

СВІТОВА ЕКОНОМІКА ТА МІЖНАРОДНІ ВІДНОСИНИ

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INNOVATION IN THE SPHERE OF AUGMENTED AND VIRTUAL REALITY TECHNOLOGIES IN EU MEMBER STATES AND OTHER COUNTRIES OF THE WORLD

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Innovation in the Sphere of Augmented and Virtual Reality Technologies in EU Member States and Other Countries of the World

Problems and prospects for the application of innovative technologies of augmented and virtual reality (AR / VR) in various business areas are considered. The main trends in and features of the formation of technological and business base for creating products in the field of AR / VR for mass use in production and customer service are highlighted. The key participants in the global market for devices and applications in this sector as well as all options for their using at the present time are listed. The areas of practical application of the existing solutions are shown, the positive and negative factors are revealed. The features of various segments of wearable devices (Microsoft HoloLens) as well as mobile applications (ZapBox) are analyzed. The necessity for further development and implementation of AR technologies against the background of increasing digitalization processes and automation of production processes in the context of Industry 4.0 is justified.

Keywords: virtual and augmented reality technologies, mixed reality technology, digitalization, Fourth Industrial Revolution.

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Давидов Д. С., Рябовол Д. А. Інновації у сфері технологій виртуальної і доповненої реальності в Європейському Союзі й інших країнах світу

Розглянуто проблеми та перспективи застосування інноваційних технологій віртуальної і доповненої реальності в різних сферах бізнесу. Відображено основні тенденції, а також особливості формування технологічної і підприємницької бази для створення продуктів у сфері AR / VR (Augmented Reality, Virtual Reality) для масового застосування у виробництві й обслуговуванні клієнтів. Перераховано основних учасників світового ринку пристроїв і додатків у цьому секторі, а також всі варіанти їх застосування на момент написання статті. Показано напрямки практичного застосування існуючих рішень, виявлено позитивні та негативні фактори. Проаналізовано особливості різних сегментів пристроїв (Microsoft HoloLens), а також мобільних додатків (ZapBox). Обґрунтовано необхідність подальшої розробки та впровадження технологій доповненої реальності, на тлі посилення процесів дигіталізації та автоматизації виробничих процесів в контексті Industry 4.0.

Ключові слова: технології віртуальної і доповненої реальності, технологія змішаної реальності, дигіталізація, Четверта промислова революція.

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Давидов Д. С., Рябовол Д. А. Інновації в сфері технологій виртуальної і доповненої реальності в Європейському Союзі і других странах мира

Рассмотрены проблемы и перспективы применения инновационных технологий виртуальной и дополненной реальности в различных сферах бизнеса. Отражены основные тенденции, а также особенности формирования технологической и предпринимательской базы для создания продуктов в сфере AR / VR (Augmented Reality, Virtual Reality) для массового применения в производстве и обслуживании клиентов. Перечислены основные участники мирового рынка устройств и приложений в данном секторе, а также все варианты их применения на момент написания статьи. Показаны направления практического применения существующих решений, выявлены позитивные и негативные факторы. Проанализированы особенности различных сегментов носимых устройств (Microsoft HoloLens), а также мобильных приложений (ZapBox). Обоснована необходимость дальнейшей разработки и внедрения технологий дополненной реальности, на фоне усиливающихся процессов дигитализации и автоматизации производственных процессов в контексте Industry 4.0.

Ключевые слова: технологии виртуальной и дополненной реальности, технология смешанной реальности, дигитализация, Четвертая технологическая революция.

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Introduction. Under modern conditions, the processes of digitalization and introduction of computer technologies into production and customer service are in the active phase of their formation and development. The Fourth Industrial Revolution (Industry 4.0), which marked the opening of a number of new areas for implementing innovation, is becoming increasingly aligned with the actual practice of both large and small businesses (not to mention the opportunities that are becoming available to the general mass of users during this process).

