GRIPS

Augmented reality: The digital technology coach tackling the technician shortage

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Augmented reality: The digital technology coach tackling the technician shortage

Skilled engineers are becoming harder and harder to find, yet the demands placed on maintenance and servicing personnel are increasing all the time. Virtual reality, augmented reality and intelligent information structures offer an effective and practicable solution: Step-by-step instructions visualised on the object, giving a "digital coach".

The fact that products today are highly digitised and highly configurable requires even experienced engineers to undertake lifelong learning and regular training. Expectations about how information is conveyed are also rising: A few years ago it was enough to provide technical knowledge about a product in a handbook and on a website, but these days the new generation of engineers expects engaging apps.

In short, the lack of engineers combined with the increasing complexity of products and the higher demands being placed on information provision makes for one explosive mixture. Over the next few years, numerous industries are likely to see service costs soar, margins shrink, service quality plummet and customer satisfaction positively nosedive.

Using virtual reality and augmented reality in combination with intelligent information structures offers an effective and widely practicable solution to this problem: Step-by-step instructions are visualised on the object, giving users and engineers a "digital coach" and dissolving the boundaries between learning and using.

Shortage of engineers and STEM candidates

Back in 2014, Emirates' very first Airbus A380 landed in Dubai for its first heavy maintenance or "3C" check, having flown about 20 million kilometres. It took 55 days for two teams of engineers working round the clock to take the plane apart, check all the parts, replace anything faulty and then put everything back into place [1].

Finding the engineers to carry out such tasks is becoming more and more difficult. In the United Arab Emirates, for example, there are only 342 licensed aircraft engineers [2]. The training of qualified aeronautical engineers can no longer keep pace with the increasing demands in and rapid growth of the air transport sector, especially in the Asia-Pacific region and the Middle East [2].

The scarcity of experienced engineers is not limited either to the aviation industry or to Asia, however – it is affecting the majority of industrial sectors and an increasing number of western countries. In a recent survey of North American automotive suppliers, 59% stated that they have difficulty finding good engineers and 75% said that they need more engineers [3].

EU countries are also suffering a shortage of engineering talent. The UK Commission for Employment and Skills reports that 43% of STEM (Science, Technology, Engineering, Maths) positions are difficult to fill [4]. There is a lack of "MINT" (Mathematics, Information Technology, Natural Sciences, Technology) candidates in German-speaking countries too: At the end of 2015, Germany was facing a shortfall of 78,000 non-academic skilled workers in trade and industry [5].

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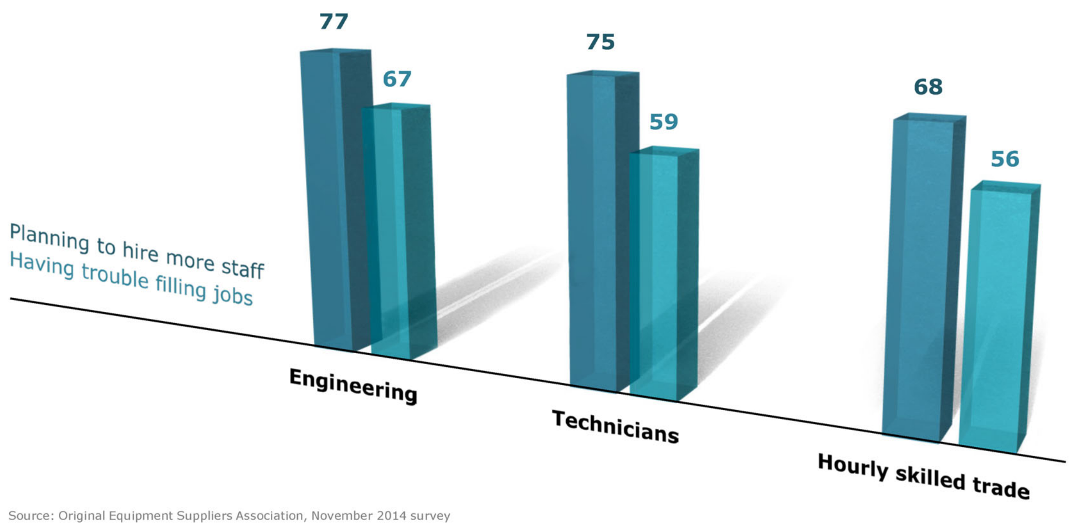

Fig. 1: Suppliers are having trouble filling positions for 2015 (in percent of suppliers responding yes).

