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Augmented Reality in the future home



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1. Introduction

Augmented reality (AR) is one of the turning-point technologies of our time. AR refers to “a situation in which a real world context is dynamically overlaid with coherent location or context sensitive virtual information.”¹ Information can either be additive to the real environment - or mask parts of it. Most of the time, however, it is additive, creating a whole new merger of artificial and real-worlds from the user’s point of view. In this way, AR alters the user’s perception of the real-world environment, while virtual reality (VR) completely simulates a digital environment.² In 2018, the global AR/VR market amounted to approximately 12 billion US dollars and is expected to expand drastically in the coming years (see Figure 1).

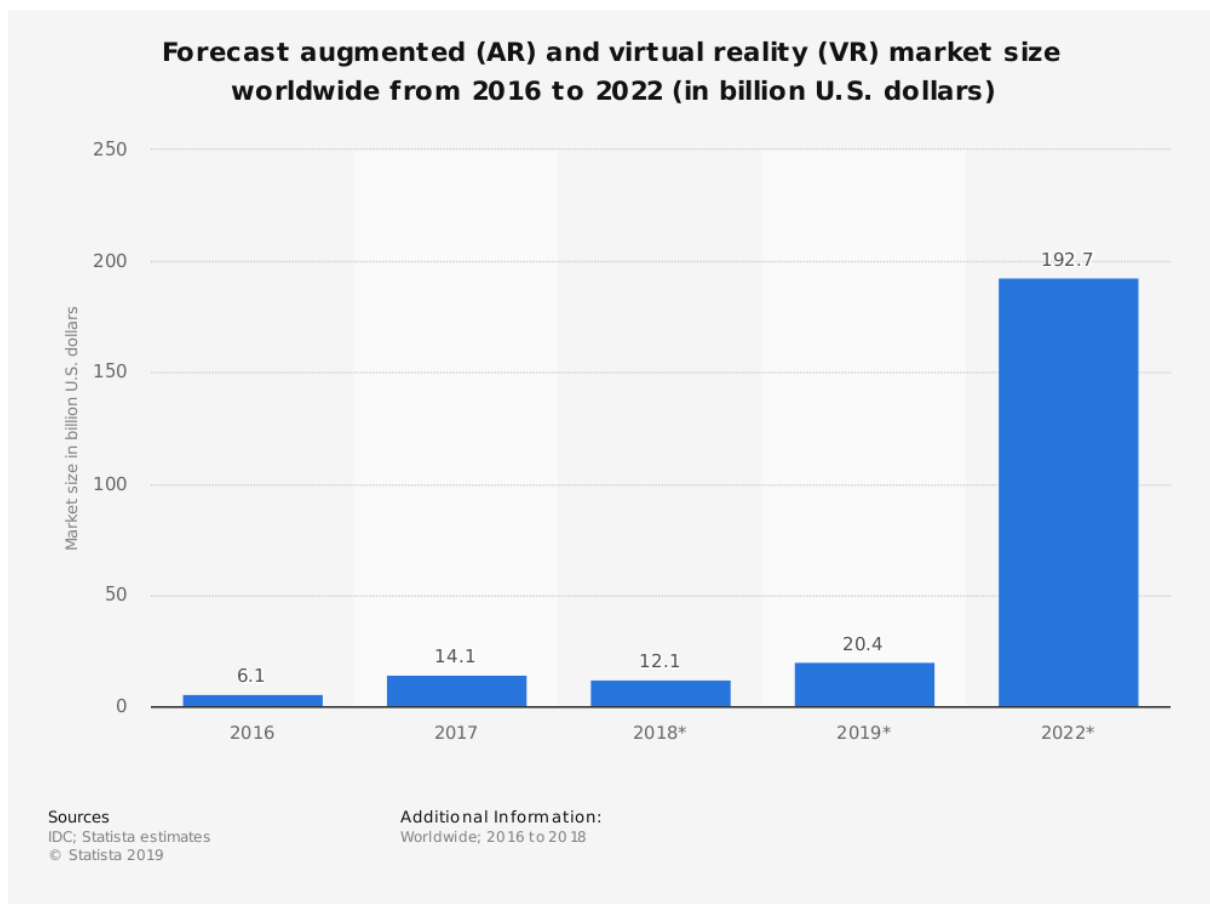


Figure 1³

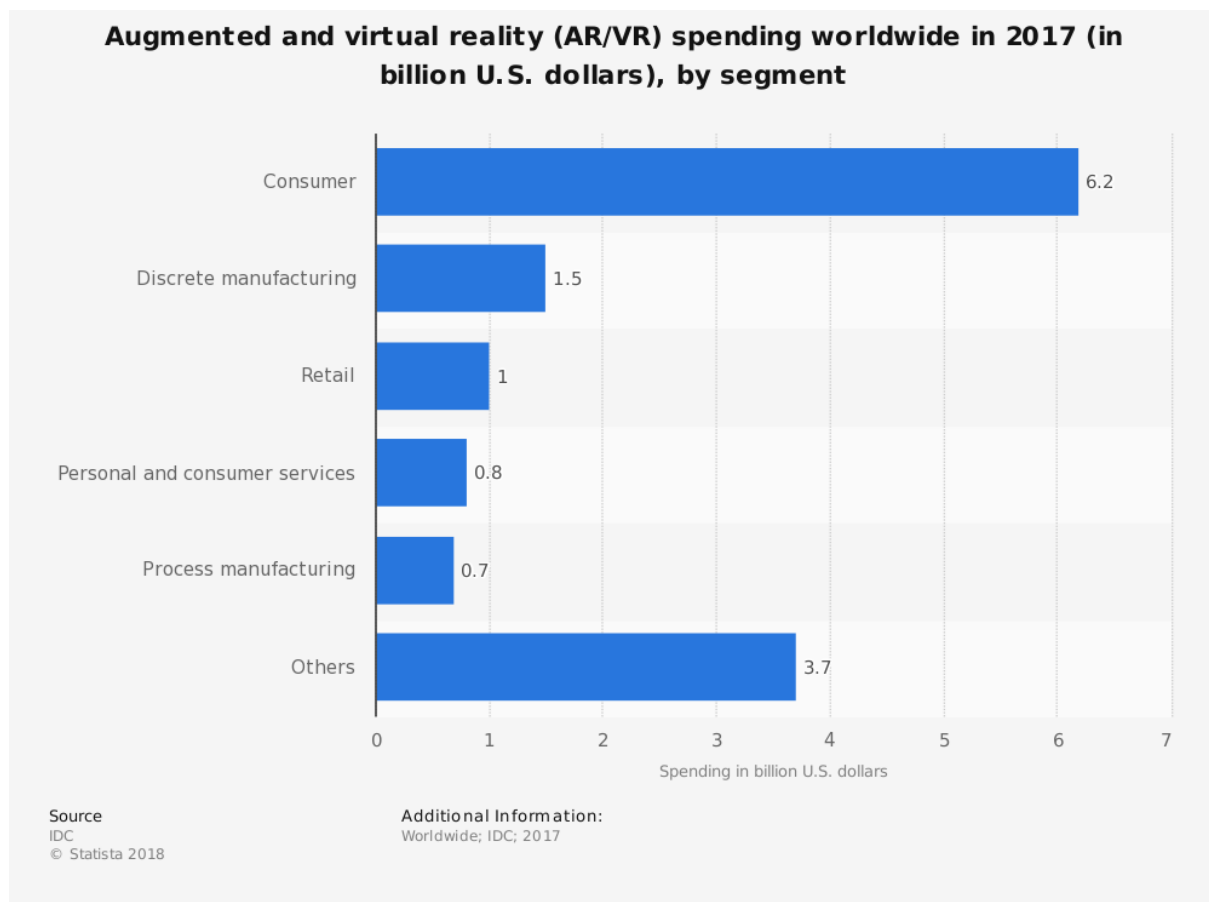
{ AR REFERS TO A SITUATION IN WHICH A REAL WORLD CONTEXT IS DYNAMICALLY OVERLAID WITH COHERENT LOCATION OR CONTEXT SENSITIVE VIRTUAL INFORMATION. }

The home of the future will involve a set of advanced digital technologies, with AR projected to be a highly relevant component. Looking at total AR/VR spending worldwide, we find that consumer spending is by far the most dominant segment (see Figure 2).

¹ <https://link.springer.com/article/10.1007%2Fs11423-007-9037-6>

² <https://www.fi.edu/difference-between-ar-vr-and-mr>

³ <https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size/>

Figure 2⁴

There are multiple technologies and platforms through which AR can make its way into the future home. The most common hardware platforms both today and in the near future are smartphones and tablet computers, as well as smart glasses, due to their size, price and availability. The latter especially provides an excellent opportunity for a hands-free assistance