For example, according to forecasts of the Germany Trade & Invest (GTAI) agency, in Germany, one of the countries leading in the development of Industry 4.0, more than 80 % of enterprises will have completely digitalized the entire supply chain by 2021 [1]. Moreover, the European Commission, through its program Horizon 2020, aims to speed up the process of implementation innovations and make it more efficient in various industries [2]. Thanks to this initiative (among other factors), over the past five years, the European Union has significantly strengthened its position in such areas as the Internet of Things (in industrial communications), M2M (machine-to-machine) interaction, 3D print [3] and other new technological areas.

In other words, today the sphere of innovative business is becoming more and more a sort of a “sandbox” for developing new concepts and technologies. One of the areas for development of products by a great number of startups (as well as large corporations) is augmented and virtual reality AR / VR.

The scope of applications of AR / VR technologies, according to many prestigious publications and authors (Harvard Business Review, Tech Crunch, Perkins Coie) can be regarded as one of the most dynamic and promising for the next decade.

With regard to this aspect, it is worth paying attention to the fact that there is a psychological inclination to overestimate the changes that will occur during the year (as it was observed with the recent rush around blockchain technology and its application), and to significantly underestimate the result of the accumulated changes over the next decade. Thus, in terms of different aspects, the very concept of virtual reality as well as currently existing technologies and gadgets (that can be used in advertising campaigns and even the manufacturing process) are a quite interesting subject for research. The **purpose** of this publication is an in-depth, structured description of the main prospects and risks associated with the analysis of achievements of both individual entrepreneurial, research projects, and global corporations within a relatively new market of augmented and virtual reality.

To illustrate the nature of the recent emergence of a virtual and augmented reality market in view of considering it as the variant of “accumulated changes”, we should use the real projects and deals. In 2014 several large companies made active efforts aimed at entering the emerging market for specific devices, allowing “immerse” a user into virtual reality. This can be a virtual space fully simulated by a computer or just a video tour representing a real place (a lot of 360° or VR180 clips can be found on the streaming video service YouTube).

As a part of this trend, Facebook acquired a VR startup Oculus for nearly USD2 billion [4]; Microsoft paid USD150 million for patents in the field of Augmented reality/Virtual reality technologies (hereinafter referred to as AR/VR) developed by the company named Osterhout Design Group [5]; Google announced launching augmented reality glasses (which in 2015 were declared a failure). In addition, in 2015 the giant Apple joined this trend and acquired the Metaio company, which is also working in the field of AR / VR [6].

At first glance, it seems that almost 4 years of the large companies’ acting in the AR / VR market will result in its strengthening and developing the structure (often with elements of an oligopoly) having little to do with the ideas brought by small startups without big budgets.

However, in 2017 all the startups developing solutions in the field of AR / VR attracted a total of more than USD3 billion investment [7]. It is also worth mentioning that the startup Magic Leap collected a significant part of all investments (about USD500 million in 2017 and more than a billion in general).

Thus, since 2014, despite the fact that the devices by such giants as Facebook or Microsoft have evolved significantly, and the very fact that big players entered a prospective market, there is still plenty of room for startups to grow. In this article, we would like to prove that now there is a great possibility for startups to create whole new ways for applying AR / VR technologies and even start a new “blue ocean” (by the bestseller book *Blue Ocean Strategy* by W. Chan Kim and Renée Mauborgne).

Even a cursory look at the current situation in the field of investment in AR / VR startups suggests that the market is still developing through “trial and error”, and that truly mass and, to some extent, revolutionary products are still in the future.

To illustrate this statement, it suffices to present some facts:

1. The market is now clearly divided in terms of growth (according to the forecast for the coming few years) – the sphere of augmented reality is clearly leading, as it provides for attracting more solvent consumers (including such ones as Boeing and NASA).

2. All possible limitations and problematic aspects regarding the user experience with devices (e.g. the need for further improvement of the software) are still actively revealed.
3. There observed tougher competition among the devices that are already in certain segments of the market (which quite often represent separate concepts of bringing AR / VR content to users). Among such devices there are: full-fledged virtual reality helmets (with screens); devices that allow using a smartphone as a screen (with installation of a corresponding software application) and a helmet with a special holder for it (both for fully virtual experience and augmented reality, when the user can interact with the image); augmented reality glasses, projecting some additional information on the lens; affordable cardboard versions, often used for the acquaintance with the technology of immersion into VR (also using a smartphone).