In Austria in 2014, eight of ten companies had problems finding personnel for roles in Engineering, Production, Research and Development [6]. And Switzerland reported a shortfall of 16,000 MINT experts in the labour market as early as 2011 [7].

Although a couple of countries have been able to bridge the skills gap in the short term, demand will explode again once the engineers of the "baby boomer" generation start retiring in the next few years. Consequently, the shortage of STEM workers will become so severe that servicing work may even have to be undertaken by less qualified personnel in the foreseeable future.

More complex products and multimedia information

Today, the average passenger car has 100 microprocessors, 50 control units, 50 sensors, eight kilometres' worth of cabling and over a million lines of programming code – and counting [8][9]. The 14 million lines of code needed to operate a Boeing 787 look practically modest by comparison. But it's not just aeroplanes that are getting more and more complex: New technology is constantly being added to all manner of capital goods, such as production systems, machine tools, aeroplanes, trains and boats, growing in complexity and offering ever more networking possibilities.

This means it is no longer sufficient to simply make technical knowledge available in the form of a printed handbook, as required by law. The increasing demands being made on information and training require comprehensive information about all aspects of a product in multimedia format. Such information should cover not only operation, maintenance, troubleshooting and repairs, but also servicing times, replacement parts, consumable materials, tools and special tools.

As a side effect, presenting product information in an attractive way will spark interest in STEM careers among young people and make it easier for talented young engineers to enter the profession. Generations Y and Z, who have grown up with video games, smartphones and tablets, expect instruction videos; they want processes to be depicted graphically, instructions to be available in product displays, and to experience training scenarios for challenging tasks with virtual reality and augmented reality. Having a "cool" working environment makes non-academic STEM jobs seem fun and therefore more attractive.

The Service 4.0 challenge

To be capable of offering products and services that are competitive both now and in the future, industrial companies must therefore set themselves a three-point challenge: How can the products of Industry 4.0 be operated and serviced reliably despite the immense complexity of information, the immense complexity of the products themselves and the shortage of suitably qualified technicians?

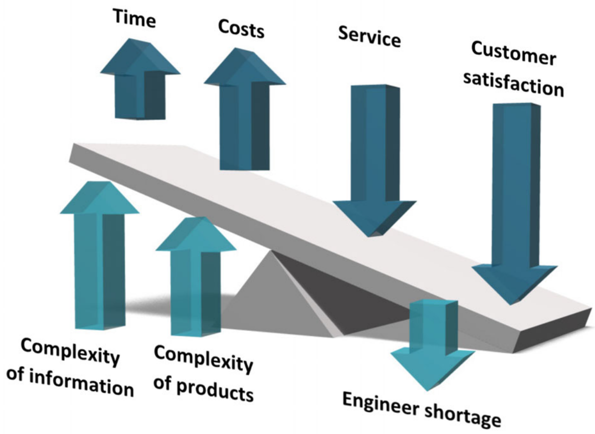

Fig. 2: The three-point challenge of Information 4.0: Complex information, complex products, not enough technicians

The product operation challenge can be overcome by designing the product and its control system to be so intuitive that users do not need much more training and help than they do currently.

As regards servicing, however, the excuse of product complexity cannot be used any longer – the problem of information must be addressed. The "Service 4.0" challenge is ultimately an "Information 4.0" challenge: How can I communicate practical servicing information for complex products in such a way that even poorly qualified, inexperienced engineers can do their job well?