experience for the user. This is achieved by using a heads-up display; a transparent display that presents data directly in front of the user's eyes, without requiring them to look away from the usual viewpoint. A predecessor of smart glasses technology was invented in the 1990s by Tom Caudell and David Mizell at Boeing, who "designed a head-mounted digital display in 1990 to help workers wiring aircraft by displaying a plane's schematics on the factory floor."⁵

In 2011, Google offered their first AR product (Google Glass), which was aimed at a bigger, more commercial market. But the AR technology was one of the first major fails in the history of the tech giant. Combining a weak marketing approach with an inconvenient user experience, Google Glasses attracted only a few early adopters.⁶ But the future for AR technology seems promising. Emerging user interfaces include contact lenses, virtual retina displays, where a display is scanned directly onto the user's eye, and "eye trap", a technology that substitutes rays of real light with synthetic computer-controlled light. While all these technologies will play an important role in the future home, AR is not limited to them. Especially in the home, large transparent screens replacing usual windows or projectors in the form of spatial augmented reality will also have an impact. In addition, reality may also be augmented using more-dimensional information in the form of holograms.

⁴ <https://www.statista.com/statistics/737615/ar-vr-spending-worldwide-by-segment/>

⁵ <https://www.computer.org/csdl/magazine/co/2009/12/mco2009120019/13rUxbCbma>

⁶ <https://thenextweb.com/contributors/2018/02/16/3-reasons-augmented-reality-hasnt-achieved-widespread-adoption/>

2. Existing Products

From 2016 to 2019, global consumer spending on AR/VR content and apps has already expanded by a factor of 3.5 (see Figure 3). The following section gives a brief overview of AR applications which are already in place.

