Interreg CENTRAL EUROPE
European Union European Regional Development Fund

CHAIN REACTIONS

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THEMATIC BRIEF Advanced manufacturing

VIRTUALITY IN MANUFACTURING

APRIL 2021

ABOUT INNOVATION BRIEFS

CHAIN REACTIONS addresses the challenge for industrial regions to increase regional capacity to absorb new knowledge and turn it into competitiveness edge and business value. There is a strong need to help SMEs to overcome capacity shortages for innovation and integration into transnational value chains.

The project aims at empowering regional ecosystems with the knowledge and tools to help businesses overcome those barriers and generate sustained growth through value chain innovation. During the project lifetime CHAIN REACTIONS publish thematic briefs presenting the rationale behind specific innovation deployment within selected business areas.

Following to the previous project brief focusing on virtuality in the healthcare industry, this new brief of the CHAIN REACTION project presents the new impact of virtuality also in the manufacturing area and how virtuality is currently deployed to support the management of production and manufacturing processes, the product design, the logistics and the maintenance operations and training implementations. This paper reviews the latest technologies and successful companies and applications scenarios particularly regarding Augmented Reality (AR) technologies.

VIRTUALITY IN MANUFACTURING

Virtual Reality and Augmented Reality

Virtual Reality (VR) and Augmented Reality (AR) both deal with digital content relayed through an immersive environment or experience.

With Virtual Reality, the user usually wears a headset that fully delves him into a new world or environment that may even mimic the real world. Both visual and audible experience take him away from known reality.

Augmented reality is similar in concept and is often confused with VR, but they differ significantly in terms of their applications. Augmented Reality overlays information and digital content on the real world, in real-time, using a display piece or eyeglasses. Like in the popular game “Pokemon Go”, it takes the existing environment and adds digital information to it to create the augmented environment. It turns the user surrounding into an interactive realm and add a touch of digital elements, objects, and another alluring glamor to make the experience more enjoyable.

If the concept of these technologies sounds like something from a science-fiction movie, it is already becoming a reality. These devices will become more commonplace everywhere, not just in single industries. Augmented reality glasses are forecasted to reach around 19.1 million units by 2021, and when combined with VR devices, could hit 59.2 million units [1].

It's only been recently that virtual technology has shown up in manufacturing environments as next-generation VR and AR become available. The new technologies are now well on their way to more widespread adoption. If the current pandemic tempers growth in AR/VR spending, the long-term outlook is still positive. Virtual reality, when used in the manufacturing industry, can help with a wide range of issues such as increasing productivity, reducing training costs and increased availability of new products to market.

An augmented reality device can tell a worker everything he needs to know, that’s happening around him, including whereabouts of colleagues, what machinery is malfunctioning, or even

what parts of a factory are off limits. He could use AR wearables to measure various changes, identify unsafe working conditions, or even visualize a finished product or structure. He could get overlay text, stats, and information relevant to his current task. Looking at a furnace or piece of equipment might show its current running temperature, revealing it as hot and unsafe to touch with his bare hands.

Let's take a closer look at some of the ways in which VR and AR can revolutionise the manufacturing industry in the next few years.

Inventory management and streamlined Logistics

Warehouse managers are facing the constant pressure of fulfilling high demand orders in increasingly shorter timeframes. When an order comes in, a worker usually has a lot of manual work to do: to check the information, to find the necessary product or goods, to scan it and report the data, to deliver it to the loading dock, and then finally to sign off on the order. Any mistake or delay in the process can lead to customer unsatisfaction, which can negatively impact the company's profit margins.

Thus, a streamlined, faultless, and well-organized task management process is needed in a warehouse to have clear inventories, enhance cycle counting, and optimize warehouse operations. Leveraging AR for warehouse management activities like order allocation, inventory control management, order picking, and material handling can highly simplify and improve complex warehouse operations, thereby overall supply chain processes.

Warehouse planning

AR can be of great help to warehouse managers and staff in the overall planning of the warehouse layout. With its potential to create digital, interactive 3D warehouse layout, AR offers the opportunity to experiment with changes to the existing warehouse design. Just by wearing an AR glass, the concerned authority can get comprehensive information on the warehouse layout with the proposed modifications incorporated. With several trials and experiments of new work models, warehouse managers and staff can inspect whether the plan effectively fits the warehouse layout. As a result, planning and redesigning of the warehouse layout (which was earlier the case) goes out of the picture, which results in tremendous cost and time savings.