Intelligent information structures: Knowledge Graphs

To excel in Service 4.0 without incurring exponential costs, we need a fresh approach to providing technical information. In the same way that Industry 4.0 is based on digital models of products and systems, Information 4.0 needs a central information model that networks and integrates all the information about a product in a single information hub. This will enable product information to be provided all for all possible applications of Service 4.0 quickly and cost-effectively.

The crux of this solution is an intelligent information model that depicts technical relationships in networked structures that can be interpreted automatically. These structures, originally called "semantic networks", were developed in the 1960s to model the meanings of sentences [10]. Since the 1980s, they have been used in artificial intelligence programs to depict complex situations and answer questions about such situations.

Google, Microsoft, Facebook, IBM, LinkedIn and Baidu – and possibly Apple as well – use these knowledge structures to provide intelligent answers to searches or to questions users ask their voice assistants, although they refer to them these days as "Semantic Graphs" or "Knowledge Graphs" instead. Knowledge Graphs are designed to manage and organise networked technical information about products, and enable such information to be reused multiple times.

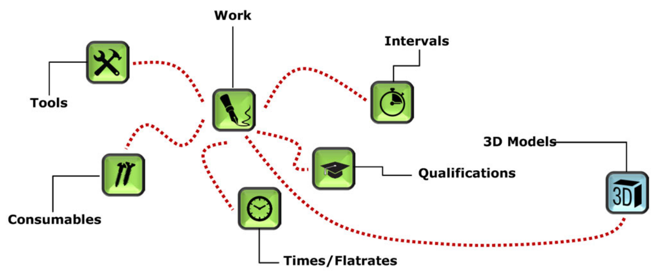

Fig. 3: Simplified Knowledge Graph for after-sales

The figure above shows a highly simplified Knowledge Graph for after-sales: The description of a task – such as replacing the gaskets in a cylinder head – is depicted in a Knowledge Graph as a network of objects and the relationships between them. In the centre is a description of the workflow. This then refers to objects that represent the tools and consumable materials (screws, seals, lubricants, etc.) used in the process.

Reference is also made to the level of training needed to complete the job, with further references to the intervals between services expressed as a specific number of operating hours or calendar months. The duration of the task is given in time or flat rate units, and a link to the cylinder head components in a 3D model assigns the target object to the work.

In comparison with simply describing the work in words, communicating information in this way opens up a wealth of additional benefits – with the cost of its compilation being virtually the same (i.e. there are no additional expenses):

- Referencing tools enable tool overviews to be generated automatically. This makes it easier for engineers – especially less experienced ones – to prepare for maintenance work that comprises several individual subtasks. Engineers can also check whether any special tools needed to perform the scheduled maintenance are available at the necessary times.

- Having a reference to consumable materials allows all the required materials to be gathered, greatly facilitating or even fully automating work preparation, stock checking and consumption planning.
- The information about intervals makes it possible to generate flexible maintenance schedules automatically. In combination with deadlines, the overall time required for the servicing job, replacement parts and consumable materials, the total costs can then be calculated.
- Linking to 3D data provides the means to auto-generate images, use 3D animations and visualise the relevant components in virtual reality and augmented reality applications.

An information hub with Knowledge Graphs is therefore the perfect solution for providing information from a single source in a way that is automated, cost-effective and practicable for all applications and digital services – in any amount of detail, tailored to the user's level of experience. The GRIPS system offered by the STAR Group is one of the few solutions in the technical sector that works with Knowledge Graphs and has been field tested by major vehicle manufacturers and industrial companies throughout Europe.

Learning on the object: Augmented reality

Summer 2016 saw Pokémon Go make the headlines on all media platforms as millions of people suddenly left the comfort of their homes to play outdoors. This hype brought people's attention to a new technological development: Augmented reality (AR).

Augmented reality does more than just make virtual monsters appear in surprise locations – it can also be used to visualise complex operations, maintenance work, diagnostic tasks and repair procedures on a product by accurately superimposing 3D models and animations over the parts that need servicing or operating.

The figure below shows augmented reality helping a mechanic to diagnose a fuel pump problem on a motorbike.