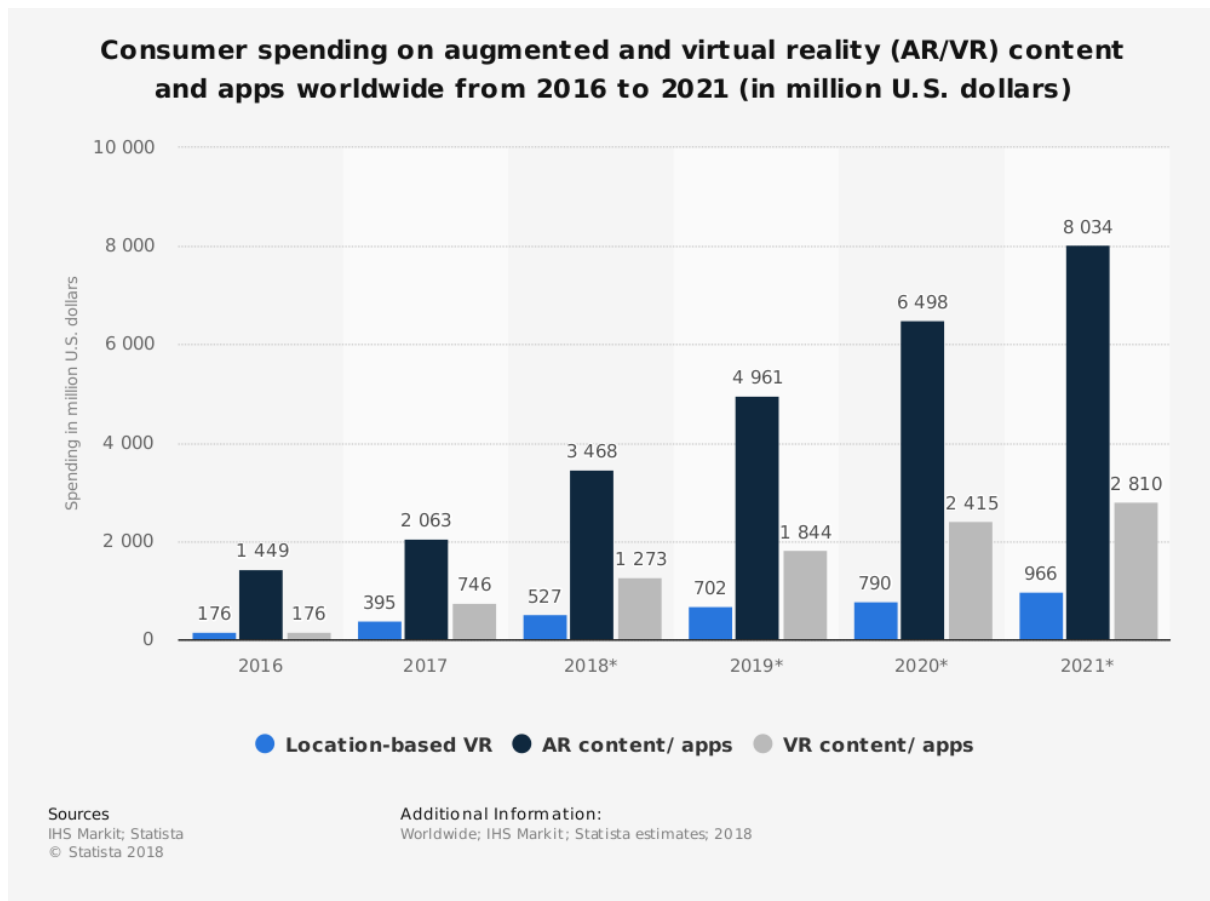


Figure 3⁷

{ SEVERAL INDUSTRY PLAYERS, SUCH AS IKEA, AMAZON AND TARGET, HAVE DEVELOPED APPLICATIONS WHICH ALLOW THE USER TO 'PLACE' SELECTED PIECES OF FURNITURE WITHIN THEIR OWN ROOM BEFORE ACTUALLY PURCHASING THEM. }

2.1 Home enhancement

2.1.1 "Painting" walls

Decorating a new or existing home is often not an easy task, as it is hard to imagine how colours will look once painted on the wall. Major painting brands, such as Behr and Sherwin-Williams, have developed mobile device applications with the aim of tackling these problems through the use of AR. The process is easy: the user takes a photograph with their smartphone camera and the application then shows how the wall would look with a particular colour paint by projecting it in.

⁷ <https://www.statista.com/statistics/828467/world-ar-vr-consumer-spending-content-apps/>

Although these applications are still quite glitchy, they are expected to improve their working quality in the near future, as the developers behind these programs (companies in this industry) constantly aim to improve both consumer experience and product quality.⁸

2.1.2 Virtually refurnishing the home

A similar development can be found in the home furniture market. For consumers, visualizing the placement of new furniture in their homes can pose a challenge. They may question the colour combination, size and dimensions before purchase. For this reason, several industry players, such as IKEA, Amazon and Target, have developed applications which allow the user to 'place' selected pieces of furniture within their own room before actually purchasing them. This process is as easy as the use of any other application; all the user has to do is to provide a photograph of the room, select a piece of furniture and place it at the preferred location. It could also be used whilst visiting a new property, as can be hard to imagine what empty rooms would look like once furnished. Similar applications allow the user to try out even more options for home improvement, for example by virtually changing the property's garage door. The main developer of these applications is the furniture retail industry, which will drive forward development in the future.⁹

2.1.3 Gardening made easy thanks to AR

Although many homeowners have a garden that could be used for growing plants, most of them don't make use of this. For this reason, MIT Design Lab has developed an AR application named "seedmate", to assist people when growing plants. The user places biodegradable growing carts and an order of their choice, and scans/photographs the constellation with a smartphone to check whether it meets their essential requirements (e.g. compatibility of the plants). In addition, the application presents the plants' sunlight, shade and nutrition requirements. Overall, this toolkit may encourage garden owners to try out growing plants because of AR.¹⁰

