INDUSTRY 4.0 TECHNOLOGICAL SOLUTIONS AND THEIR EDUCATION CONCEPT IN THE BOSCH SMART SHOP FLOOR LABORATORY

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Abstract

The development of the Smart Shop Floor logistics simulation laboratory started as a flagship of collaboration between the Budapest Business School and the Robert Bosch GmbH, in 2018. The assumption is that the students and those interested in the laboratory can carry out and conduct impact assessments through exact industrial study cases as far as the complete procedure is concerned. After about a year and a half of development, the laboratory is ready to fulfil its function: to enhance students' knowledge and competences in a "traditional" education environment.

As a teacher, our main duty is to teach today's students to think and to prepare them for future jobs. At present, we can only hope to guess the challenges of tomorrow which will appear as a consequence of the present high-level digitization, robotization, and automatization. Thus, in this fast-changing world, the teachers of today have to prepare the students at high level under increasingly difficult circumstances. What is already certain in our present situation is that students need to be able to think, solve problems as effectively as possible and polish their digital abilities to a very high level, if they want to be successful.

Keywords: i4.0, digitalization, digital transformation, BOSCH, AR, laboratorial education

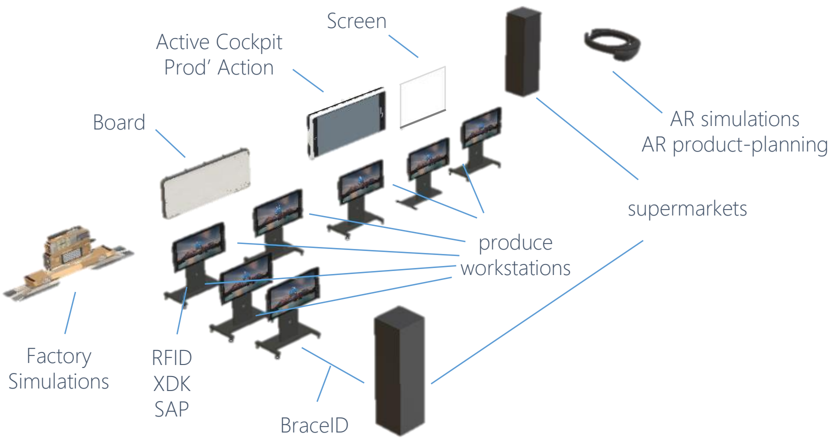
1. Introduction

According to research (Brusilovsky, 2001), as a result of robotization and automatization, 75 million jobs will be lost within 5 – 10 years, and 133 million new ones will emerge. The question is what type these jobs will be. We usually entertain the preconception that robotics and artificial intelligence will not only affect the factory workers but, according to the research of WEF, financial analysts, bookkeepers, auditors, bank officers, statistical analysts, insurance agents, administrators and assistants are to face the same risk. It is true that the assemblers and the drivers are in the most endangered category. Those workers will be needed mostly who are able to develop these systems, take part in the automatization of the processes or work in fields where machines are of no use, for example the improvement of the users' experience.

As a consequence, the knowledge of the industry 4.0 technologies will be indispensable for the employees of the future. They can learn it either in a sharp environment which is not always possible, but the second-best solution can be working under laboratory circumstances. Thus, for example, in the robotics laboratory one can find the smaller version of the same industrial robot that works in the sharp environment with the same programming and operation, user environment, so, if they acquire the relevant knowledge in the laboratory they will find a way around in the industrial sharp environment. At the same time, if students do not receive the suitable level of education in connection with the digital revolution of today, they will start with a huge disadvantage on the labor market (too).

On this basis, we consider the education under laboratory circumstances very effective. In what follows, I introduce the units of the laboratory, which simulate the production processes first of all, both from the professional and the education methodological points of view, and we also present some experience, opinion on the basis of the pilot educations.
Figure 1 shows the spatial and methodological division of the laboratory:

Figure 1:
A Smart Shop Floor setup of the laboratory



Source: own illustration

2. Screen

Students can learn the theoretical material of the laboratory with the flipped classroom method, which means that the students prepare from the theoretical knowledge in advance what is needed for the laboratory and they can go and see the practical aspects of all these too, making the use of the practice-oriented opportunities more effective.

The theoretical connection of the given device/method is continuously displayed on the screen which the students have checked with the above- mentioned method, thus, making the integration of their theoretical and practical knowledge more effective. Besides, they strengthen the flipped classroom method this way, too.

