support or inhibit the success of Augmented Reality.

As mentioned in the previous section, there are a number of models are available to determine the user acceptance of technology. Because of the high predictable value of UTAUT, the questionnaire of UTAUT will be used. UTAUT contains a user questionnaire with selectable building blocks to determine the extend of acceptance of technology. The relevant building blocks are selected, based on the relevancy to Augmented Reality. A survey is carried out with possible users of Augmented Reality applications. The estimated number of responses is 50. The survey will result in factors that support or inhibit the success of augmented reality applications.

Research model   The basis for the research model will be the results of the UTAUT model. For reference, Figure 1.6 shows the initial research model of UTAUT. However, the results of UTAUT show that seven constructs that have direct impact on user intention. They will be included in the initial research model for a theoretical reference. These constructs are performance expectancy, effort expectancy, attitude toward using technology, facilitating conditions, self-efficacy, social influence, and anxiety.

Target group   The target group of this questionnaire will be consumers that might use augmented reality for private use. This includes entertainment, gaming, personal assistance etc. The questionnaire explicitly will not be used for a professional user target group, i.e. supporting of professional tasks in working conditions.
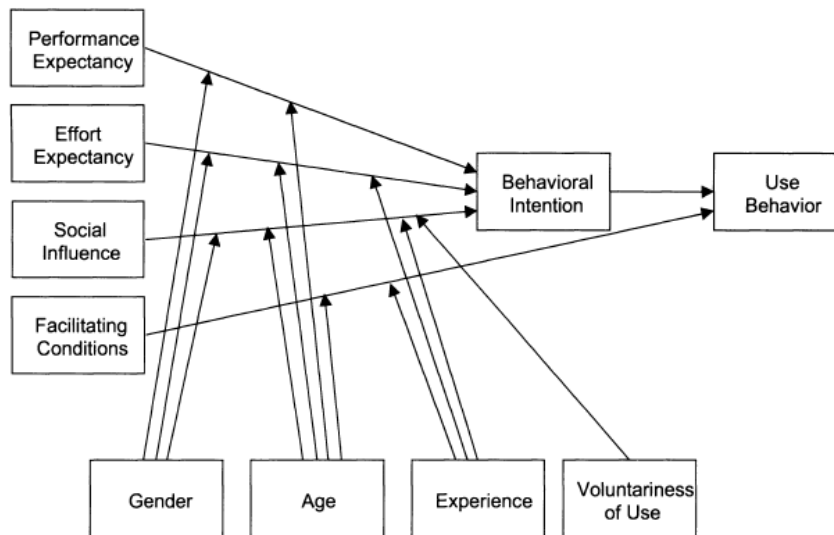
Figure 1.6: UTAUT Research model

Setup In the questionnaire, an introduction to augmented reality technology is be given. There are a lot of technologies and applications that could be used. Due to the limited time, the scope will be narrowed to Handheld Displays (i.e. mobile phone) and applications for a consumer target group. This explicitly excludes Head Mounted Displays and Spatial Displays as technology, as well as use in a professional environment.

Two applications will be presented in the questionnaire, using a short text and video. The first is Layar[4], which provides a framework to add information to live images captured by the camera of a mobile phone. In particular, an example of an real estate application is given. The second application is a virtual dressing room[5][6], developed by the on-line shop Tobi. Users can view an image om theirself which is captured via a webcam, and try different clothes which are shown on top of this image. The questionnaire ends with some general questions.

Questions The building blocks of the UTAUT model are changed to comply to the augmented reality context as described before. The main questions can be found in Appendix A. The phrase 'augmented reality' can be replaced by either 'Layar' or 'the virtual dressing room'. Answers could be given on a seven-point scale ranging from 1 (completely disagree) to 7 (completely agree). The Behavioral Intention questions had a seven-point scale ranging from 1 (extremely unlikely) to 7 (extremely likely). Due to the nature of the applications (for consumer usage), it is assumed that the applications would be used voluntary, so no questions about voluntariness of usage were asked. The UTAUT questionnaire was extended with general questions about the gender, age and experience level with new technology of the respondent.

1.6.3 Results

The questionnaire has been put online during using Thesistools.com during one week in July 2010, and has been promoted via social media (Twitter, Facebook, LinkedIN etc.) and direct mails. In this section, the results of the questionnaire will be presented and discussed.

Respondents In total, 59 respondents have filled in the questionnaire. Of these 59 results, 49 were complete and had answers to all questions (the other 10 had at least three missing answers). For a better quality of conclusions, only the 49 fully completed results will be used during the analysis. Table 1.5, 1.6 and 1.7 show some statistics about the respondents. Due to the network that was queried, we expect most of the respondents to be students with higher education.

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[4]Layar video available via: `http://www.youtube.com/watch?v=b64_16K2e08`

[5]Virtual Dressing Room video available via: `http://www.youtube.com/watch?v=NxQZuo6pFUw`

[6]Virtual Dressing Room demo available via: `http://www.tobi.com/editorial/tobi-blog/1039-try-it-on-in-our-virtual-dressing-room?p111609`

Age group	Frequency	Percent
0 - 10	0	0%
11 - 20	7	14.3%
21 - 30	30	61.2%
31 - 40	2	4.1%
41 - 50	6	12.2%
51 - 60	3	6.1%
60+	1	2.0%

Table 1.5: Participant ages (n=49)

Gender	Frequency	Percent
Male	39	79.6%
Female	10	20.4%

Table 1.6: Participant gender (n=49)

Reliability   The questionnaire consisted of seven groups of questions. To check the internal consistency of answers within a group, a Chronbach Alpha consistency analysis were executed. In statistics, a group is considered internally consistent when the α value is above 0.60.

The results are shown in Table 1.8 for Layar and Table 1.9 for the Virtual Dressing Room. For Layar, the α value of Facilitating Conditions was below zero, indicating an measurement error within one of the questions. We assume the the measurement error existed due to the different interpretation of human and technical resources. After removing question FC3, the α value reached its highest value, although it is just above zero.

The Chronbach Alpha analyses show that for both Layar and the Virtual Dressing Room, the α value is far below 0.60. The results of this construct do not have enough internal consistency, and will not be used for further analyses. The Social Influence of Layar also has a α value below 0.60. Removing question SI3 raises the α value to 0.928. This shows that respondents feel a difference between support from the environment and encouraging to use from their environment.