⁸ <https://www.cnet.com/how-to/decorate-your-house-ar-apps/>

⁹ <https://www.theverge.com/2017/11/1/16590160/amazon-furniture-placement-ar-feature-too>,
<https://erinlyyc.com/2018/04/08/use-augmented-reality-iphone-redecorate-home/>,
<https://www.gadgets salvation.com/blog/2017/11/16/5-augmented-reality-tools-for-home-improvement/>

¹⁰ <https://design.mit.edu/projects/seedmate>

2.2 AR reshapes online shopping

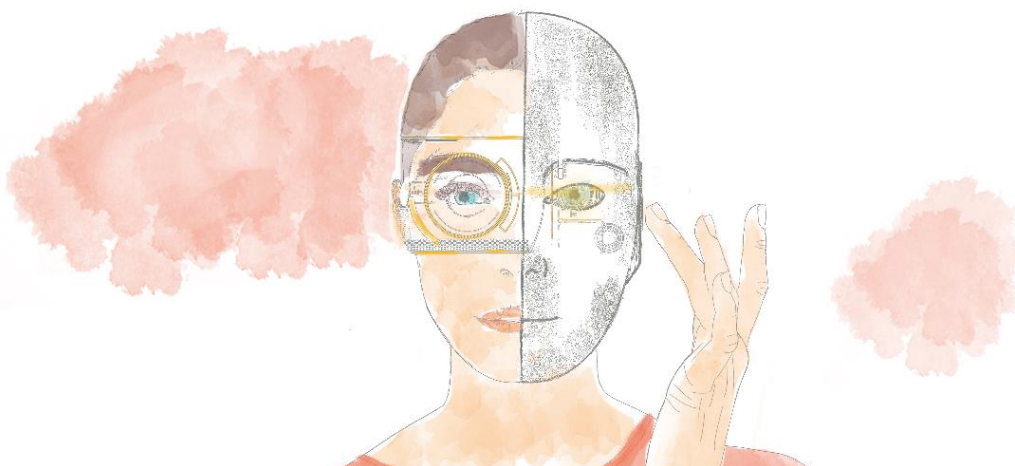
2.2.1 The future dressing room

Shopping for new clothes in the comfort of home is both convenient and increasingly important. However, consumers are not able to try on the desired clothes if they do not leave home. Consequently, the clothing industry has developed online tools which allow a virtual fitting with the assistance of AR. The consumer only has to record themselves with a webcam, select the desired piece of clothing and then will see themselves wearing it. It is also possible to save this fitting recording in order to share it with friends. The existing 3D tools work with any kind of clothing or accessories, including (sun)glasses, jewellery, etc. According to a survey by yougov, 70% of participants are interested in these applications, which will work more smoothly in the future due to the industry's effort to 'bring the store home', thus saving time and money for both consumers and companies.¹¹

THE CONSUMER ONLY HAS TO RECORD THEMSELF WITH A WEBCAM, SELECT THE DESIRED PIECE OF CLOTHING AND THEN WILL SEE THEMSELF WEARING IT.

2.2.2 The future of the beauty industry

Some consumers struggle to find suitable make-up or hair colours. To tackle this issue, Perfect Corp. has developed a set of AR apps which allow prospective customers to try on hundreds of make-up and hair colours – from the convenience of their smartphones. Over 200 business partners worldwide are already adopting Perfect AR apps to support their consumers' choices.¹² French beauty supplier L'ORÉAL has launched an online application using technology from Modiface¹³ which allows prospective customers to try on hundreds of make-up and hair colours – without leaving their home. In order to function well, the application needs the consumer's face to be well-lit. Other than that, the tool is easy to use and provides consumers with a precise estimation of suitability before buying the product – straight out of the home.¹⁴



¹¹ <https://yougov.de/news/2017/08/29/virtuelles-anprobieren-schon-vor-online-kauf-wisse/>

¹² <https://www.perfectcorp.com/technologies/overview>

¹³ <http://modiface.com/>

¹⁴ <https://www.loreal-paris.co.uk/modiface/try-on-makeup-and-hair-colour-instantly>

2.3 Impacts of AR on information and communication

2.3.1 Taking exhibitions home

Visiting an exhibition can be both entertaining and educational. However, it often takes some time to travel to the venue and entrance fees can be expensive. Therefore, many people who would be interested in visiting a museum stay at home. Consequently, the BBC has developed a smartphone application which aims to allowing users to view historic artefacts from the comfort of home. The application works by inserting the artefacts into any room – users are even able to walk around them. In addition, written information about the objects is provided for educational purposes. Currently, only a limited number of artefacts are available to explore in this way, for example an Egyptian mummy. However, this number is expected to increase continuously.¹⁵

2.3.2 Revolution of home-played games

With the rise of smartphones, playing games on these devices is a popular way to spend time across all age groups. Recently, developers have started to integrate elements of AR into their products. The most prominent example is “PokemonGo”, which is, however, mainly played away from home. On the other hand, the game “Star Wars Arcade: Falcon Gunner” can be played at home. It works by capturing what is in front of the player in real life and integrates it into the game. Many future game developments can also be expected to work in this way, by integrating objects in the player’s home environment into the game, which makes the game more reality-related and generally interesting to play.¹⁶