3. I4.0 Factory Simulation

Entering the room, we can see the whole factory simulation 4.0 of the Fischer Fabrik to the left of the door which can help those very much who have not yet been in a factory.

Factory simulation from fischertechnik is a training model, consisting of fischertechnik modules, which simulate a small factory. This consists of several individual models, such as the "automated high-bay warehouse", a "multi-processing station with oven", a "vacuum gripper robot" and a "sorting line with detection". By linking several stations, the processes can illustrate a produce line.

The model has four 24 Volt printed circuit boards and can be controlled via any conventional PLC. This way you can create a completely unique program and with the aid of the assignment plan directly control the inputs and outputs. However, the individual programs must be matched to each other, so that it does not lead to a collision.

The process of the following sequence is provided through the structure of the model. The vacuum gripper robot loads the rack feeder of the automated high-bay warehouse with workpieces. This stores the workpieces in the high-bay warehouse, sorted according to color. Finally, the workpieces are taken out of storage again, brought to the multi-processing station and machined there. After this the machined workpieces are sorted in the sorting line according to color and conveyed into storage locations. From there the workpieces are picked up again by the vacuum gripper robot and transported back to the high-bay warehouse.

After you have unpacked the "Factory Simulation" and removed the transport locks, perform a visual inspection to see whether any components have come loose or been damaged during transport. If necessary, put the loose components back in the correct place. Compare your model with the comparison pictures of the "Factory simulation", which is stored on the eLearning portal. Check whether all cables and hoses are connected. Using the assignment plan, the unconnected cable can be connected correctly.

3.1. Vacuum Gripper Robot (VSG)

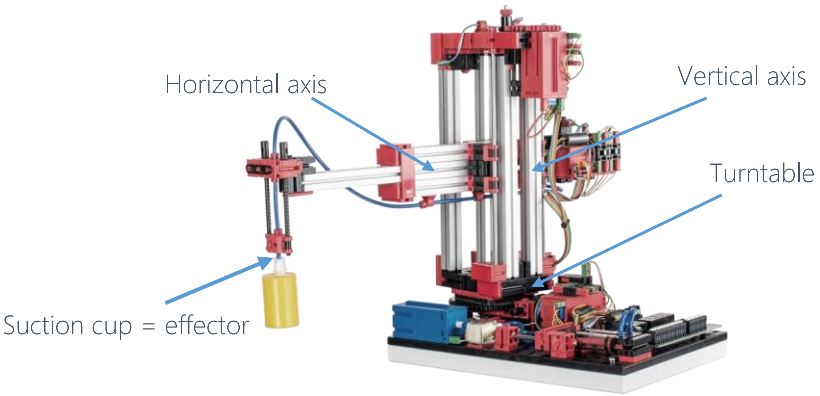
What are robots?

The Society of German Engineers (VDI) defines industrial robots in VDI guideline 2860 as follows:

“Industrial robots are universal handling systems with several axes whose motions with respect to movement sequence and paths or angles are freely programmable (i.e. with no mechanical or human intervention) or sensor guided. They can be equipped with grippers, tools or other means of production and can perform handling and/or production tasks.”

The 3D vacuum gripper robot is therefore an industrial robot that can be used for handling tasks. A workpiece can be picked up with the help of the vacuum gripper robot and moved within a workspace. This workspace is the result of the kinematic arrangement of the robot, and it defines the area that can be reached by the robot's effector. In the case of the vacuum gripper robot, the suction cup of the effector and the workspace correspond to a hollow cylinder whose vertical axis coincides with the robot's axis of rotation.

Figure 2:
Kinematic arrangement of the 3D vacuum gripper robot



Source: Fisher Technik

The geometry of the workspace is the result of the kinematic setup shown in Figure 2 and comprises one rotary axis and two linear axes.

The typical job for this type of robot can be broken down into the following work steps:

- Positioning the vacuum gripper at the workpiece location;
- Picking up the workpiece;
- Transporting the workpiece within the workspace;
- Setting down the workpiece.

Positioning the vacuum gripper or transporting the workpiece can be defined as a point-to-point motion or as a continuous path. The individual axes can be controlled sequentially and/or parallelly. This is significantly influenced by the obstacles or predefined intermediate stations present in the workspace.

It is practical first to integrate a reference run in the program in order to establish the absolute position or the absolute angle. To do this, the three axes of the robot are moved to their reference positions and then their positions or angles are set to zero. Now the position of the workpiece can be approached, and the workpiece picked up.

The following steps can now be carried out sequentially:

- The gripper robot moves to the alternate position;
- Set the workpiece down;
- The gripper robot pauses at this position;
- Pick up the workpiece again.