Correlations   A correlation analysis is carried out to check whether there is a signification relation between the different constructs. A correlation between -1.0 and -0.5, or between 0.5 and 1.0 can be considered as correlated. A 95% confidence interval will be used to determine significance.

Table 1.10 shows the correlation matrix for Layar, Table 1.11 shows the correlation matrix for the Virtual Dressing Room. Italic values are significant ($p < 0.05$). For both Layar and the Virtual Dressing Room, a strong correlation between PE - AT can be seen. Both also have significant correlation between PE - BI, AT - BI can be seen. Layar also has a (negative) significant correlation between SI - EE and ANX - EE. The Virtual Dressing Room has a signification correlation between ANX - BI. Overall, it has to be mentioned that the correlations for the Virtual Dressing Room are lower than the correlations for Layar.

A high correlation does not directly imply a casual relationship. A regression analysis is needed to conform such a relationship.

Answer	Frequency	Percent
None	2	4,1
Very little	2	4,1
Little	3	6,1
Not a little, not much	2	4,1
A bit	6	12,2
Much	17	34,7
Very much	16	32,7

Table 1.7: Experience with new technology (n=49)

Question	M	SD
Performance expectancy ($\alpha = 0.705$)		
PE1	4.22	1.462
PE2	4.27	1.287
PE3	5.12	1.252
Attitude toward using technology ($\alpha = 0.686$)		
AT1	5.29	1.041
AT2	3.61	1.592
AT3	4.71	1.500
AT4	4.08	0.932
Social Influence ($\alpha = 0.401$)		
SI1	2.63	1.439
SI2	2.73	1.538
SI3	4.76	1.164
Facilitating conditions ($\alpha = 0.02$)		
FC1	3.61	2.379
FC2	5.47	1.815
FC3 (removed)	3.80	1.915
FC4	4.88	1.867
Anxiety ($\alpha = 0.951$)		
ANX1	2.24	1.562
ANX2	2.20	1.541
ANX3	2.06	1.573
ANX4	1.96	1.471
Behavioral intention to use the system ($\alpha = 0.894$)		
BI1	2.96	2.111
BI2	2.90	2.064
BI3	2.22	1.723
Effort expectancy ($\alpha = 0.712$)		
EE1	5.04	1.190
EE2	5.37	1.349
EE3	4.63	1.167
Other		
KNOWL.	1.84	0.773
GENDER	1.20	0.407
AGE	3.41	1.189
EXPER.	5.45	1.826

Table 1.8: Descriptive Statistics, Factor Loadings, Squared Multiple Correlations, and Cronbachs Alpha of the Observed Indicators to explain acceptance of Layar

Question	M	SD
Performance expectancy ($\alpha = 0.871$)		
PE1	3.43	1.882
PE2	3.22	1.598
PE3	4.49	1.502
Attitude toward using technology ($\alpha = 0.865$)		
AT1	4.73	1.800
AT2	2.73	1.693
AT3	3.90	1.874
AT4	3.24	1.677
Social Influence ($\alpha = 0.712$)		
SI1	2.24	1.407
SI2	2.27	1.440
SI3	4.04	1.732
Facilitating conditions ($\alpha = 0.035$)		
FC1	4.63	2.233
FC2	5.69	1.698
FC3	2.57	1.720
FC4	4.24	2.006
Anxiety ($\alpha = 0.911$)		
ANX1	2.22	1.558
ANX2	1.71	1.155
ANX3	1.65	1.182
ANX4	1.80	1.384
Behavioral intention to use the system ($\alpha = 0.958$)		
BI1	1.59	1.189
BI2	1.73	1.319
BI3	1.53	1.101
Effort expectancy ($\alpha = 0.827$)		
EE1	5.06	1.478
EE2	5.43	1.414
EE3	4.53	1.445
Other		
KNOWL.	1.16	.373
GENDER	1.20	.407
AGE	3.41	1.189
EXPERIENCE	5.45	1.826

Table 1.9: Descriptive Statistics, Factor Loadings, Squared Multiple Correlations, and Cronbachs Alpha of the Observed Indicators to explain acceptance of the Virutal Dressing Room

Q	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0 KN	1	.11	.00	.19	*.29*	.27	*.28*	*.39*	-.22	-.19	*.42*	*.49*	*.56*	-.21	.01	*-.33*	*-.34*	*-.30*	-.26	*.66*	*.68*	*.42*	.23	.08	*.37*
1 PE1		1	*.48*	*.50*	*.41*	*.32*	*.46*	*.34*	-.16	-.07	*.39*	-.07	.01	-.04	-.08	-.18	-.06	-.11	-.21	*.31*	*.38*	*.32*	-.09	-.17	-.07
2 PE2			1	*.35*	*.38*	*.31*	.21	.26	.28	*.33*	.10	.10	-.19	-.02	.15	-.15	-.01	.04	-.07	.25	*.38*	*.46*	-.17	-.25	-.11
3 PE3				1	*.60*	*.30*	.20	*.29*	.00	.16	*.35*	-.05	.19	-.02	-.04	-.24	-.24	-.27	-.28	.19	*.34*	*.34*	.09	-.14	-.01
4 AT1					1	*.28*	*.32*	.25	-.08	.05	*.42*	.05	.28	.04	.07	*-.42*	*-.28*	-.27	*-.37*	*.36*	*.41*	*.43*	.24	.00	.14
5 AT2						1	*.28*	*.50*	.13	.16	.00	.06	.24	.20	-.23	-.10	-.04	-.03	-.22	*.31*	*.35*	*.43*	-.04	-.06	.08
6 AT3							1	*.67*	*-.30*	-.16	.20	.08	*.36*	.02	.12	-.23	-.18	-.18	*-.30*	*.33*	*.31*	.21	.23	.11	.26
7 AT4								1	-.02	.06	.08	.04	*.32*	.16	.03	-.07	-.10	-.07	-.10	*.34*	*.38*	*.34*	.05	-.06	.16
8 SI1									1	*.87*	-.30	.05	*-.34*	.18	.02	.18	.15	.27	.23	-.25	-.21	.12	*-.40*	-.27	*-.31*
9 SI2										1	-.20	.06	-.19	.11	.03	.14	.12	.23	.21	-.11	-.07	*.29*	*-.32*	-.21	-.25
10 SI3											1	*.33*	.21	*-.39*	.15	*-.37*	*-.35*	*-.31*	*-.30*	*.34*	*.41*	.26	.01	-.13	.01
11 FC1												1	.20	*-.45*	.00	-.11	-.09	-.14	-.11	*.32*	*.39*	.22	.03	-.09	.14
12 FC2													1	-.04	-.25	*-.53*	*-.47*	*-.49*	*-.50*	*.34*	*.35*	.13	*.51*	*.52*	*.35*
13 FC3														1	-.25	.06	.12	.18	.08	-.18	*-.33*	-.21	-.12	-.20	-.12
14 FC4															1	-.06	-.11	-.10	.00	.09	.06	.25	.01	.05	.12
15 ANX1																1	*.77*	*.77*	*.87*	-.26	*-.33*	-.11	*-.50*	*-.33*	*-.42*
16 ANX2																	1	*.85*	*.84*	-.18	-.23	-.07	*-.30*	-.23	*-.35*
17 ANX3																		1	*.87*	-.19	*-.29*	-.08	*-.39*	*-.37*	*-.37*
18 ANX4																			1	-.19	-.26	-.08	*-.37*	*-.34*	*-.35*
19 BI1																				1	*.86*	*.64*	.17	-.09	*.34*
20 BI2																					1	*.71*	.21	-.02	.24
21 BI3																						1	-.12	-.10	-.01
22 EE1																							1	*.43*	*.73*
23 EE2																								1	.23
24 EE3																									1