Order picking

AR can simplify the entire order picking process. AR engages warehouses workers in the "vision" or "guided" picking. When an operator is informed about a scheduled pick-up, he can move around the facility wearing an AR-based smart glass, which helps them find through visual and audio assistance the exact location of a certain package/product and highlights it for easier pinpoint process and pickup. Warehouse employees can navigate towards needed supplies and make the overall process of order-picking much faster and more efficient. This is even possible to gamify the picking process thus increasing their employee's motivation in a simple manner. As and when he moves his head, the smart glass scans the barcode of items he sees in the cart. Then, the system can propagate the order status.

Logistics company DHL successfully deployed smart glasses and AR in a warehouse in the Netherlands and then expanded these efforts in augmented reality in numerous facilities in North America. In cooperation with DHL customer Ricoh and wearable computing solutions expert Ubimax (now TeamViewer), it uses the technology to implement "vision picking" in warehousing operations. The pilot proved that AR offers added value to logistics and resulted in a 25% efficiency increase during the picking process. [2]

Figure 1 - Augmented reality supported picking in DHL warehouse [3]

Factory floor planning

In mass-production manufacturing, factory planning – where to place tools, equipment and personnel – is crucial for productivity and efficiency. But engineering a new plant or altering an existing one involves design, testing and trials, and any unexpected delays or a production line shutdown, even a temporary one, can be very costly. Virtual technology can be used for factory floor planning in order to simplify and significantly shorten the process. Virtual reality (VR) technology has become ever mature today with affordable and yet powerful hardware. Virtual environment allows designers to test out "what if" scenarios in relative ease. Virtual plants can be designed to test production flows and how workers and robots perform tasks before changes are made in the physical world. Even ergonomics can be tested and refined to assure everything runs smoothly and efficiently in the new plant or altered line or plant. Initial trials suggest that a virtually planned floor can be completed in a fraction of the time, bringing new products to the line fast.

In the manufacturing industry, there is a growing interest of adopting VR to improve existing work procedures. Previous studies indicate a well-designed manufacturing layout can reduce the operating cost by 50% [4]. With the increasing complexity of the manufactured products and the demands for higher efficiency, various research and practice have been devoted to resolve it. Among the various attempts of modeling the virtual environment, three major approaches can be identified based on how the virtual model is created: 1) Methodologies and algorithms were developed to automatically extract and convert image, video data obtained into spatial data and thus transform existing physical facilities into virtual objects [5]; computer-aided design (CAD) software or virtual reality modelling language (VRML) can be used to model manufacturing facilities completely virtually in computers [6]; 3) a hybrid approach combining the previous two with the target of benefiting from the advantages of both [7].

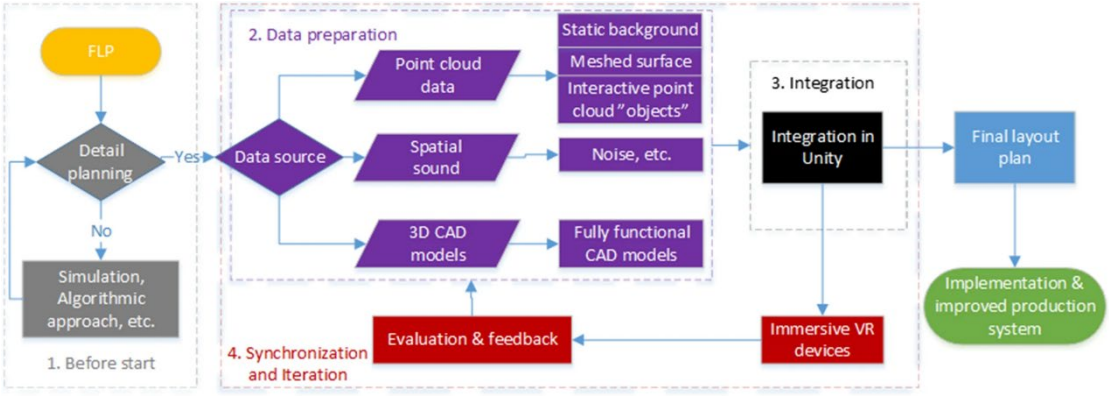

Figure 2 - Conceptual framework of the guidance to hybrid virtual factory modelling [8]