For the position control the pulse count of the encoder and the direction of rotation of the motor is combined and, since this is a monotonous movement, can thus approach positions or angles precisely. During this movement the three axes can be controlled parallelly, as long as there is no obstacle present in the workspace.

For this purpose, the following measurement and set point values are required:

- Target position or target angle;
- Actual position or actual angle;
- State of reference switch;
- Motor direction of rotation;
- Measured encoder pulse.

During the suction process of a workpiece the suction cup must first be lowered, in order to create an airtight connection between the workpiece and the suction cup. Then a vacuum must be created in order to temporarily fasten the workpiece on the suction cup. Now the suction cup can be lifted with the workpiece. The function for setting down the workpiece can also be divided into three sections. First, the suction cup is lowered, then the air is removed from the cylinder, eliminating the vacuum, and finally, the suction cup is raised again.

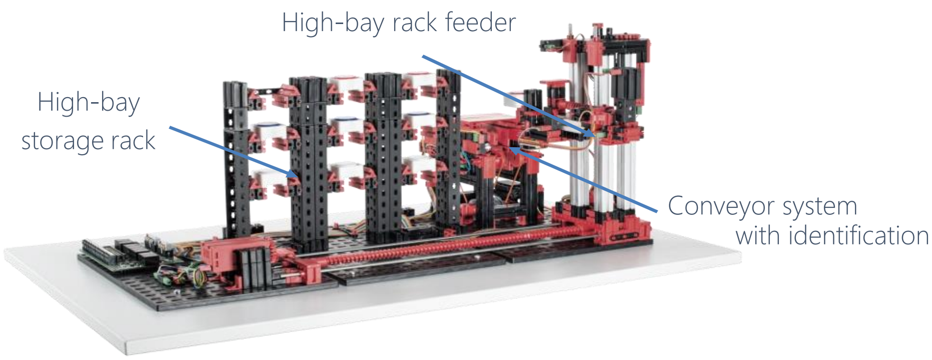
3.2. Automated High-Bay Warehouse (HRL)

What is a high-bay warehouse?

A high-bay warehouse is a space-saving storage area for storing and retrieving goods. In most cases high-bay warehouses are designed as pallet rack storage systems. This standardization provides for a high level of automation and connection to an ERP (Enterprise Resource Planning) system. High-bay warehouses are characterized by superior space utilization and high initial capital costs.

Storing and retrieving goods is handled by rack feeders that move in a lane between two rows of racks. This area is part of the receiving station, where the identification of goods also takes place. Using conveyor systems, such as chain, roller or vertical conveyors, the goods arrive and are transferred to the rack feeders. If the rack feeders are automated, no one is allowed to enter this area. In the case of the automated high-bay warehouse, the goods are transported on a conveyor belt. The goods are identified by a barcode.

Figure 3:
High-bay warehouse areas



Source: Fisher Technik

Goods are frequently stored based on the dynamic warehousing principle. There is no fixed arrangement between storage position and goods, so the goods to be stored are placed in any free spot. This ensures path efficiency. The warehouse management system saves the position of the stored goods, making them available. A (partly) automated identification of goods, which is usually done using FRID chips or barcodes at a central location called the identification site, and standardization of storage areas (same external dimensions, same permitted unit weights) are indispensable.

The ABC strategy, in which the warehouse is divided into three zones at varying distances from the storage/retrieval area, is used to further streamline the pathways. Frequently required goods are placed in the A zone, which is directly next to the storage/retrieval area. Correspondingly, rarely needed goods are stored in the C zone, which is far away from the storage/retrieval area.

With the automated high-bay warehouse you can demonstrate both the dynamic and the static storage. In the case of static warehousing, for instance, each row is assigned a color. For instance, the top row is assigned the color white, the middle row is assigned red and the bottom row is assigned blue. The individual colored rows are filled from the position closest to the pre-loading zone to the position farthest away from the pre-loading zone.

Regardless of whether you want to use the static or dynamic warehousing, it is practical first to integrate a reference run of the high-bay rack feeder. To do this move the vertical and horizontal axes to their reference positions and then set their positions to zero.