Table 1.10: Correlations Matrix of the Observed Variables of Layar. *Note:* correlations significant at $p <.05$, significant correlations are in Italic.

Q	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0 KN	1	-.07	.11	-.07	-.12	.00	-.09	.07	.20	.11	-.11	-.08	.01	.18	.14	.22	.21	*.37*	.11	.20	.22	.24	-.21	.06	-.09
1 PE1		1	*.79*	*.70*	*.59*	*.44*	*.70*	*.61*	.03	.06	*.33*	.05	.02	-.06	.16	-.01	-.01	-.15	.07	*.41*	*.48*	*.37*	.25	.09	.23
2 PE2			1	*.60*	*.48*	*.35*	*.45*	*.55*	.03	.04	.23	.09	.06	-.12	.05	-.02	-.01	-.08	.06	.25	.27	.22	*.29*	.08	*.35*
3 PE3				1	*.73*	.21	*.52*	*.44*	.00	.04	*.45*	.07	.14	-.02	.01	.11	.00	-.13	.07	.23	*.31*	.19	.10	.22	.19
4 AT1					1	*.35*	*.66*	*.55*	-.05	.00	*.33*	-.10	.01	.01	.17	-.02	-.11	-.19	.00	.12	.20	.06	.10	.02	.09
5 AT2						1	*.61*	*.72*	.19	.17	.17	-.02	-.14	.03	.06	.07	.18	.05	.22	*.44*	*.45*	*.43*	.10	.00	.15
6 AT3							1	*.81*	-.11	-.07	.23	.05	.03	-.07	.13	.11	.00	-.12	.07	*.35*	*.40*	*.31*	.13	.06	.16
7 AT4								1	.00	-.02	*.29*	.01	-.02	-.01	.03	.11	.07	.02	.11	*.40*	*.41*	*.37*	.09	.01	.17
8 SI1									1	*.90*	.33	-.14	-.07	.23	*.33*	.20	.11	.15	.26	.12	.13	.14	.08	.03	.05
9 SI2										1	.22	-.03	-.19	*.32*	*.29*	*.34*	.23	.28	*.36*	.14	.16	.19	.06	.01	.02
10 SI3											1	-.04	.14	-.18	.00	.01	-.09	-.19	.09	.11	.19	.01	.09	.10	.11
11 FC1												1	*.30*	-.37	-.04	.01	-.01	-.09	-.25	.00	-.01	-.05	.18	.26	.24
12 FC2													1	-.15	.18	-.19	*.39*	*.39*	-.37	-.21	-.22	*.33*	*.42*	*.58*	*.49*
13 FC3														1	.15	.20	.33	*.40*	.15	.06	.02	.13	-.24	-.09	-.17
14 FC4															1	-.11	-.04	-.15	-.09	.17	.10	.15	*.38*	.21	.26
15 ANX1																1	*.75*	*.68*	*.78*	.15	.27	.24	-.21	.01	-.21
16 ANX2																	1	*.80*	*.77*	.22	*.32*	*.37*	-.27	.01	-.26
17 ANX3																		1	*.63*	.19	.22	*.34*	*.29*	-.01	*.29*
18 ANX4																			1	.23	*.37*	*.36*	-.10	.00	-.17
19 BI1																				1	*.89*	*.92*	.12	.04	.13
20 BI2																					1	*.87*	.02	.11	.04
21 BI3																						1	.03	-.02	.06
22 EE1																							1	*.54*	*.77*
23 EE2																								1	*.54*
24 EE3																									1

Table 1.11: Correlations Matrix of the Observed Variables of the Virtual Dressing Room. *Note:* correlations significant at $p < .05$, significant correlations are in Italic.

	Regression	p	R^2
PE - BI	*0.454*	0.001	0.206
AT - BI	*0.512*	0.000	0.262
SI - BI	0.097	0.506	0.009
ANX - BI	-0.23	0.112	0.053
EE - BI	0.097	0.509	0.009
AT - PE	*0.572*	0.000	0.327
SI - PE	0.259	0.072	0.067
ANX - PE	-0.196	0.176	0.039
EE - PE	-0.169	0.246	0.028
SI - AT	0.059	0.685	0.004
ANX - AT	-0.262	0.069	0.069
EE - AT	0.152	0.296	0.023
ANX - SI	0.067	0.646	0.005
EE - SI	*-0.409*	0.004	0.167
EE - ANX	*-0.481*	0.000	0.231

Table 1.12: Regression analysis of Layar. *Note:* regressions significant at $p < .05$ are in Italic.

Regression analysis   With a regression analysis, it is possible to show the predictive value of variables in a model. The regression is standardized so the values are between -1 and 1. A 95% confidence interval will be used to determine significance of the predictive value.