R3DT: Intuitive planning "as in real" in the virtual assembly hall

The Cross Connected software developed by R3DT enables virtual walking through factory floors with the help of gaming VR headsets and makes the workflow comprehensible. The machine set-up can even be changed in the VR room. Feasibility studies and process simulations for modified production structures are possible at any time. 3D models are securing protection against industrial accidents, planned gripping areas, separation systems, visibility conditions and escape routes.

All in all, the VR tool provides valuable insights from the basic evaluation to the concept and detailed planning. The software can also be used for coordination and documentation during implementation monitoring. The early virtual instruction of technicians and workers shortens the set-up and start-up times of new production lines.

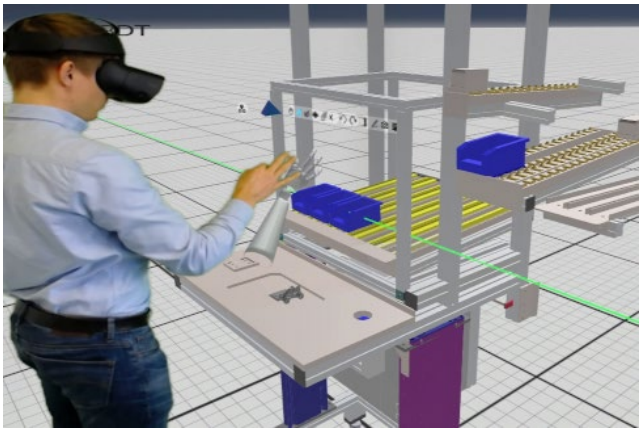

Figure 3 – Example of virtual reality implementation in assembly hall [9]

Vehicle design and build

Using virtual technologies delivers significant improvements in the areas of cost, time and quality. With VR, product designers and engineers have the ability to explore options that would have been cost- or time-prohibitive in the past.

Concepting, prototyping, and traditional design can be incredibly lengthy and resource-intensive processes. They also require several revisions and back-and-forth communications between related parties. That's before anything is even passed to production and manufacturing, which also requires further review before a final production is launched.

AR can eliminate some of the tedium of this process by augmenting and enhancing the task at hand and streamlining collaboration and communication between parties. Imagine if a director or executive can see the actual product being designed and constructed in real-time through AR. They could provide insights and direction that would eliminate the back-and-forth that many conceptual systems require.

Ford was one of the first automakers to go all-in on virtual technology, beginning in 1999. Today, Ford employs dedicated virtual reality specialists to lead the way for engineers to design and build entire vehicles, including autonomous vehicles, in a virtual environment. Ford has a mandatory, multifunctional VR review for all vehicles that go into production [10].

Airbus has used a Mixed Reality Application (MiRA) to combine virtual mock-ups into its production line, giving workers access to complete 3D models of the aircraft they are making.

Microsoft's HoloLens technology for Thyssenkrupp

The thyssenkrupp company is a good example of how a business can use AR in manufacturing to optimize the design process of a manufacturing project. ThyssenKrupp partnered with Microsoft's HoloLens technology, an AR platform, and is now using this technology to create stairlifts designed for individuals with mobility issues. Every home has a unique staircase design so Thyssenkrupp uses AR technology to measure a staircase and create a virtual model of it. The dimensions are calculated via the app, which captures 3D point cloud data and transmits it to the manufacturing team for further analysis. The HoloLens AR technology has finally digitally transformed the process across many phases of production from the beginning of the sales cycle all the way through the manufacturing process. ThyssenKrupp also even equips its lift repair workers with Microsoft HoloLens mixed reality smartglasses, which will allow them to bring digital models and other useful

Figure 4 – Microsoft's HoloLens technology for Thyssenkrupp [11]

forms of information directly into their fields of vision when they are on the job site. All these technologies allow thyssenkrupp to make decisions quickly, as well as making near real-time design approval for stairlift manufacturing plans possible. In addition, salespeople can offer customers a visualization of how the new stairlift will look and function within their home.