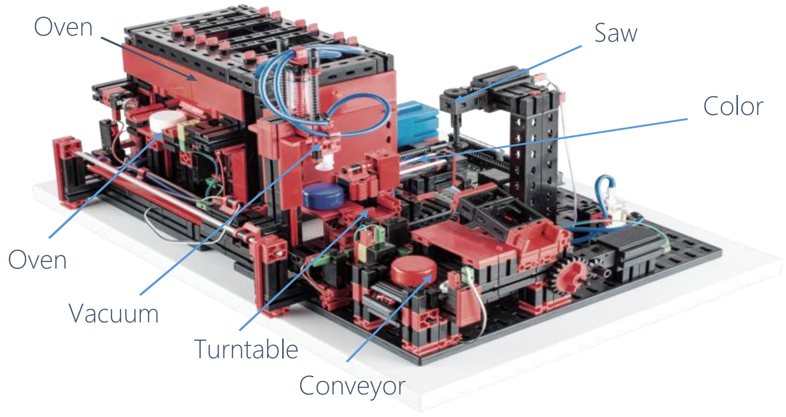
For the factory simulation the static warehouses are suitable, since the workpiece carrier is already in the high-bay warehouse and the workpieces are sorted from the sorting line. If the rack management is now designed so that the high-bay warehouse is filled in sequence, the workpieces are automatically stored sorted by color, since the VSG picks up the sorted workpieces from the storage locations of the sorting line. Thus, the white workpieces are stored in the top row, the red workpieces in the center row and the blue workpieces in the bottom row. For this no signals of the track sensor are required, which simplifies the program.

While the vacuum gripper robot transports a workpiece from the storage locations to the HRL, the rack feeder simultaneously picks up an empty workpiece carrier from the high-bay warehouse and places on the conveyor belt of the "conveyor system with identification". The conveyor belt should now transport the workpiece carriers to the other end of the conveyor belt. When the VSG has placed the workpiece in the workpiece carrier, the workpiece carrier including the workpiece should be conveyed by the track sensor and placed on the extension of the rack feeder. Then the rack feeder stores the workpiece on the corresponding storage location. To remove from storage the rack feeder removes the loaded workpiece carriers and transports them to the conveyor system with identification. From there the vacuum gripper robot can remove the workpiece again.

3.3. Multi-Processing Station with Oven

In the case of the multi-processing station with oven, the workpiece automatically runs through several stations that simulate different processes. These processes use different conveyor systems, such as a conveyor belt, a turntable and a vacuum gripper robot. Processing begins with the oven. The processing starts as soon as the vacuum gripper robot places the workpiece on the oven feeder. The light barrier is interrupted when this happens, thus opening the oven door and drawing in the oven feeder. At the same time, the vacuum gripper is called, which brings the workpiece to the turntable after the firing process. Following the firing process, the door of the oven should be opened again, and the oven feeder move outward again. The already positioned gripper robot should pick up the workpiece as with the VSG, transport it to the turntable and set it down there. Provisions are made that the turntable positions the workpiece under the saw, waits there for the duration of processing and then moves to the position on the conveyor belt. There the pneumatic actuated ejector pushes the workpiece onto the conveyor belt, which conveys the workpiece to a light barrier and then transfers it to the sorting line with detection. Crossing the light barrier should cause the turntable to return to its starting position and the conveyor belt to come to a delayed stop.

Figure 4:
Areas of the multi processing station with oven



Source: Fisher Technik

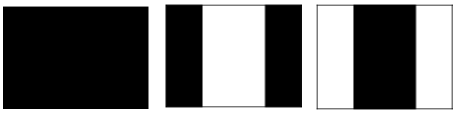
The program sequence can be controlled due to the many inputs and outputs present. Therefore, it is practical here to divide the program into three units: oven, vacuum gripper robot and turntable. The particular processes should communicate with each other and thereby ensure that no collisions occur.

However, if a dynamic warehousing is desired, the signal of the track sensor must be implemented. In addition, the barcodes shown in Figure 8 must be placed on the workpiece carriers, so that they can be differentiated on the basis of the three colors (white, red and blue).

The workpiece is identified by the automated high-bay warehouse using a simple barcode. The workpiece carriers have a code on them, which is assigned the color white, red or blue. This code is analyzed by a trail sensor. Here the track sensor registered light/dark differences and now these must be assigned a color.

The time interval is limited through the two light barriers before and after the identification unit. Since undesirable reflections can occur on the edges of the workpiece carriers, these must be dismissed in order to avoid false interpretations. This can be dealt with if the width of the light areas (reflective points) or the number of sequential time increments are interpreted as light. So then, for example, the light areas which include more than five sequential time steps can be evaluated as marking, and those which have less than five sequential time steps as reflection. Thus, the defined minimum width limits the number of patterns to be distinguished which can be used to identify the workpiece, but it is sufficient for coding the three colors.