Table 1.12 shows the standardized regression for Layar. For the first step, it is interesting to look at the predictive value of variables to Behavioral Intention as dependent variable, as this construct shows the degree of acceptance. It can be seen that Performance Expectancy and Attitude to Technology are the two constructs that have a significant predictive value to Behavioral Intention. When these constructs two are taken as new dependent variables, no predictive values can be found within the 95% confidence interval. However, at a 90% confidence interval, the SI - PE and ANX - AT regressions are significant predictive values. Finally, EE has a predictive value to both SI and ANX. This shows that all constructs can be used to determine Behavioral Intention, however only PE and AT have a predictive value at the 95% confidence interval.

Table 1.13 shows the standardized regression for the Virtual Dressing Room. It can be seen that next to Performance Expectancy and Attitude to Technology, also Anxiety has a significant predictive value to Behavioral Intention. The two remaining constructs, EE and SI only have a predictive value at a low confidence interval. This shows that only PE, AT and ANX have a predictive value at the 95% confidence interval.

The tables also show the squared multiple correlation (R^2) explanatory power. The higher R^2, the stronger the explanatory power of the independent variables for the dependent variable. However, the value of the explanatory power depends on discipline where the questionnaire is used. For the IT domain, a value of 0.50 has a moderate explanatory power.

The combined R^2 of PE and AT to BI for Layer is 0.301, which is a fairly moderate explanatory power. The combined R^2 of PE, AT and ANX to BI for the Virtual Dressing Room is 0.248, which is also a fairly moderate explanatory power.

1.6.4   Conclusions

Combining all results gathered from the questionnaire data analysis, a new model can be made for the applications. Figure 1.7 shows the standardized path model for Layar, with Performance Expectancy and Attitude to Technology having high predictive values for Behavioral Intention. Figure 1.8 shows the standardized path model for the Virtual Dressing Room, with Performance Expectancy, Attitude to Technology and Anxiety having high predictive values for Behavioral Intention. It is remarkable that the model for the Virtual Dressing Room has less valuable predictors and explanatory values than the Layar model. This could be coherent with the lower intention to use the Virtual Dressing Room.

Both Layar and the Virtual Dressing Room have Performance Expectancy and Attitude to Technology as strong predictive and explanatory constructs for Behavioral Intention. Factors that play a role within these groups are usability, usefulness, fun and productivity. It can be prudently concluded that technology acceptance factors for Augmented Reality in this application domain are related to usability, usefulness, fun and productivity. Applications might be accepted and successful when attentions is paid to these factors.

	Regression	p	R^2
PE - BI	*0.363*	0.010	0.131
AT - BI	*0.403*	0.004	0.163
SI - BI	0.170	0.243	0.028
ANX - BI	*0.314*	0.028	0.099
EE - BI	0.072	0.621	0.005
AT - PE	*0.678*	0.000	0.460
SI - PE	0.207	0.154	0.043
ANX - PE	-0.006	0.969	0.000
EE - PE	0.261	0.070	0.068
SI - AT	0.153	0.292	0.024
ANX - AT	0.051	0.729	0.003
EE - AT	0.125	0.392	0.016
ANX - SI	0.198	0.173	0.039
- SI	0.093	0.523	0.009
EE - ANX	-0.189	0.193	0.036

Table 1.13: Regression analysis of the Virtual Dressing Room. *Note:* regressions significant at p <.05 are in Italic.
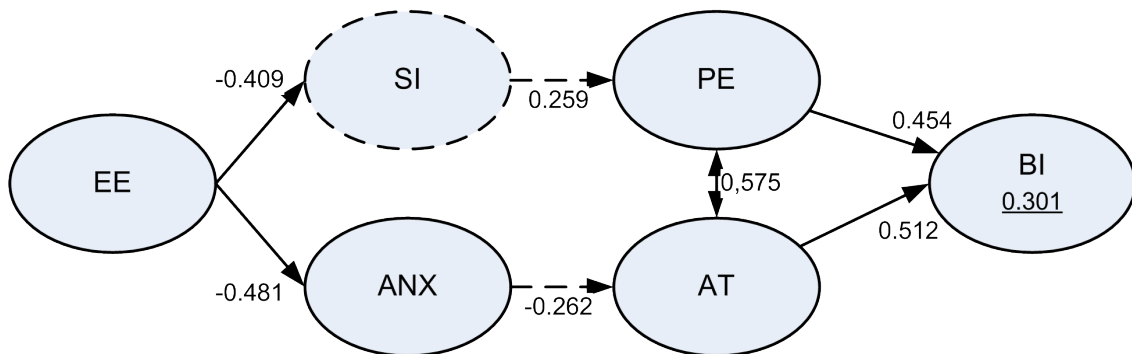
Figure 1.7: Standardized path coefficients of the adjusted UTAUT model for Layar. p <.05. Dotted lines are non-significant paths. Squared multiple correlations (R^2) are underlined.

1.7 Technology aspect

Introduction, structure etc.

The technology aspect of augmented reality applications are important to look at. This research describes applications of augmented reality from a technological point of view and tries to look for how it could be developing in the coming years. It tries to find out which augmented reality applications are already currently available, with a focus on describing trends in augmented reality applications over the last two years. The important thing is finding out which technologies are necessary and successful for improving the application of augmented reality technology. Several issues with current technologies will be discussed, as well as several already successful applications.

1.7.1 Methodology

The methodology used in the technology study is described in this section. The literature research approach as used in [Vermolen] is used here as a basis. This ensures that the literature study will be focused and select the most important papers for this research. After the literature study, the Augmented reality technologies described in the relevant papers are divided into different categories. Then, per category, an overview of some of the problems and success factors are given. A conclusion is given last.