Maintenance and quality management

Modern manufacturing involves putting quickly together hundreds and thousands of pieces in complex assemblies. Whatever is manufactured, assembly instructions need to be carefully followed.

What if your maintenance personnel could see the exact hardware and equipment that may require servicing and get instant notification of potential issues that could arise? Better yet, just imagine if the system were expanded to allow them to see the dates of the last service, operation times, potential failure points, and more.

A member of your maintenance crew would only have to have an augmented reality device which would relay the information to them every time they were on the warehouse or factory floor. This eliminates guesswork from the process, making repairs faster and enabling faster response and recovery times, streamlining the entire operation.

Imagine if your maintenance crew could see exactly what equipment and hardware needed servicing, as well as any potential issues. Better yet, imagine if that same system were expanded to show them operation times, date of last service, potential points of failure, and much more.

A maintenance crew could don an AR device that relays this information every time they visit the factory or warehouse floor. This would take the guesswork out of the process, allowing for faster repairs, quicker response and recovery times, and better operations all around

SmartMixedReality for inspection at Airbus

Testia is an Airbus Group company specializing in inspection and quality control solutions. One of its roles is to market an AR solution under the name SmartMixedReality. Since 2011, Airbus has used this solution in their manufacturing facilities which is known Airbus-internally under the name MiRA [12]. This tablet-based technology has many application areas and are used on all aircraft programs today. According to Airbus, almost 1000 Airbus employees use MiRA every day. A very good example of this is the inspection of bracket installation in fuselage assembly where a tablet with a camera superimposes a virtual image of the as-designed assembly over the real as-built product.

Figure 5 – The MiRA Tablet [12]

This technology quickly enables the engineer to detect any deviation. At the end of the inspection, management automatically receives a report generated by the operator including details of any non-conforming parts which can be replaced or repaired quickly for improved quality control. According to Airbus, the introduction of AR has reduced inspection times in some cases from 3 weeks to 3 days.

AR for improving quality assurance with Porsche

Quality control is imperative in the automotive industry, and Porsche has a high-quality reputation to maintain. Porsche is thus experimenting intensively with augmented reality at its quality centre in order to obtain even faster and more precise information about car individual components. For instance, a tablet is currently being used to display with added digital images work steps and details about a vehicle's production. It can identify minor deviations in order to determine if there are any problems with body part fits. Even the smallest deviations from the standard are detected immediately in this way and it becomes clear where vehicle body components fit together perfectly or not yet ideally.

Figure 6 - Porsche Production 4.0 [13]

With AR, the company can measure everything from dimensional accuracy to surface finish and the functional efficacy of power windows, lights and other components.

The company wants to ensure every one of its vehicles is free of manufacturing defects. Porsche already upgraded its factories at Leipzig and Zuffenhausen with an initiative called Porsche Production 4.0. The initiative involved creating robots to perform repetitive tasks and an AR application that raises the bar of its quality control protocols [13]. Porsche Production 4.0 uses computer-generated images and optical measuring to measure up to 16 million points per scan, allowing the dimensions of a vehicle to be plotted in a high-definition point cloud.

Assembly training

Numerous studies point to a reduction in workers available for manufacturing jobs and a growing skill gap. In manufacturing, one of the issues with putting new worker on the floor is that they are unfamiliar with necessary protocols, equipment, and procedures. This can even lead to safety issues. Technical training and development can be costly when dealing with large, complex pieces of machinery or dangerous equipment. Workers are faced with complex products and processes every day. Outdated documentation and tools make their life even more complicated. Traditional manuals are history.

Both VR and AR have demonstrated in various industrial sectors great potential when it comes to training. Both AR and VR can speed the onboarding of new workers and improve worker productivity by offering more immersive on-the-job training. Operators can be trained for VR assembly tasks before they put into the real shop-floor assembly. AR smart glasses that project video, graphics and text can visually guide a worker through assembly or maintenance tasks. They could shadow existing personnel but remain out of the way to observe. They could deliver the necessary updates and information to help them understand what's happening, why, and how that relates to their duties.

Software provider Upskill and GE Renewable Energy conducted a productivity study using AR to assist workers in wiring a wind turbine. A GE Renewable technician compared first-time use of smart glasses powered with Upskill's Skylight software against the traditional process for wiring of a wind turbine. The technician saw an immediate 34.5% productivity improvement using AR [14].