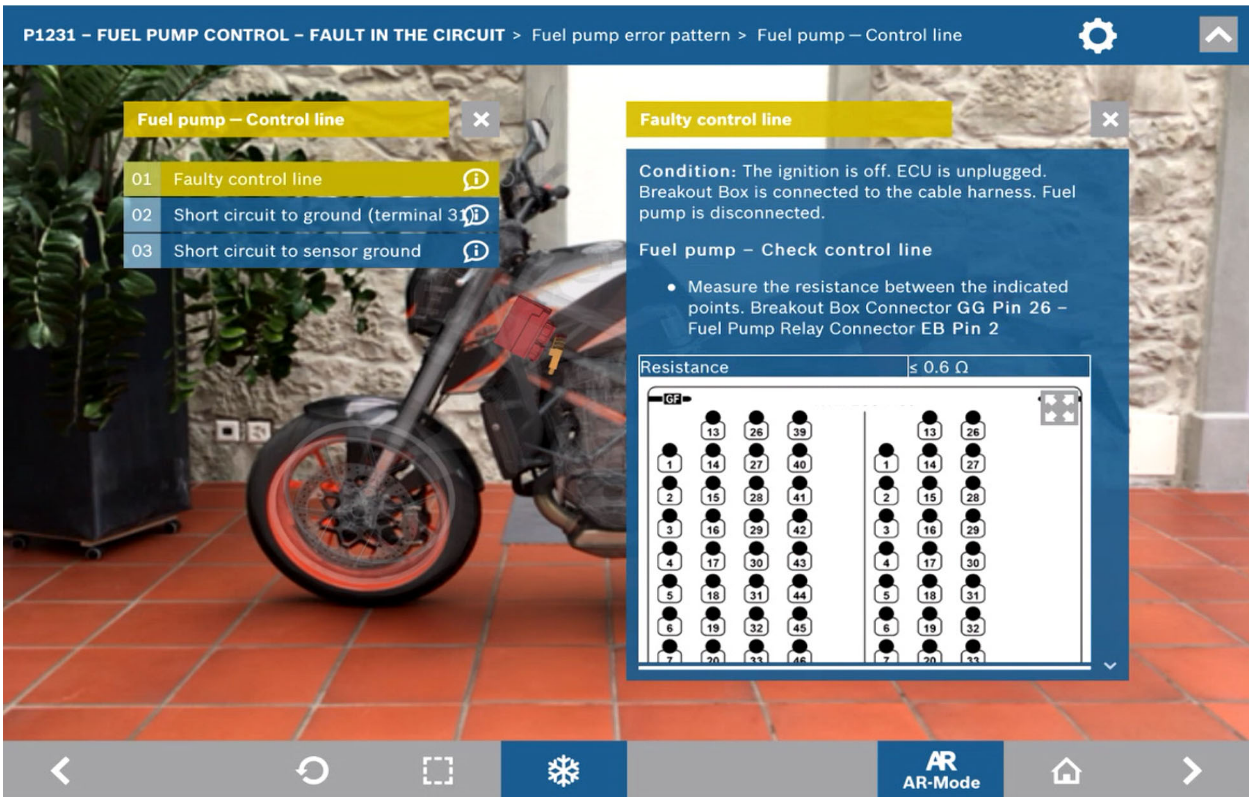

Fig. 4: Technical diagnostics supported by augmented reality

The engineer sees the components contributing to the problem – the fuel pump and the control unit – and where they are fitted. The object that requires diagnostics (fuel pump) is shown in red and the diagnostic procedure is described step by step. The plug-in contacts for the first step ("Check the resistance") are magnified in a close-up image. The relevant connector on the red model flashes as well. Readings from the diagnostic tool can also be depicted on the object.

Individual steps such as removing the filler cap cover can even be illustrated using animations (see figure below).