The steps taken while doing the literature research are the following:

1. Finding relevant conferences and journals.

2. Selecting databases for locating relevant articles.

3. Writing down the search criteria with which to find the relevant articles in the databases.
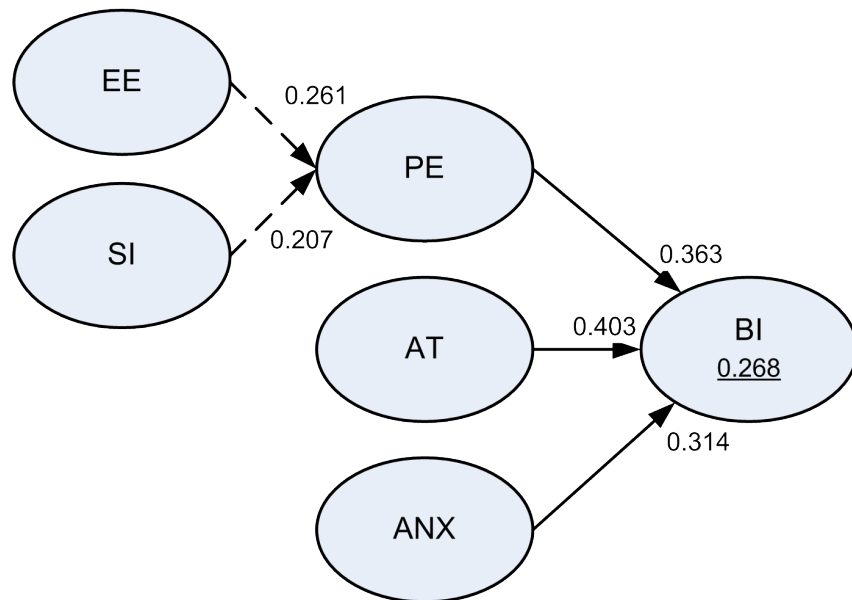
Figure 1.8: Standardized path coefficients of the adjusted UTAUT model for the Virtual Dressing Room. $p < .05$. Dotted lines are non-significant paths. Squared multiple correlations (R^2) are underlined.

4. Excluding papers that are false positives (that turn up among the relevant search results when using mild criteria, but turn out to be irrelevant when using harsher criteria that cost more time to implement). Exclusion is done in the order show below, by scanning the:

   (a) Title
   (b) Abstract
   (c) Entire text

1.7.2 Literature Research

This section describes the literature research done in order to make the categorization of augmented reality techniques. The methodology used is described in the section methodology above.

Relevant conferences and journals

There are some conferences that contain a paper on an application of augmented reality in a specific situation. These were ignored. Besides that, a number of conferences have been held with their main topic being augmented reality or something very closely related (e.g. virtual reality) in the years 2008-2010. These years were selected to make sure the literature research stays focused and because we can assume that these conferences discuss the latest advancements in augmented reality:

- Augmented Reality Conference: Advancing the Business of AR, San Francisco (CA, USA), April 21, 2010
- are2010, Augmented Reality Event (ARE), Santa Clara (CA, USA), June 2-3, 2010
- 1st European AR Business Conference, Berlin (Germany), April 23, 2010
- IEEE Virtual Reality 2008, Reno (NV, USA), March 8-12, 2008
- IEEE Virtual Reality 2009, Lafayette (LA, USA), March 14-18, 2009
- IEEE Virtual Reality 2010, Waltham (MA, USA), March 20-24, 2010
- 7th IEEE and ACM International Symposium on Mixed and Augmented Reality - ISMAR 2008, Cambridge (UK), September 15-18, 2008.
- 8th IEEE and ACM International Symposium on Mixed and Augmented Reality - ISMAR 2009, Orlando (FL, USA), October 19-22, 2009.

There were not a lot of journals with relevant information on augmented reality. The two journals found that were relevant are:

- The International Journal of Virtual Reality (IJVR).

- Presence. http://www.mitpressjournals.org/loi/pres

Database selection

The database generally used by scholars at the University of Twente is Scopus. Scopus is the world's largest database with publication data and summaries of articles from over 14.000 scientific journals. Furthermore, it has the required search options for this literature research. Scholar.google.com was used as a back-up for Scopus in case Scopus could not find a conference or journal.

Search criteria

Search criteria were used to find papers on Scopus. The search criteria used were:

1. The title of a conference or journal, as listed above. Often only a part of the title was taken as input for the search query, because of the chance of missing a conference or journal by inputting the entire name.

2. The year was selected to be 2008, 2009 or 2010, as to limit the number of papers found. These papers will most likely discuss the most advanced augmented reality techniques, and limiting the years in which to search helps in narrowing down the search domain.

3. The keyword used was "augmented reality". The search options were set to look for this keyword in the abstract title, abstract and keywords in Scopus. Google Scholar does not have this option, so when used, the search options were set to look for this keyword anywhere in the article.

After applying the above criteria, there were 285 papers left to narrow down. All four of the conferences listed above that took place in 2010 failed to provide any papers when looking on Scopus or scholar.google.com. However, searching for the other conferences and journals found more than enough results to continue with the next step in the literature research.

Excluding papers

While making these selections, the criteria that each paper was tested against was: could the paper contain information likely to provide an answer to the research question? The papers with irrelevant titles were excluded first. These included papers focusing on the human-interaction side of augmented reality applications, or papers about other topics than augmented reality. This resulted in a selection of 191 possibly relevant papers.

Next, papers with irrelevant abstracts were excluded. After excluding irrelevant papers here, a selection of 79 papers was left. Each of these was still (possibly) relevant, but further narrowing down would take place as described below.

The exclusion process is shown in figure 1.9.

Not all of the papers that followed from the excluding based on the abstracts were finally used in this paper. Some did not give any relevant information after scanning through the entire paper. They were naturally left out.

Reading some of the important parts of the papers gave an insight in the different technological problems that augmented reality faces. Some of them can be solved, others worked around but both take time (i.e. developing the solutions). Others will not be solved, but might be less of concern.

1.7.3 Categorization

During the selection of the papers based on abstracts, a categorization was already partly made. This categorization was done based on use of the augmented reality technologies. This section describes the categorisation as well as the different categories. It gives a short overview of the problems and success factors and a short future outlook on the technology based on the literature research. The categorization is by no means exhaustive. A categorization based on different criteria could be made as well (e.g. one based on the kind of technologies involved instead of the application). Papers could also fall into multiple categories, then one was chosen that was deemed the most related. The augmented reality applications can be categorized as follows:
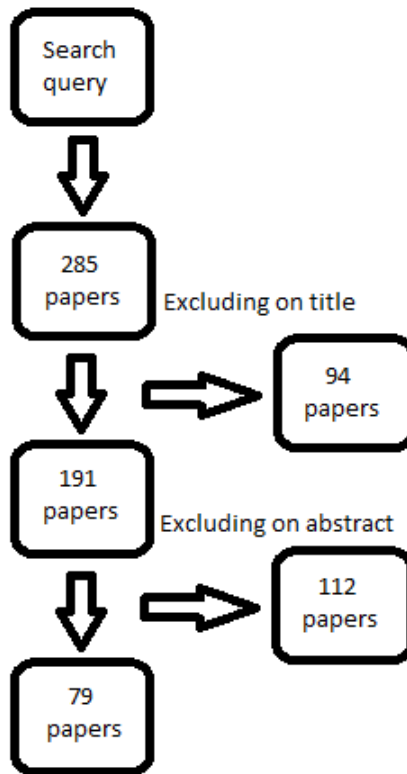
Figure 1.9: The selection of papers during the literature research

- Common technologies

- Art

- Engineering

- Medical

- Mobile phone

- Multimedia

- Navigation

This is quite a list and therefore each category will be described shortly below. In the end, 47 papers were used as a reference.