RE'FLEKT - Germany

Automobile company Bosch has been collaborating with startup AR firm Reflekt since 2013 to stay in the front of the automobile industry. RE'FLEKT designs in-house custom augmented reality and mixed reality (MR) applications.

One of the startup's products is Reflekt One, an AR platform for enterprises which allows them to create interactive manuals through a no-code content platform, as well as assist workers in the manufacturing processes. With the AR Viewer the workers can visualize critical information and IoT data on all major platforms and AR glasses. Visual step-by-step instructions displayed in the worker's field-of-view thus provide a friction-less experience. Another product, Reflekt Remote, enables easier and more efficient remote customer support through the usage of AR.

Jaguar Land Rover (JLR) teamed up with Bosch and RE'FLEKT to develop an application that visualized and provided "X-ray" vision into the Range Rover Sport vehicle dashboard. The app allows technicians in training to see everything behind the paneling without removing and then reinstalling the dashboard **[15].**

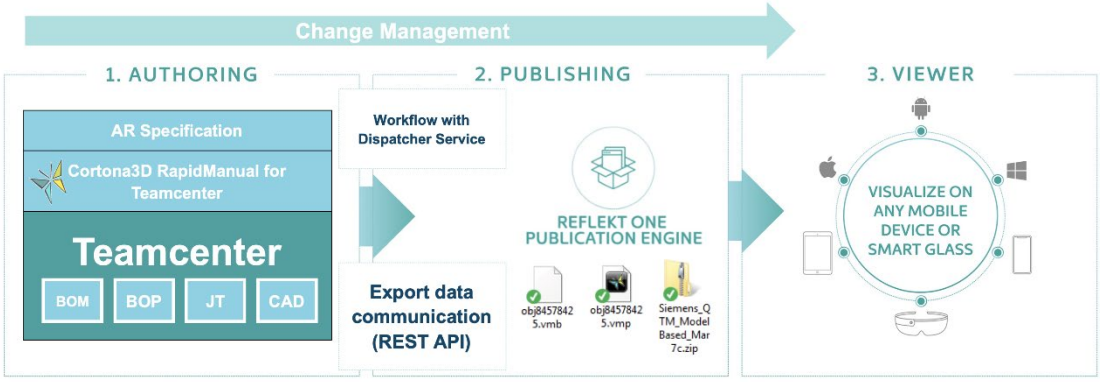

Figure 7 - Connecting Siemens Teamcenter to REFLEKT ONE [16]

Inglobe - Italy

Inglobe Technologies develops HyperIndustry, a product that supports field technicians with paperless Augmented Reality instructions in real time using mobile devices and smartglasses. HyperIndustry displays relevant areas under the hood of a car for engine repair training, as well as other tasks such as assisting employees in more complex tasks [17]. By pointing the camera towards equipment, object recognition is enabled, and the worker can instantly access procedures that provide contextual information including 3D highlights, pictures, videos and documents.

Conclusion

It's important to remember that the cases discussed in this thematic brief are just a small handful of the true potential the virtual technology has to offer, especially in manufacturing and product development. Early adopters in the manufacturing industry are thinking innovatively when it comes to AR and VR. As they consider the future, they're coming up with many different ways to use these potentially disruptive technologies to speed new products to market, reduce training costs and increase productivity. Many key players see virtual technology as important to staying competitive in the manufacturing marketplace.

AR and VR are considered by some managers and business leaders to be critical for creating the smart factories promised by Industry 4.0 (and IioT). Indeed, these technologies are an integral part of Industry 4.0 concepts, as it enables workers to access digital information and even overlay that information with the physical world. While not being broadly adopted in some applications, the compound annual growth rate of the industrial AR market is projected to grow rapidly [18].

However, manufacturers are often worried of buying into new technology trends, worried that the investment will not generate a tangible return. But AR is one trend that can truly benefit manufacturers, and here are several reasons they should invest in it. It may take some time, but AR will undoubtedly revolutionize manufacturing and companies should give it serious consideration. However, it is important for businesses to remember that to reap the full benefits of AR, it still requires careful obsolescence management, selective equipment upgrades, and a willingness to explore the diverse applications of the technology.

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