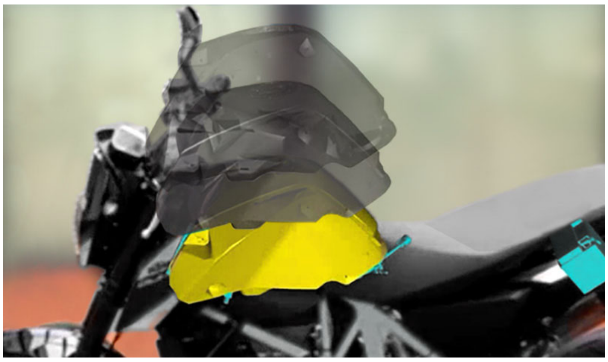

Fig. 5: Work step animation in an AR representation

The AR application given above was created by the STAR Group in GRIPS using two-year-old Knowledge Graph information and little manual input.

Employing the future-proof Knowledge Graph approach enables existing information to be easily used to generate numerous AR applications for any product model.

Fast and flawless: The benefits of augmented reality

Displaying work instructions on an augmented reality image can help even untrained engineers to familiarise themselves with new products and learn on the job:

- The location of an assembly or component is clearly visible.
- Having the image displayed on the object reduces the risk of errors and speeds up performance of the work.
- The procedure is easier to understand and get a feel for.
- Providing instructions on the object makes for a steep learning curve.

These benefits have been corroborated by a study by Boeing in which three groups of participants with similar qualifications were asked to assemble an object [11]. The participants had never done this task before. The instructions were communicated using model illustrations and a step-by-step guide (model-based instructions or MBI).

The first group were given a desktop PC, which was set up close to the object being assembled. The second group were given the same MBI but on a tablet that they could place next to the object. The third group used a tablet with an augmented reality image that projected the components to be fitted onto the object. Each group had two attempts at assembly; the time they took and the errors they made were recorded each time.

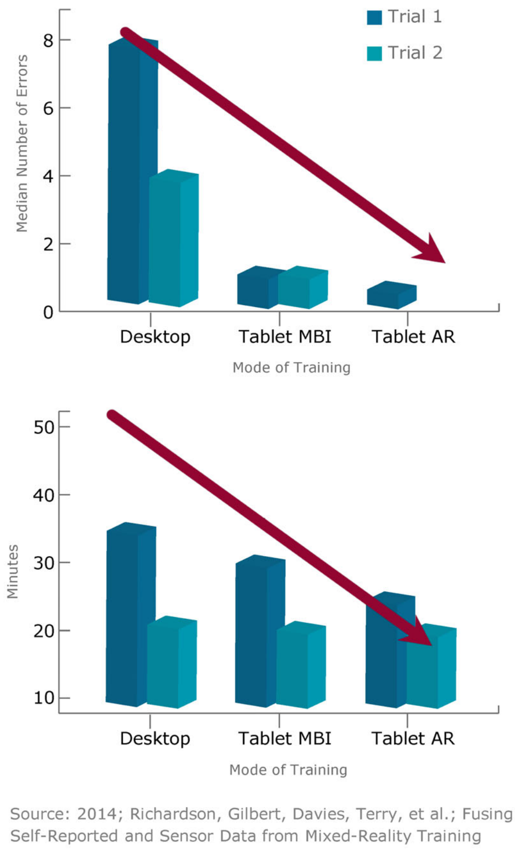

Fig. 6: Results of the study by Iowa State and Boeing: Average error rates and completion times

The results clearly show just how beneficial AR is: The desktop group made an average of eight errors in their first attempt and four errors in their second attempt. The second group made one error in their first and one error in their second attempt. Having the instructions on the tablet close to the object being assembled evidently brought considerable advantages. The AR also averaged one error in their first attempt – but their second attempt went without a hitch.

The time taken by each group to complete the task, especially the first time around, also varied wildly: Group 1's first attempt took an average of about 35 minutes, while group 2's took a little over 30 minutes and group 3's took just under 25 minutes. Completion times levelled out at 20 minutes for the second attempt, with group 3 being the quickest once again.

In summary, the study shows that augmented reality helps people learn how to do new or complicated tasks more quickly while making a minimal number of errors, even on their very first try. This means that even less qualified users and engineers can carry out operations and servicing work that they would otherwise – that is to say using conventional communication methods such as handbooks and websites – scarcely be able to do. This can be used to make up for the lack of skilled engineers.