Common technologies

This section discusses a number of common technology within the field of augmented reality.

Success factors Some factors involved in most augmented reality technologies are latency [Lee et al., 2010], noise and orientation errors on tracking distant objects in augmented reality [Livingston and Ai, 2008]. Another one is spatial tracking [Huber et al., 2009]. This refers to the ability of an augmented reality system to keep track of certain objects that it picks up via its camera. Contrast sensitivity and color perception of the augmented reality displays also play a role, as when these are not good enough, a user's visual capabilities can be reduced in such capacity that using the system is not viable anymore [Livingston et al., 2009]. But the study found out that even by using only medium contrast, users would be able to use the augmented reality device well enough. A different problem for augmented reality objects is the recognition of the boundaries between physical world and the virtual world [Chen and MacIntyre, 2008].

Another problem is that a lot of environments need to be prepared for working with augmented reality. Markings are needed for the augmented reality system to pick up certain locations. [Lee and Hllerer, 2008] discusses a way of user interaction for augmented reality on unprepared tabletop

environments. This could lead the way for greater applications of augmented reality applications on unprepared environments.

A lot of research is done to detect a physical object and create a virtual 3d object equivalent of it [Sherstyuk et al., 2008]. This virtual object can then be used for collision detection with other, virtual objects [Beaney and Mac Namee, 2009] or in other ways be manipulated.

Future outlook The papers show that the factors involved can be reduced a lot. Latency can already be reduced to a minimum. In reducing noise, a better camera helps a lot. While mobile phones often contain cameras that have quite a bit of noise, the cameras get better every year.

Some researchers are also focusing on hear-through augmented reality technologies instead of see-through augmented reality technologies [Lindeman et al., 2008]. This could lead to a greater amount of augmented reality sound applications or combinations of visual and audio applications in used in a museum or entertainment park.

Art

This section discusses art and related endeavours such as art exhibitions.

Success factors In the arts, painting in a new way can be learned by using augmented reality techniques. If someone wants to learn Chinese painting, that person can use the latest advances in the field [Duh et al., 2009]. Other artists make use of augmented reality to create art by using the technology itself to create a collage of multiple photos [Papagiannis, 2009].

An interesting application of augmented reality in is the use in an art exhibition. By carrying a camera, head-mounted display and eye tracker, the user can look at a painting while the display shows the user information on the painting [Park et al., 2008]. Another application is as an augmented reality museum guide with a handheld device [Miyashita et al., 2008].

Future outlook In our opinion augmented reality systems will see an increased use in musea and exhibitions. It is a new and exciting technology that exhibitions often like to take advantage of because people will find it interesting. Such systems can also be reused from exhibition to exhibition, thereby giving it a reason for long term use too.

Engineering

The term engineering here covers different applications of augmented reality, mainly collaboration, construction, engineering, industrial and space planning.

Success factors In teleconferences [Kantonen et al., 2010], multitouch interaction setups [Seichter et al., 2009], or collaboration efforts between people (possibly situated at different locations), augmented reality can help display things that another participants can see. These collaborations can be greatly supported by augmented reality [Nilsson et al., 2009].

Maintaining equipment, such as an armored personnel carrier turret, can benefit from augmented reality by enhancing the view of the engineer with labels and instructions for reparations [Henderson and Feiner, 2009].

Industrial building acceptance is the process of determining whether a product that has been built is actually the one that was commissioned before final approval and payments are done. Augmented reality can help here by displaying a video image of the product and then overlaying a 3D model on top of it [Schoenfelder and Schmalstieg, 2008]. Some research brings together the mobile phone with industrial design applications. In [Hakkarainen et al., 2008], a mobile phone is used to help with assembly in a production line. The display functions as a manual by displaying a step by step guide for an assembly task.

A spatial augmented reality user interface is described in [Marner et al., 2009]. It is meant for an industrial designer applying digital airbrush to augment a physical model.

Augmented reality sees its use in space planning by displaying an overlay of a room or (enclosed) space. Technology can then be used to sort the space [DiVerdi et al., 2008] or for interior or architecture design or for factory layout [Lee et al., 2008]. This can also be applied in the outside world for use in civil engineering [Schall et al., 2008].

Future outlook   Businessess and industries can have a great benefit by using augmented reality techniques. Quality control becomes much easier, as well as assembly or maintenance steps. Spacial planning is another area where augmented reality applications can be very convenient. Also, collaboration efforts by participants at different locations can become a lot easier.

When you already have a physical model, or it is easier to get a physical model, it could be more practical to use augmented reality techniques, other than rebuilding these models in a computer program.

Medical

This section describes some medical applications of augmented reality. Both surgeons and patients can benefit from augmented reality technology, as described below.

Success factors   Except for virtual reality practice environments for surgeons, the medical environment also features some augmented reality applications. Dangerously close to virtual reality comes a visualization environment in absence of direct vision. This ensures that a surgeon can still see what he is doing while not being able to see with his own eyes. Another application is using a see-through head mounted display that displays augmented reality information [Bichlmeier et al., 2008].

An important, recurring benefit of augmented reality is its use in training. Surgeons can learn to use an ultrasound by using an augmented reality ultrasound simulator [Blum et al., 2009a]. Employees working in a clinic can undergo training by using a physical representation of a patient, connected with a virtual patient for feedback [Blum et al., 2009b]. This way the trainee gets to work with a physical body while still getting feedback and not having to train on a live patient.