2.3.3 Becoming a master drawer

Drawing is a common way to spend time at home in an entertaining and relaxing way. However, seen from an objective perspective, most people are not particularly talented. In order to improve the user’s drawing skills, the application SketchAR was developed. With the use of this software, becoming a master drawer is an easy process: all the user has to do is to choose a sketch from the app’s database and project it onto the paper to trace. Even though it may seem uncomfortable to hold a smartphone while drawing, there is definitely an increased likelihood of a better outcome compared to conventional drawing.¹⁷

2.3.4 Social Media and AR

Sending pictures of one’s ordinary room to friends via a social media application like Snapchat or Instagram would not be very amusing for either the sender or the recipient. For this reason, most social media platforms have introduced options to decorate a picture with the use of AR. The process is quite easy: the user can take a photo or video as usual and then add a virtual component that fits the conversation vibe. For example, a dancing character of themselves next to the boring study documents. Since this technology has been used for some time, it functions well. Nevertheless, application developers are expected to continuously add more additional AR features.¹⁸

¹⁵ <https://www.bbc.com/news/technology-42966371>

¹⁶ <https://www.pcworld.com/article/2010894/how-augmented-reality-is-redefining-entertainment.html>

¹⁷ <https://sketchar.tech/>

¹⁸ <https://www.forbes.com/sites/lilachbullock/2018/11/16/ar-and-social-media-is-augmented-reality-the-future-of-social-media/#550a223de141>

3. AR and the Grand Challenges

Today, society faces a great number of challenges, which need to be mastered in order to ensure a fulfilled and safe life for future generations. Some of these vary across regions, others extend over any level and area. Industrialized countries are faced with an ageing population, unhealthy lifestyles and obesity¹⁹, whereas climate change enforces challenges globally.²⁰ AR could offer solutions to certain drivers of environmental innovation – especially in the area of transport- which will become at least partly redundant in the future.

3.1 Less transportation, fewer emissions

Travel is an important activity for many people and the reasons for it are varied: Business, vacation, education or entertainment, or just to visit loved ones. While AR may not replace vacations, it can substantially lower the number of required business travel or visits. This would be made possible by the same technology already presented: using life-sized holograms²¹ of the people the user wants to spend time with. As personal body contact in the corporate world is generally avoided, in contrast with private affairs, this would be the main field of application. By using this technology, corporations may save a great amount of money on their employees' travel expenses. In addition, the incentives for working from the comfort of one's home may also be increased, which also saves travel time, transportation costs and fuel. In terms of private use, this technology of course does not replace personal contact, however, it provides an accessible compromise and may also reduce travel expenses.

{ GERMAN COMPANIES ALONE COULD SAVE 1 BILLION EUROS PER YEAR, IF THEY WERE TO REPLACE HALF OF THEIR BUSINESS TRAVELS BY VIDEOCONFERENCING TOOLS. }

On a global scale, this technology may help to reduce the use of scarce resources and the carbon emissions produced by individual transportation and airplanes, as these are the most common means of transport for business travellers. So far, there has not been any scientific study that measures, or at least estimates, the global reduction in transport related carbon emissions thanks to AR communication solutions. However, according to "toplink", German companies alone could save 1 billion euros per year, if they were to replace half of their business travels by videoconferencing tools.²² As this type of communication is not as advantageous as the AR-technology described, the latter's potential is even greater. Thus, if at least some businesses were to cut back on travel, especially on extremely polluting air travel thanks to this solution, there would be a significant impact. Even though it can be expected to find a big echo in companies' future strategies, this will nevertheless be hard to measure on a global scale.

{ WITH THE HELP OF THIS TECHNOLOGY, 'ALMOST REAL' DAILY VISITS AND CONVERSATION WOULD NO LONGER BE IMPOSSIBLE... AND COULD ASSIST ELDERLY OR DISABLED PEOPLE TO REMAIN LIVING INDEPENDENTLY }

¹⁹ <https://www.who.int/ageing/about/facts/en/>

²⁰ <https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/>

²¹ https://www.researchgate.net/publication/324663795_TeleHuman2_A_Cylindrical_Light_Field_Teleconferencing_System_for_Life-size_3D_Human_Telepresence

²² <https://www.toplink.de/ueber-toplink/presse/einsparpotenzial-durch-videokonferenzen/>

3.2 Ageing Populations

The population in most industrialized countries is rapidly ageing due to declining fertility rates and/or rising life expectancy changes the demographic structure of most industrialized countries, forcing governments to approach the problem of an increasing number of elderly people with physical or mental incapacities. Many such elderly people experience (severe) feelings of loneliness, which can lead to depression or other mental health problems. Frequent visits, especially by family members, will become more difficult due to an increasing number of other duties, especially professional ones in today's fast paced world.

Applying technology effectively can strongly contribute to improving the health and welfare of these elderly people, for example by using AR and providing life-sized holograms. They would engage the device, which projects the hologram directly into their room. With the help of this technology, 'almost real' daily visits and conversation would no longer be impossible, even if the relative lives far away. In addition, AR may assist elderly or disabled people to remain living independently. This could be achieved by providing AR-rehabilitation training for people experiencing cognitive deficits, or adjusted entertainment or additional 3D content for people suffering from memory loss. The same technology (paired with other medical technologies like remote sensors, which transmit live data of the patient's current status) may also reduce the number of home visits a doctor has to make.²³ This reflects the global trend towards increased homecare, and therefore contributes to the reduction of (public) healthcare costs as well as emissions from hospitals and transportation.