As for the general figures describing the situation in the industry, according to the forecast data presented on Statista.com, in 2018 the size of the AR / VR market was expected to be about USD27 billion [8]. However, the forecast for 2022 is more than USD209 billion!

The gaming industry is one of the most promising in terms of widespread adoption of virtual technologies. This is a very dynamic and rapidly changing sphere characterized by high competition, which is still relatively open to new ideas. According to a survey of entrepreneurs and employees of AR / VR startups, 59 % of respondents identified this industry as the most promising one in terms of investment activity [9].

In turn, educational startups as a possible magnet for investments were chosen by 26 % of the respondents; health-care and real estate – 26 % and 21 % respectively; advertising and marketing – 20 %; live events and defense projects – 19 %; movies and television, retail (e.g., the already implemented feature of viewing a product using AR technologies in the mobile application by Amazon.com) – 18 %; the manufacturing (assembly assistance, displaying additional information about components and errors in real time) – 17 % [9].

It is also worth listing all the largest possible dimensions and areas of application of AR / VR technologies, with regard to already existing products and companies [10]:

- Console and mobile games (PlayStation VR, Pokemon Go);
- Arcade and theme park games (VR Coaster);
- Media (Sky, VR Movie);
- Sports and music (NBA, DeNA/SoftBank, Formula One, LiveNation);
- Marketing (travel and real estate agencies);
- Automotive (car demonstration in AR/VR);
- Education (zSpace AR);
- Medicine and healthcare (diagnostics, modeling, training);
- Manufacturing (NEC and Fujitsu);
- Aerospace and defense industry (developing and producing complex systems and components, creating simulators for staff training);
- Offices (online conference);
- Retail (advertising, online shopping).

According to Statista, the distribution of VR market shares as of 2018 is as follows (by delivery of devices):

- SONY – 43 % (PlayStation VR);
- Oculus (Facebook project) – 19.4 %;
- HTC – 12.9 %;
- Microsoft – 3.2 %;
- Others – 21.5 %.

Before proceeding to issues of practical application of AR / VR technologies in business, we should also consider the aspect of classifying AR / VR technologies as sustaining or disruptive innovation (based on the book *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* by Clayton M. Christensen).

On the one hand, the main players in the market of wearable virtual reality devices are known – these are big global corporations like Facebook, Sony and Microsoft. However, these devices have a high price, despite the fact that they are gradually being updated and improved. It is also obvious that they mostly deal with their long-term customers, who have already proved their interest (except for Google Cardboard). Moreover, their products are superior to analogs (e.g., the mentioned above cardboard virtual reality glasses with the use of smartphone) both in technological aspects, ergonomics, and design.

The listed characteristics, despite the brevity of their description, allow considering companies that have large market shares of wearable AR / VR devices as mainly focused on developing and implementing “supporting innovations” within the range of already existing products and customers.

However, as in any market (at the forefront of technological progress), the emergence of separate trends and concepts that in the future can change the rules of the game for all participants is inevitable. Here we can note the sector of devices that allow by means of a smartphone to get almost the same experience from virtual reality as by using their expensive analogs. Unlike the previous example, startups in this sector are to a large extent aimed at attracting more and more new customers and audiences that previously could not think of the availability of VR technology, or what it can offer them.

The increasing trend in AR which implies pointing a smartphone's camera at a special picture-code is also worth noting. Given the availability of such technology (this will be discussed in the final part of the article), the prospects for its implementation appear to be very broad.

It should be admitted that the quality of products in many cases leaves much to be desired, but the main thing to be borne in mind is that it the “sandboxes” that present the value for customers. They can even bring in to creation of a completely new market and its leader.

Further, guided by the main purpose of this publication, we proceed from general introduction into AR / VR market and technology directly to real cases of improving the production process and customer service (in small, medium-sized and large businesses).

It is necessary to define the main areas in which a business can receive benefit from introducing AR / VR technologies:

1. Staff training. Pilots have already been use large and expensive flight simulators long, but with the development of new VR devices, training employees for other dangerous professions can reach a completely

different level. According to forecasts, VR training the market will grow to almost USD6 billion in 2022 [11].