Some applications leaning quite to virtual reality include rehabilitation applications. Patients can use an augmented bicycle to recover from certain injuries or disabilities by cycling [Ranky et al., 2010]. Other applications are the use of a headset as equipment, but this can be considered as virtual reality instead.

Future outlook   The medical world can use a lot of augmented reality applications. For rehabilitation of patients and training of personnel. However, especially specialists such as specialized surgeons are known to be reluctant towards changing their work methods, even if this can lead to their work becoming more efficient. Also the costs of such techniques are taken into account and are a reason for the lack of applications in actual support of surgeries and operations.

Mobile phone

Technologies built for mobile phone devices have a lot of limitations hardware-wise. Another limitation is that applications developed for mobile phones have to keep into account the different types of mobile phones used and the different hardware specifications present on these devices. A developer can assume certain minimum specifications, knowing that an application that runs on a mobile phone equipped with better hardware will run smoother, but the developer will have to make a choice for these minimum specifications anyhow. However, the fact that a great many people nowadays have a mobile smartphone with augmented reality capabilities and that the mobile phone is cheaper to buy than e.g. a tablet PC makes the mobile phone a target for augmented reality application developers.

A lot of the augmented reality mobile phone technologies presented here are also applicable to other situations. However, in this case in the research they were specific applications of augmented reality on mobile phones.

Success factors   A technology used and researched in some mobile phone augmented reality applications is marker tracking [Wagner et al., 2008]. This technology made augmented reality a viable technology in the early 2000's. Nowadays, research focusses on how to make augmented reality technologies need less obtrusive markers or none at all. Shape recognition and pose estimation are other technologies that are being researched [Hagbi et al., 2009]. This happens mainly by analysis of contour structures.

Some problems that are still present are the effects of augmented reality on depth perception. Objects that are away appear even farther away and appear to the user to be smaller than they actually are or should be [Jones et al., 2008].

Blur and smearing effects can be caused by moving the camera around wildly [Klein and Murray, 2009]. This can cause an augmented reality application to lose track of objects. Also equipping mobile phones with better camera's can help in dealing with these issues.

Most mobile smartphone users nowadays have heard of Layar (which is also discussed earlier in the paper). A different prototype mobile augmented reality client has been rsearched, which contains the real world with geospatial media sharing and social connection [Murphy et al., 2010].

It can also be done the other way around. A virtual world can be augmented by things from the real world [Laaki et al., 2010]. Especially social environments and games like Second Life can benefit from this. Users can enhance their characters and the world with real life objects they own (for example relics brought along in a vacation).

Future outlook Mobile phones continue to be an attractive target for augmented reality application developers, while they continue to be hampered by hardware specifications. Hardware does get better though, paving the way for more demanding and more interesting applications to be developed. Most of the issues discussed above can be dealt with up to a certain amount by applying certain techniques. However, is the mobile phone a great device for augmented reality? It is available to many people, but most people do not want to be walking around while holding a mobile phone in front of them for even a short period of time. This could also distract the application users from e.g. traffic.

Multimedia

The multimedia aspects of augmented reality are discussed in this section. These include augmented reality books and entertainment such as gaming.

Success factors An interesting new entertainment idea is augmented reality books [Grasset et al., 2008]. This could be used for educational purposes (young children). It could also be used to enhance the experience of reading books like poetry books [Scherrer et al., 2008]. There it uses a computer screen to avoid head-mounted displays.

With some historical sites it is nice to see archaelogical ruins that have been dug up. However, wondering what it looked like in earlier times before it fell to ruin, an augmented reality system can show that. Yuangminguyan was a royal garden in China that was burnt down in 1860. Augmented reality technology was used to reconstruct what it looked like [Huang et al., 2009].

Another idea is using augmented reality for advertisement in shopping venues [Hurwitz and Jeffs, 2009]. Because the technology is still relatively new, using augmented reality in this way might get people's attention. It will be interesting to see whether these ways of advertising work.

In the gaming industry, board and tabletop games could be enhanced by augmented reality with additional digital content to increase the experience and enjoyment [Leitner et al., 2009].

Other gaming ideas include an augmented reality outdoor game based on Lemmings [Engelhardt et al., 2009]. This game needs human players to move physical objects around.

An augmented reality enhancement to massively multiplayer online games like Second Life are described in [Lang et al., 2008]. These games can be enhanced by taking virtual world and real world parts and blending them together with augmented reality.

An interesting game thought up is a game which can be used for city exploration [Herbst et al., 2008]. This shows a cultural use of augmented reality.

A magician could use augmented reality for one of his shows [Carreras and Sora, 2009]. This could entertain people because of its newness. The audience was pleasantly surprised.

Augmented reality weather is being researched based on use of weather effects in games [Heinrich et al., 2008]. This research could help make augmented reality gaming more realistic or otherwise more engaging.

Future outlook We do not yet see augmented reality books become a success as a consumer product because we see people either reading a book or enjoying a video experience like tv or a movie. For specialized cases such as a training center or for children's learning they might become more succesful.

The historical sites are a very interesting applications of augmented reality, as it provides users a better experience of feeling that they are present in a historically significant area.

About the gaming ideas, we are wondering whether they will really take off. Maybe a company specializing in providing an entertainment experience using augmented reality could become a succes, making it a more interactive experience than other ways of entertainment like going to the movies. More research has been done to gaming. [Phillips, 2009] proposes different type of games that augmented reality can play a role in. These include puzzle hunts for guiding people in a museum, battle chess based on the location of physical pieces and laser-tag games. Most of the

suggestions are augmented reality enhancements to existing games or adding augmented reality gaming elements to things like tours.

Navigation

Navigation includes navigating outdoors such as in cars.

Success factors Some research has been done as how to make navigation through a building easier. A head-up display was used in one of these researches [Tnnis et al., 2008]. Different types of arrows were researched here to find out whether these kind of navigation cues are effective while navigating large distances.

Other kinds of navigation researched are for use in a car and using augmented reality to enhance the vision of the driver in its blind spots [Yoshida et al., 2008]. This is especially useful for trucks as there are regularly accidents with truckers and people that are located in one of its blind spots. Another research placed the augmented reality application outside to e.g. help in assisting a driver to see through an obstructed intersection [Barnum et al., 2009].