Conclusion: From amateur mechanic to product whisperer

Knowledge Graphs present information in an intelligent way; with the help of augmented reality, this information can then be displayed on an object needing work as the situation requires.

This enables new approaches to be applied to training and to helping engineers with Industry 4.0 products – in terms of both operating and servicing. Operating and servicing information is compiled more efficiently; technicians can use it more easily and more quickly, and are less likely to make mistakes when doing so. This reduces servicing times and cuts the cost of rectifying errors and training employees while improving customer satisfaction.

In the future, not only augmented reality solutions but also voice assistants based on Knowledge Graphs – a sort of "Workshop Siri" – will find their way into servicing work. Engineers will be able to ask products questions directly (like "How much oil should I put in here?" or "What tightening torque should I use to secure the fuel pump?"), as General Electric demonstrated for a gas turbine just last year [12]. These developments will turn engineers technicians from amateur mechanics into veritable "product whisperers".

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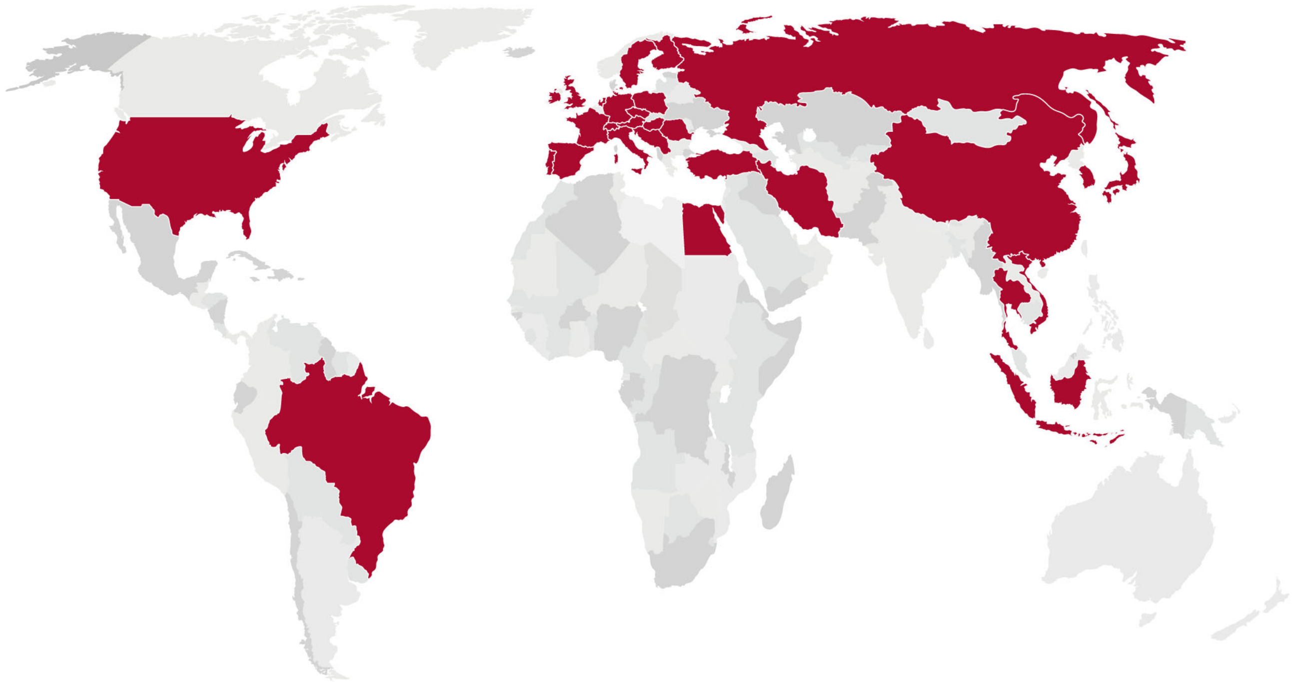

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