2. Demonstrations of real estate and other large objects. Example: Matport.

3. Retail sector. There will be no need for assistants, not to mention the possibility to look through the full range of products in the supermarket to select your individual diet. This area is characterized as a promising one by the magazine Harvard Business Review [12].

Example: Dent Reality.

4. Making purchase decisions. AR / VR technologies can provide an additional opportunity to make the right purchase decision through the virtual “trying on” of clothes. They can also be employed in buying other products, such as furniture or interior items.

Let us consider some of the most proven devices produced by VR companies and those that can compete with them in the form of disruptive innovations.

Microsoft HoloLens. This device allows a user to interact with the so-called “mixed reality” (MR). One of the functions that can be widely used in business processes may be the remote interaction with holograms that are “projected” into the real world. The interaction itself is carried out by gestures and the user’s sight.

“We’re seeing mixed reality broadly as a new kind of dimension, literally, of how we’re going to interact with information”, said Greg Sullivan, director of communications for the Windows and devices group at Microsoft [13].

It is no secret that many technologies and ways to use them, which are the basis for multi-billion businesses, have moved to a wide range of users from less open sectors. However, these specific sectors are often those at the forefront of science and technology. There are many examples: GPS (a project developed as part of the Navy and the US Air Force) [14]; Bluetooth (the original concept and patent of 1942 suggested a new way to control torpedoes) [15]; some of baby food ingredients were developed by NASA [16]; CMOS (complementary metal oxide semiconductor) is a sensor which makes it possible to take a photo with a smartphone and carry around a miniature action camera (also NASA) [17]; NASTEK lenses, allowing ski and snowboard fans to see a 12-15 % better in the sunny weather, are also (partly) the development of specialists from the space sphere [18].

In this context, the HoloLens, or rather its contribution to the creation of the Orion spacecraft (which should replace the closed Space Shuttle program as well as return Americans to the moon) can also be added to this list. The fact is that the feature of the group use of the HoloLens and its functions of creating holograms overlaying the real object of the physical world make it possible to quickly and visually outline the scope of work and accept all the necessary instructions – at least, as stated by Decker Jory, Spacecraft Technician Senior Specialist at Lockheed Martin Space [19]. For Decker and his team, this device (though wearing it becomes slightly uncomfortable after three hours) is able to replace more than 1500 pages of text instructions for assembling the heat shield skeleton for the Orion spacecraft [19].

It should also be noted (in the context of the fact that AR / VR technologies receive practical approval in the largest technology companies and projects before being offered to mass-market consumers) that Boeing developed its own version of AR glasses. Getting wiring through a passenger airliner is a very difficult task, and employees have to keep a lot of data in their mind in order to imagine all the aspects of cable running.

However, according to Brian Laughlin, an IT Tech Fellow at Boeing, “By using augmented reality technology, technicians can easily see where the electrical wiring goes in the aircraft fuselage-.

They can roam around the airplane and see the wiring renderings in full depth within their surroundings and access instructions hands-free”. [20].

Despite the fact that HoloLens is a non-mass use device (because of its high price), it is included in this article, since it partially illustrates the way that AR solutions from the aerospace industry have to go to be successfully employed in small and medium-sized businesses [21].

1. According to a recent study, 77 % of American consumers now own smartphones [22]. As for the European Union, in Western European countries, this figure is 62.1 %, and in Central and Eastern Europe – 43.6 % [23]. There is also a trend of expansion of age groups and regions covered by smartphones. This fact allows speaking about the presence of significant opportunities for the broad-based introduction of AR / VR technologies (in the form of special software) in retail, entertainment, education, etc.

To date, there are already special platforms for developers (ARKit from Apple and ARCore from Google) which allow creating programs for specific needs of a client company more quickly and efficiently.

For example, using the capabilities of ARCore has made it possible to make the process of choosing a property to buy more timesaving and interactive. Sotheby’s International Realty Affiliates LLC, a company represented in 70 countries of the world, in partnership with the developer roOomy introduced an AR application with the function of choosing the interior design [24]. This has allowed reducing costs of the physical presence of agents and made the process of selecting an object easier (taking into account all individual preferences of the client).