Figure 5:
Color codes



Source: Fisher Technik

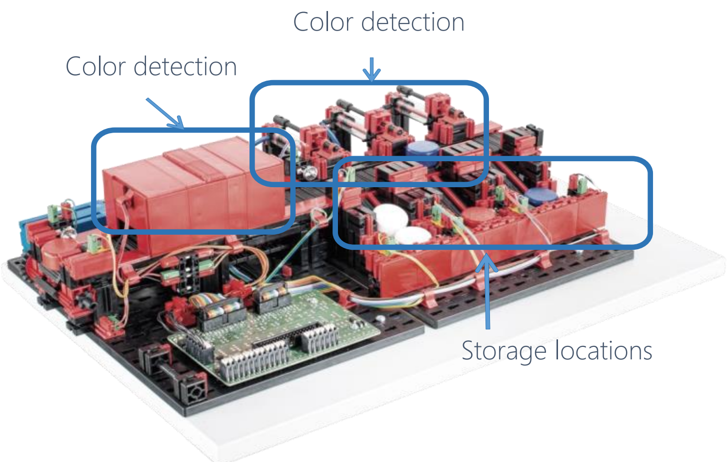
Figure 5 shows the assignment between the codes used and the respective colors. These marks are applied to the workpiece carrier side facing the trail sensor, thus allowing assignment of a workpiece carrier to a colored workpiece.

In the factory simulation the vacuum gripper robot (VSG) is the interface to the other models. Here the vacuum gripper robot is to pick up the workpieces from the storage locations of the sorting line with detection and transport them to the "Conveyor system with identification" of the automated high-bay warehouse (HRL). The VSG should first pick up the workpieces from the first storage location (white), until the light barrier located there indicates that there is no more workpiece in the storage location. After this the other workpieces should be picked up in the same manner. It should now place the workpieces in the ready standing workpiece carrier on the conveyor system with identification. If all 9 workpieces (3 white, 3 red, 3 blue) are stored in the high-bay warehouse, they should be taken out of storage sequentially and brought to the multi-processing station. For this the VSG should remove the workpieces from the standing ready workpiece carries, transported to the "oven" of the multi-processing station and there placed on the extended oven slider. After the workpieces in the sorting line have been sorted according to color, the vacuum gripper robot should transport these back to the high-bay warehouse.

3.4. Sorting Line with Detection

The sorting line with detection is used for the automated separation of differently colored building blocks. In this process, a conveyor belt conveys geometrically identical, yet differently colored components to a color sensor, where they are separated according to their color. The conveyor belt is powered by an S motor and the transport route is measured with the help of a pulse switch. The ejection of workpieces is handled by pneumatic cylinders, which are assigned to the appropriate storage locations and are actuated by solenoid valves. Several light barriers control the flow of the workpieces and whether the workpieces are in the storage locations.

Figure 6:
Areas of the sorting line with detection



Source: Fisher Technik

During this process, color detection is handled by an optical color sensor, which emits a red light and can detect their color based on a surface reflection. Technically speaking, the color sensor is therefore a reflective sensor which indicates how well a surface reflects light. The sensor's measured value is therefore not proportional to the wavelength of the measured color and even the assignment of color coordinates or color spaces (e.g. RGB or CMYK) is not possible. In addition to the object's color, ambient light, the surface of the object and the distance of the object from the sensor influence the quality of the reflection. For this reason, it is imperative that the color sensor is protected from ambient light and the surface of the objects are similar. In addition, it is important that the sensor is installed perpendicularly to the object's surface. Threshold values that limit the measured values of individual colors differentiate between the colored workpieces. Since the value ranges of different color sensors differ, these limit values must absolutely be determined.

The process should be started, and the conveyor belt switched on as soon as a workpiece is transferred from the processing station to the conveyor belt of the sorting line and in the process interrupts the light barrier. For the color detection the workpiece runs through a darkened sluice, in which a color sensor is installed. During this time interval the color should be measured, and the workpiece assigned. Meanwhile, the measured value should be compared with two limit values to assign the workpiece the color white, red or blue. While the first limit value (for example "limit1") can be used to distinguish between white and red, the second limit value (for example "limit2") can be used to distinguish between red and blue. These limit values must be determined with the aid of tests. Ejection can be controlled with the help of the light barrier located before the first ejector. Depending on the color value detected, the corresponding pneumatic cylinder can be triggered with a delay after the light barrier is halted by the workpiece. This is where the pulse switch comes in, which senses the rotation of the gear wheel driving the conveyor belt. Unlike a time-dependent delay, this approach can withstand disruptions in the conveyor belt speed. The ejected workpieces are fed through three chutes to the particular storage locations. Simultaneously, the storage location, which is found closest to the detection is assigned the color white, the center the color red and the furthest away the color blue. The storage locations are equipped with light barriers that detect whether the storage location is filled or not. However, the light barriers cannot tell how many workpieces are in the storage location.