Future outlook We see augmented reality applications becoming succesful in its use in cars. Cars get made 'smarter' by technological enhancements with computers all the time anyways, so adding augmented reality to the newer developed cars is made easier. They make navigation easier and could prevent accidents.

1.7.4 Conclusion

Currently, a lot of research is done towards augmented reality. The existence of conferences purely dedicated to augmented reality shows that at the moment this field is hot in the scientific world. The academic world believes augmented reality is a growing field, likely to find many more applications soon and increase the use of the already existing applications.

Mobile applications and industrial applications are very popular. Medical applications are not that widely used yet but this can change as specialists learn how to benefit from using these techniques. Many of the mobile phone applications of AR could be extended to another kind of device. A visor seems like a logical solution to people not wanting to hold their mobile phones all the time while using an augmented reality application, but they are not practical and economical for consumers yet.

An entertainment park like "The Efteling" in the Netherlands could benefit from augmented reality. It could host an environment and then display a scene by means of augmented reality. This could help the park by advertising with new technologies as well as having an entertainment value for visitors.

The succesfactors and possible problems that have to be overcome for augmented reality to become more successful have been discussed in earlier sections. All in all, augmented reality will eventually not be held back by technological problems from becoming a success. Researchers will likely find ways around the issues that do exist. However, it remains to be seen whether consumers will actively use augmented reality applications. Business applications will be used.

1.8 Conclusion

Research question: What are success and failure factors from a business, user and technological perspective for an implementation of a business model framework for Augmented Reality applications?

The business aspect of AR applications has been discussed through the use of a business model framework. The research was aimed at finding a suitable framework, and then adapting it to be specialized to the AR domain. The framework we chose was the Osterwalder Business Model Ontology, as this is widely used and applicable to the domain, to some extent. For each of the nine elements of the framework, we found AR specific sub elements. All in all, this has lead to a new ontology of business models, that specializes Osterwalder's original framework. In the sense of success factors, the framework shows what elements are to be considered for any business. Combined with the knowledge of what successful business models are (by looking at successful applications), this can lead to a new venture also being successful. Further research is needed to find out what combinations and implementations of the elements of the framework are in fact a success.

For the user aspect of Augmented Reality, there has been a focus on technology acceptance. An adjusted UTAUT questionaire has been used to determine technology acceptance of two specific augmented reality applications, which might be used to geralize for augmented reality applications in general. There were 49 useful responses to the questionare. The analyses of the results shows that for both applications the constructs Performance Expectancy and Attitue to Technology have a signification explanatory preditible value. Factors that play a role within these groups are usability, usefulness, fun and productivity. It can be prudently concluded that technology acceptance factors for Augmented Reality in the researched application domain are related to usability, usefulness, fun and productivity. These factors may play an important role for certain customer segments (people who are used to new technologies etc.), or applications with a specific value proposition (business applications).

The technical aspect of augmented reality has been discovered in the technical section of this paper. A quantitative literature study has been done, with emphasis on a small number of relevant conferences and journals. Of the papers that came out of the search query, the papers were selected on title and then on abstract. The papers were categorized and per topic the success factors and possible problems were discussed, as well as a short future outlook of that application. The number of 285 papers was reduced to a number of 47 that were eventually used as references in this paper. The findings are that augmented reality technologies still have some problems. However, none of those problems cannot be overcome or worked around from a technical perspective. User acceptance and actual relevancy of the technology therefore play a greater role in determining whether augmented reality applications will see more succes in the (near) future.

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Appendix A: Questionnaire

Performance expectancy (PE)

- PE1 I would find *Augmented Reality* useful in my daily life
- PE2 Using *Augmented Reality* enables me to accomplish tasks more quickly
- PE3 I find benefit in using *Augmented Reality*

Effort expectancy (EE)

- EE1 My interaction with *Augmented Reality* would be clear and understandable
- EE2 It would be easy for me to become skillful at using *Augmented Reality*
- EE3 I find *Augmented Reality* technology easy to use
- EE4 Learning to operated *Augmented Reality* is easy for me

Attitude toward using technology (AT)

- AT1 Using *Augmented Reality* is a bad/good idea.
- AT2 *Augmented Reality* makes work more interesting.
- AT3 Working with *Augmented Reality* is fun.
- AT4 I like working with *Augmented Reality*.

Social influence (SI)

- SI1 People who influence my behavior think that I should use *Augmented Reality*.
- SI2 People who are important to me think that I should use *Augmented Reality*.
- SI3 In general, my environment supports the use of *Augmented Reality*.

Facilitating conditions (FC)

- FC1 I have the resources necessary to use *Augmented Reality*.
- FC2 I have the knowledge necessary to use *Augmented Reality*.
- FC3 *Augmented Reality* is not compatible with other systems I use.
- FC4 A specific person (or group) is available for assistance with *Augmented Reality* difficulties.

Anxiety (ANX)

- ANX1 I feel apprehensive about using *Augmented Reality*.
- ANX2 It scares me to think that I could lose a lot of information using *Augmented Reality* by hitting the wrong key.
- ANX3 I hesitate to use *Augmented Reality* for fear of making mistakes I cannot correct.
- ANX4 *Augmented Reality* is somewhat intimidating to me.

Behavioral intention to use *Augmented Reality* (BI)

- BI1 I intend to use *Augmented Reality* in the next 6 months.
- BI2 I predict I would use *Augmented Reality* in the next 6 months.
- BI3 I plan to use *Augmented Reality* in the next 6 months.

General questions

- Additional questions about experience with technology, usage of applications, gender and age were asked.

Appendix B

Key partners	Key activities	Value proposition	Customer relationships	Customer segments
Development technology provider Software platform provider Device manufacturer Internet service provider Application broker	Designing software Implementing software Testing software Fixing problems Documenting problems	In situ, utility, training, social gaming, location layers, virtual demo, experiential education, enhanced classifieds, 3D virals, personalized shopping, cooperation, blended branding, augmented events, intertainment, understanding systems, recognition & targeting	-	Manufacturers, architects, "smartphone"users, students, teachers, gamers, shop customers, shopkeepers, museums, zoos, educational institutions, business professionals, home entertainment users, mechanics, marketers
	Key resources Patents Expertise Devices Staff		**Distribution channels** Internet Application brokers Stores	

Cost	Revenues
Staff Internet hosting	Advertisements Application fees