This example illustrates the entire spectrum and scale of the perspective spread of AR technologies with the use of a smartphone in a small business (driven by reducing cost of developing mobile apps).

Moreover, with the release of ARCore, Amazon has developed and implemented in its mobile app (which has more than 100 million installations in Google Play) the ability to “present” a particular product at home [25].

The very fact of the attention being paid to the implementation this type of AR technology by one of the largest companies in the world (with a capitalization that fluctuates around one trillion US dollars) indicates the possibility of further expansion of the technology [26]. It also should be noted, that the largest retailer of furniture and household goods IKEA is already working on the development of special applications for fitting furniture in 3D and for the visualization of assembly instructions [27].

2. As for European startups and case studies of real use of AR applications for smartphones in a variety of entertainment and marketing projects, it is worth highlighting in detail the Zappar company, located in London and founded in 2011 with an initial investment of USD3.8 million [28].

The mobile app ZapWorks, developed by the startup, as well as the eponymous platform allow to create and retrieve personalized, customized for the needs of the customer objects of augmented reality. Due to the simplicity and several levels of the complexity of creating special codes (Zapcodes), which enable viewing a virtual object (an image or even a 3D animation), this is one of the leading instruments in the sphere of mobile AR. It is worth noting that the number of downloads of the app developed by Zappar on Google Play has already exceeded 1 million, which points to the demand for such applications among ordinary users [29].

The startup currently has dozens of completed projects, the unique codes of some of them having been scanned more than 100 000 times. The list of its customers includes Coca-Cola, Shazam, BBC, Sony Music, Netflix, Tesco, etc. [30].

It is also worth noting that the startup works not only in the field of augmented reality but also develops its own mixed reality (MR) solutions. Mixed reality not only involves layering virtual information on the real world, as well as augmented does, but due to a wearable device ZapBox – cardboard glasses with lenses for a smartphone and special cardboard marker controllers in hands – allows a user to feel more immersion and involvement [31]. The project was successfully funded on Kickstarter (the campaign raised USD84,356). It has not been put on the market yet, but the developers position ZapBox as a cheap alternative to Microsoft HoloLens – priced at only USD30 [32].

Among the achievements of this startup (in addition to its own platform and partnerships with large companies), it should be noted that the format Zapcode, despite the relatively low prevalence, may be considered as a competitor of the QR code. It is worth listing the main advantages of the format created by Zappar:

1. Zapcode has the two times smaller minimum size for scanning than a QR code (which size is 1.5 cm).
2. This new format does not need a safe area around, which allows placing it more organically on a background image.
3. Zapcode can be scanned by a smartphone even at an angle.
4. QR code simply contains a link to the website while Zapcode has a wide range of capabilities for integrating video, audio, 3D animation, photos and web links.
5. QR codes do not provide any statistical data for users. At the same time, one can see complete information on the number of scans of a particular Zapcode on the ZapWorks platform.

It is also worth noting that the Finnish startup Varjo Technologies (that has recently attracted an investment of USD31 million), is working on the release of a VR device with the resolution of a human eye. To date, according to the authors of the project, the poor quality of the AR / VR image is one

of the most relevant factors limiting their use by professionals (such as engineers and doctors) [33].

To provide a resolution comparable to the human vision, it is necessary to provide an image of 50 megapixels (for each eye). A prototype created by a startup has specifically this resolution, and this is 20 times more than all the analogs available on the market [34].

Conclusions. Summarizing the results of this publication, we can say that now the market for AR / VR technologies (hardware and software) still looks quite dynamic and is in the process of its formation. Despite all the initiatives by large companies, whose products today are being used in the production process, the market remains to be open for startups, allowing them to expand capabilities of individual users and businesses with a small budget.

The considered examples in the sphere of augmented reality based on the use of a smartphone suggest that the forecasts concerning the growth of both the size of the market for this seemingly conceptual technology and interest in it are quite possible to become real in the nearest future.

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