From this storage location the vacuum gripper robot can now pick up the workpiece once more and transport it to the high-bay warehouse to store it there again.

The Logistics Laboratory enables the simulation programming of the Fischer factory too. The PLC-s are intelligent industrial controlling systems which make sure that the same device (hardware) fulfils several controlling duties according to the uploaded program. This is a very important aspect, if we think of the fact that the present market requires that a product or a technology producing a product should be flexible, meeting the customers' demands. This means that, if the production technology of a product must be changed, one does not have to buy a new controller by all means, but it is enough to reprogram the already existing one according to the new procedure. This procedure does not function in case of the traditional wired controls, or it can only be solved in a very complicated way. Consequently, the designers of the modern control systems rather use the PLC-s which are getting cheaper and cheaper. The name originates from the Anglo-Saxon naming of Programmable Logic Controller. After the German literature, SPS (SpeicherProgrammierbar Steuerung) or PEAS (Programmierbar Eingang-Ausgang System) AR simulations are also used.

4. AR Simulations

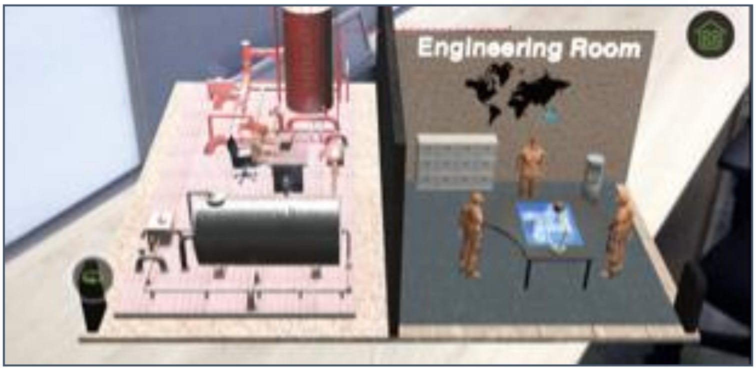
The Laboratory has several AR simulation possibilities which – just like the Fischer industry 4.0 production simulation – also strongly develop the digital competences of the students. Such AR simulation systems are going to be introduced which used by all modern Digital Logistic, AI conferences, workshops and in the smart industrial environment.

Digital twin

The basic idea is that with the assistance of the internet of the subjects we can create the digital twin of the physical client based on the data of the parts of the device and the measurements of further sensors. The digital twin in the cloud enables many new functions and solutions, for example the predictive analysis. If we combine it with the software warehouse in the cloud, the digital twin can also support the development of the new applications. Its main advantage for the developers of the applications is that they do not have to switch to the client and download the data. Instead, they run the applications in the safe sand box created in the cloud and regulate the data access of each application. Since, the applications do not run on the client but just in the cloud, the sand boxes can decrease the safety risks.

Finally, this approach cuts down on the development costs dramatically, so, one can develop new applications for the internet of the objects with the speed that is expected in the days of clouds. A good example is a vehicle safety application that is based on the usage habits: instead of building a cheap telematics unit into the vehicle of each client, the application can be run in the cloud and with the assistance of the digital twin the individual driving points of the driver can be calculated in real time (Figure 7 and Figure 8).

Figure 7:
Digital twin in the factory in AR 1.



Source: own illustration

Figure 8:
Digital twin in the factory in AR 2.

Source: own illustration

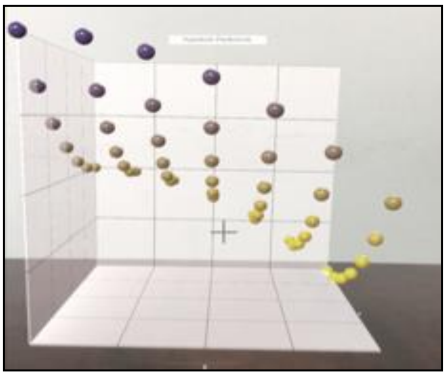
4.1. Graphmented

Create stunning charts and dashboards using augmented reality and share it live in AR with your colleagues. Graphmented transforms your desk and walls into a dashboards workstation. Drop sheets, charts, presentations and website shots on your desk or walls as if they were real objects and make use of your whole room. With Graphmented you can:

- Show your charts as never before;
- Record stunning videos of data and 3D charts exploration;
- Stream the app to screens, projectors or Apple TV through Quicktime;
- Supports data CSV, Excel files, and Google Sheets;
- Supports PDF Presentations;
- Share your dashboard live as if were magically in the air;
- Supports adding screenshots from any website to the dashboard;
- Place dashboards on horizontal or vertical surfaces, or even show dashboards without any surface.