3.3 Schools of tomorrow

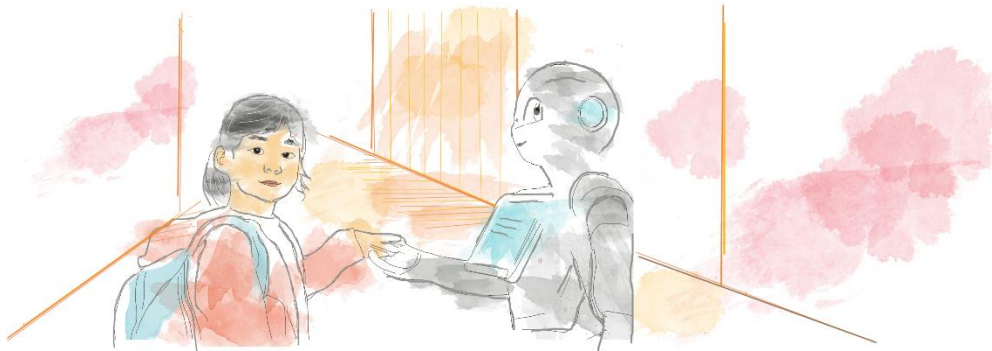
{ HOLOGRAMS INSERTED INTO THE STUDENTS' REALITY WOULD MAKE THE CONCEPT OF EMISSION-REDUCING DISTANCE LEARNING MORE ATTRACTIVE FOR CHILDREN AND OLDER STUDENTS AROUND THE WORLD }

Children may not attend school for a variety of reasons. These could be temporary, due to illness or other factors, or they may not be able to attend school at all. In Australia, for example, travelling distances are usually much longer than in Europe, and daily trips to school are time consuming, expensive and not environmentally-friendly, as – to give an extreme example – some citizens are even forced to use personal planes. Whether it is temporarily difficult, or not possible to attend school, AR could offer a solution. As already described, AR in the form of life-size holograms would provide a feeling of personal interaction – even if the other person is far away.²⁴

²³ <https://www.sciencedirect.com/science/article/pii/S235197891500133X>

²⁴ <https://www.inside-it.ch/articles/44322>, <https://www.nzz.ch/wissenschaft/technik/kommunikation-video-chats-werden-dreidimensional-ld.92644>

In the case of education, a teacher could be livestreamed directly into the children's homes, and the children into school, both in the form of a hologram. Of course, livestreams of lectures at many schools and universities worldwide are already available. The decisive difference, however, is that people, especially children, are less likely to listen well or to concentrate on a livestream than an AR representation. This is because they do not perceive it as 'real' and so feel it to be less important than a normal/live lesson. In addition, the background of the speaker, in e.g. a lecture theatre with a large audience, may be distracting. Therefore, holograms inserted into the students' reality would make the concept of emission-reducing distance learning more attractive for children and older students around the world.



4. Future trends and developments

In light of the grand societal challenges, the future of AR seems promising. But up to now, its potential has not been fully exploited and there is still plenty of room for innovative and disruptive AR solutions. The following section gives a brief overview of current trends and developments in the AR sector.

4.1 AR in the future home

4.1.1 A window showing more than what's just outside

It is a common routine for people to look out of the window after getting up to see what the new day is like. However, weather forecasts or information about temperatures are not available in this way. To make the daily 'look out of the window' more informative and relevant, the Korean technology company Samsung has developed a fully transparent LCD panel, which uses natural daylight as background lighting. With the help of this technology, the user can receive valuable information at a glance after getting up. This could include the weather forecast for the day, up-to-date stock prices, breaking news, etc. Furthermore, the screen may also play an entertainment role, for example showing cartoon characters playing in one's own garden to children.²⁵

4.1.2 The future of 3D TVs

Around 2010, leading manufacturing companies introduced the concept of experiencing 3D from the comfort of home with 3D television devices. However, sales did not skyrocket as expected. Besides bad timing and additional costs, this can partly be explained by users needing to wear big and bulky 3D glasses throughout the TV session.²⁶ In 2016, production of these devices was