Graphmented establishes a new era for dashboards. We have tons of features in our pipeline, so please don't hesitate to send us your feedback and leave us a review. This is the fuel that will keep us adding more great features.

Figure 9:
3D diagram in AR



Source: own illustration

4.2. Virtual Factory

Step into the exciting world of industrial innovation and digital reality with the Internet of Rubber Ducks! See a smart factory come to life through Deloitte Digital's Virtual Factory app, an interactive demonstration of real-time problem-solving that can uncover hidden value in the factory with Internet of Things-enabled technology.

Using an example production line for rubber ducks, the in-app augmented reality experience allows you to see firsthand how pairing industrial assets and systems with IoT sensors and gateways can enable a digital supply network and unlock measurable value across an entire production system.

Open the app, download the Target Image, then point your mobile device camera at indicated markers to begin optimizing your factory today.

Figure 10:
Virtual i4.0 factory in AR

Source: own illustration

4.3. AR Smart Factory

Welcome to the next industrial revolution, where machines communicate with technicians and assembly lines offer insights through meaningful data. We invite you to explore our interactive factory, where you can learn more about IIoT systems and how TE sensors are building the future of manufacturing. Follow the instructions below for the TE AR Smart Factory experience:

1. Download the free TE AR Smart Factory app on your AR-compatible iOS device;
2. Open the TE AR Smart Factory app;
3. Point your device's camera at a horizontal surface that has stable and moderate lighting;
4. An AR model factory will appear on your screen;
5. Explore the model factory by tapping the areas along the right side of your screen;
6. Move your device around to zoom in/out and focus on the different areas.

Figure 11:
AR Smart Factory

Source: own illustration

4.4. Augmented Workstation

Take a look at one of our example configurations or configure your own robot cell. Thanks to the ARCore, you can place and rotate the robot cell freely in the room, or even adjust its configuration afterwards. Test how the Advanced Robotic Workstation fits into your production and simply change individual components as needed. To see your chosen robot moving, start the simulation. Augmented Workstation saves your last configuration so you can reload your last state when you restart the app. To load a configuration from the ESSERT Online Configurator, simply use the integrated QR code scanner and scan your generated code from our website. Useful tips for placing: When placing the workstation, ensure good lighting conditions and a textured background. If you have a monochrome floor without a pattern, use an artificial marker. For example, put a flat book on the destination or put a cross on the floor to give the app a visual anchor. Point your camera from the hips to the ground until it creates a white grid. The robot cell can be placed on this surface. Enlarge the grid by filming more floor space. Then tap in the grid where you want to place the Advanced Robotic Workstation. As our workstations become more configurable, you will always be kept up to date in this app.

Figure 12:
Augmented workstation

Source: own illustration

4.5. Torch AR

Start designing in 3D in minutes. Design and share augmented reality experiences with no special equipment or skills.

Built especially for mobile product designers who want to start adding AR features to existing apps or design new, standalone experiences, Torch's familiar gestures and tools make it easy for you to use your existing skills to design 3D experiences without prior 3D knowledge.

Place objects in space, modify their properties, add complex interactions, run through the entire prototype in Play mode, and invite friends to collaborate in real-time – all without ever leaving 3D.

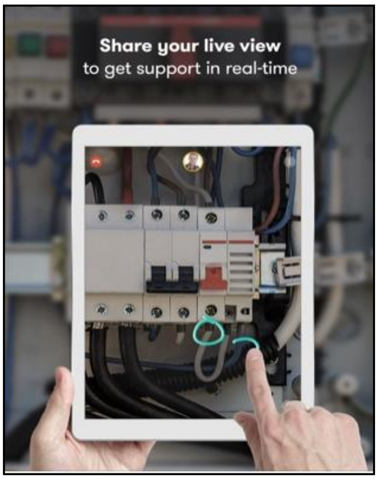
Design on the device. Build prototypes that take advantage of ARkit features. No need to constantly switch between desktop, headset, and device.

Work together in real-time from anywhere. Share for feedback with any device.

Torch's interactions system lets you go beyond simple AR sticker apps to build powerful multi-scene augmented reality experiences that engage and excite.