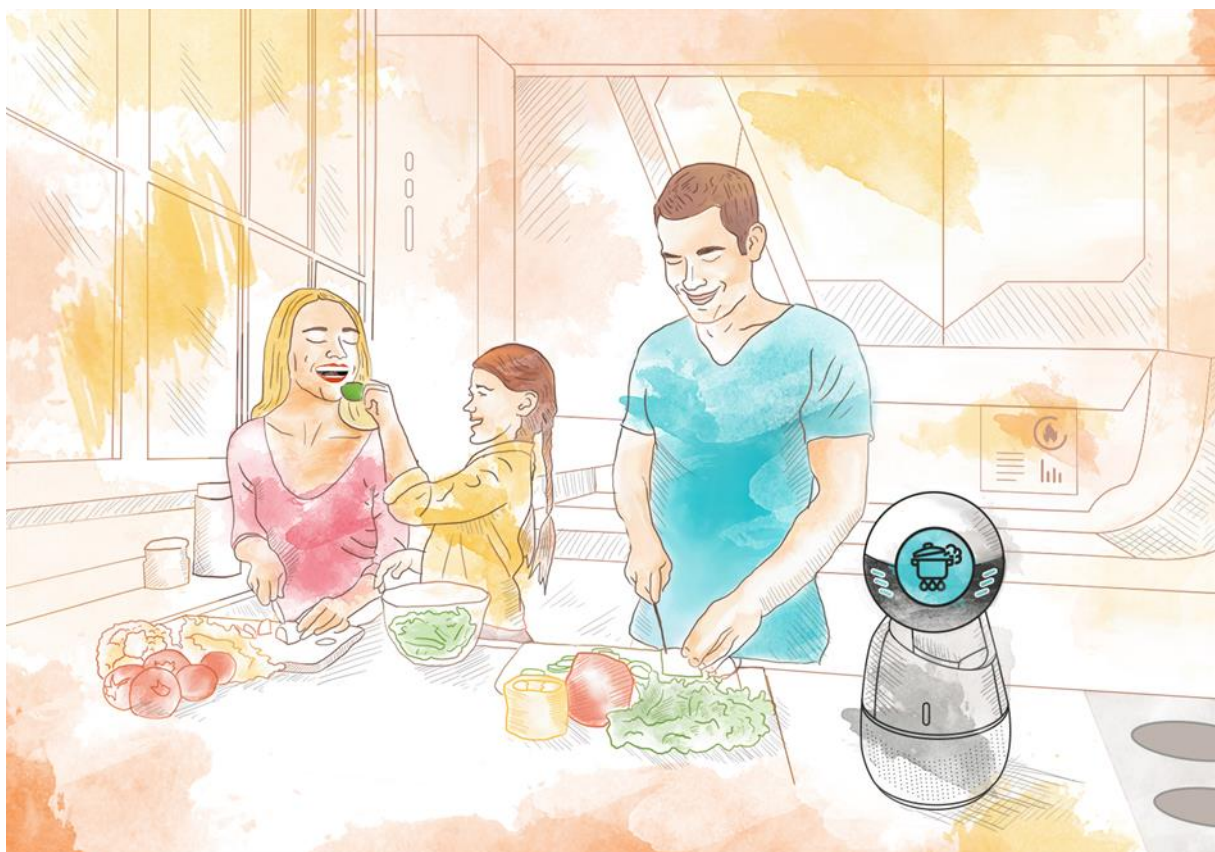
²⁵ <https://www.trendsderzukunft.de/samsung-smart-window-fenster-der-zukunft-werden-zum-multimedia-touchscreen-display/>
²⁶ <https://www.lifewire.com/why-3d-tv-died-4126776>

stopped completely due to lack of demand. Now, however, the company TronXYZ has developed a screen which lets users experience 3D TV without wearing an extra device such as special glasses.²⁷ This works by controlling light direction from the pixels on the screen so that each eye can see different pixels. This new approach to AR uses the same technological principle as the human brain uses to view the real world. There is a high potential that this improved and more convenient 3D technology will enhance entertainment experiences in the future home.

4.1.3 Cooking made easy thanks to AR

Most households enjoy cooking a fresh meal regularly. However, starting with the choice of a dish, the process, is not always easy and often ends in unsatisfying results. Swedish furniture seller IKEA has developed a stove concept named the "table for living". This normal-looking table has a camera-equipped projector that can recognize ingredients lying on its surface, giving the user an idea of what to make with what is on hand. If the user accepts one of the recommendations, the table will present the step-by-step recipe. There is an induction cooktop hidden in the table, so the user will not have to move between counters. As this new development will help to save future users' time and resources, while creating flavoursome dishes, it has the potential to carry AR and smart technology into the kitchen.²⁸

{ THIS NORMAL-LOOKING TABLE HAS A CAMERA-EQUIPPED PROJECTOR THAT CAN RECOGNIZE INGREDIENTS LYING ON ITS SURFACE, GIVING THE USER AN IDEA OF WHAT TO MAKE WITH WHAT IS ON HAND. }



²⁷ <https://www.tronxyz.com/>

²⁸ <https://www.engadget.com/2015/04/20/ikea-concept-kitchen-2025/>

4.1.4 More than smart assistants

Smart assistants like Alexa, Siri and Google Assistant are being rapidly implemented in people's homes and provide valuable task assistance every day. One important aspect of real interaction, however, is still missing: visual appearance. The Japanese developer Taro Minoboshi has created a smart assistant which comes with a hologram inside the gadget.²⁹ Like all other tools in this field, it can control the user's smart home devices, and provide them with relevant information. In addition, however, this box can take the role of a personal companion. It recognizes the user's face and reacts to their speech in a personal and visually expressive way.

Some sources go one step further: they expect to see fully sized, human-like holographic assistants in the future. Microsoft has already developed AR glasses specifically designed for this reason.³⁰ While most users might only see an artificial hologram person as a funny and maybe useful gimmick, for people experiencing loneliness, especially older people, it may be an essential tool for maintaining a stable mental health condition. By providing company with the help of holograms, home care providers may also save costs through reducing personnel while providing 24/7 assistance to their customers. Furthermore, children could be entertained, and to a certain extent looked after by holograms, saving valuable time for busy parents. Although many developmental steps are still to be conducted, the potential field of application is enormous.

4.1.5 Redundancy of maintenance services

It is not uncommon for certain technologies to sometimes stop working, for numerous reasons. When such inconveniences occur, the internet might offer solutions on how to repair the technology. However, applying these procedures are sometimes more complicated than expected. When purchasing new household equipment, the same thing can occur: the user manuals provided often contain poorly written or translated text as well as confusing diagrams, making them too difficult to use.

AR however, could revolutionize repair and installation processes. Columbia University computer science professor Steve Feiner has been working on a project named "ARMAR" since 1991. This tool provides the user with optical (2D and 3D) and short text instructions about the item and the required use of the tool. It runs by using "Goblin XNA", the lab's open-source platform for developing AR applications. Although ARMAR has been mainly developed for the US Marine Corps, Feiner also sees its future application in everyday life. The user's primary advantage is the ease of application and therefore the ability to save time on unpleasant but necessary tasks.³¹ German car manufacturer Mercedes-Benz has already introduced AR user manuals for its premium segment cars, demonstrating the functional capacity of this technology.³²

{ THE USER'S PRIMARY ADVANTAGE IS THE EASE OF APPLICATION AND THEREFORE THE ABILITY TO SAVE TIME ON UNPLEASANT BUT NECESSARY TASKS. }

4.2 AR in future health and fitness

4.2.1 Visualizing veins and organs

Sometimes, even the best-trained nurses struggle to find a vein for an injection at the first try. The same can happen to people who have to inject medicine through the veins on a regular basis at home, for example diabetes patients. The AR-product AccuVein has been developed to eliminate

²⁹ <https://www.digitaltrends.com/home/gatebox-azuma-hikari-virtual-assistant-news/>

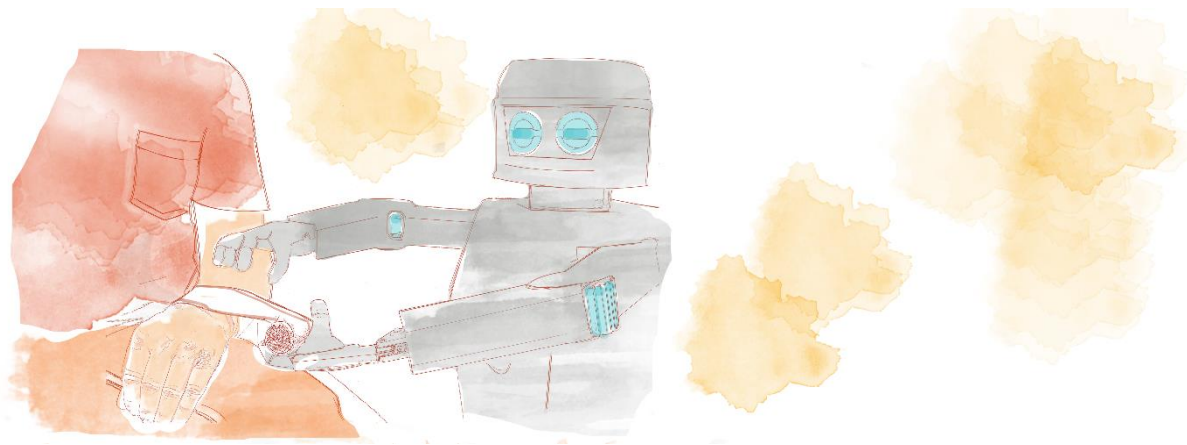
³⁰ <https://www.heise.de/newsticker/meldung/Holoportation-Microsoft-zeigt-beeindruckende-3D-Videochats-mit-der-Hololens-3151946.html>

³¹ <https://www.oreilly.com/ideas/augmented-reality-and-the-ultimate-user-manual>

³² <http://www.quytech.com/blog/augmented-reality-instruction-manual-user-manual/>

such situations. With this tool, it is possible to project a map of the patient's veins onto their skin, making it easy to hit the intended vein at the first try. Similarly, the location of organs might be projected into the operating room, assisting physicians during surgery.³³ Another solution would be to insert the veins map directly into the view of the user, with the help of an AR-platform such as smart glasses. This product is not yet widely applied, as it may still be glitchy, but the potential for similar tools is enormous. Especially for chronically ill or older people, such tools may eventually make the need to see a carer for medicine injection redundant.³⁴

WITH THIS TOOL, IT IS POSSIBLE TO PROJECT A MAP OF THE PATIENT'S VEINS ONTO THEIR SKIN, MAKING IT EASY TO HIT THE INTENDED VEIN AT THE FIRST TRY.



4.2.2 Working out made into a game

Physical exercise can improve health and reduce the risks of developing diseases, such as type 2 diabetes, certain types of cancers, and cardiovascular diseases. However, some people lack the motivation or knowledge to perform regular activity that can improve their quality of life. AR may help to change consumer attitudes. By using hands-free platforms such as smart glasses, future fitness applications will show different types of information while working out. Potential variations are infinite. Showing real-time performance data, such as burned calories, provides immediate feedback and motivation. Cardio exercise in particular can be performed without gym equipment when using AR, allowing work outs to be performed at home. This could take place by converting the user's body into a controller, turning the work out into a game.³⁵ This contributes to a higher entertainment factor and thus increases the likelihood of exercising more regularly.

5. Conclusion

Even though the basic concept of AR has been around for a long time, it is only now that AR has started to gain momentum. Starting from simple things like AR-powered pictures in Snapchat or Instagram, to holograms which may significantly improve our healthcare systems – AR will find its place in the homes and hospitals of tomorrow.

³³ <https://medicalfuturist.com/top-9-augmented-reality-companies-healthcare>

³⁴ <https://healthmanagement.org/c/healthmanagement/issuearticle/the-future-of-augmented-reality-in-healthcare>

³⁵ <https://www.einfochips.com/blog/experience-smart-fitness-with-augmented-reality-and-virtual-reality/>,
<https://www.vrfitnessinsider.com/the-future-of-augmented-reality-in-fitness/>