Add 2D files and 3D models with a simple gesture. Add complex interactions with a few taps. All without code or prior 3D experience.

Figure 13:
Torch AR



Source: App Store – Torch AR

4.6. Chalk Vuforia

Vuforia Chalk facilitates AR remote assistance between your experts and field technicians. It's an easy way to solve complex or unfamiliar problems.

Your organization can benefit via reduced repair time and travel costs, as well as better knowledge transfer from an aging workforce to new employee technicians, with the devices already in their hands.

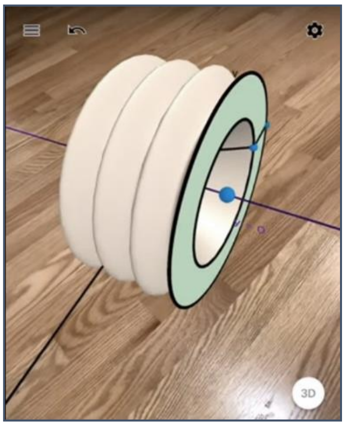
The powerful remote guidance experience of Vuforia Chalk combines live video, audio and the ability for both the remote and local participant to annotate their live shared view. Annotations in Chalk accurately stick to real-world objects, even when people move around, utilizing advanced augmented reality developed on the best-in-class Vuforia AR platform.

Vuforia Chalk enhances troubleshooting and support far beyond simple "see what I see" apps. What will you 'Chalk' first?

5. AR Product Planning

Students, having become familiar with the complex operation of the industry 4.0 factories and with the AR space with the assistance of the simulations, can use the notions and apply the different industry 4.0 methods confidently. The next step is the designing of products in the AR environment. We apply the GeoGebra 3D AR software here and the trial and student versions of CREO 6.0.

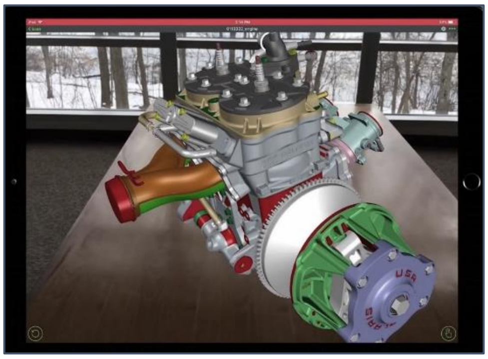
Figure 14:
Product design in GeoGebra 3d AR environment



Source: own illustration

Creo is used by thousands of leading design and production companies in the fast-changing world of product development so that they can produce better products faster. The engineers can enhance innovation with the embedded simulation to a new level and can form their ideas into connected, intelligent products with the plans controlled by IoT. Moreover, they can also communicate with their partners, customers in real-time with the assistance of the integrated outspread reality all over the world.

Figure 15:
Product design in the Creo 6.0 AR environment



Source: 3HTi – Creo 6.0

PTC started the renaissance of design. The companies create their products digitally and all over the world several thousand of companies turn to Creo in order to apply the real-time simulation, additive production supporting design and the safe, cloud-based extended reality that involve people in the processes.

Creo Simulation Live, that has been announced lately, provides a real-time feed-back on the results of the design decisions that enable the design controlled by the integrated simulation. Creo Simulation Live is a simulation that is fully integrated into the Creo, modelling the environment which software is quick as lightning and easy to use, it can yield results within seconds because it runs in the background. The designers can iterate faster from now on, they can detect the problems quicker, make their working processes less complicated, cut their costs, try several versions and they can design better products faster.

AR improves the design and cooperation working practices of the engineers. This cloud-based technology gives a new, effective and spectacular device into the hands of the engineers so that they can share the designs with their colleagues, partners and suppliers safely. A Creo AR Design Share is accessible in every workplace, the designers and the producers can iterate faster, they need less prototypes and in the design juries they can share the designs clear to all. A new important function of Creo 6.0 is the AR permission management. It can even be shared with 10 models and the designs can be displayed on smart phones, tablets or on HoloLens in a more spectacular way than ever before. The AR experiences can be accessed and started with the use of links, ThingMarks™ QR codes easily.

The new version provides all those design tools which are necessary to make use of the advantages of the additive production. The users can design, optimize, validate and control the printing without leaving Creo in order to decrease the production times and defects. Creo 6.0 provides even bigger designer flexibility to create stochastic foam or function-controlled lattice structure. The designers can analyze and optimize the production orientation, thus decreasing the printing time, minimizing the need of support materials and maximizing the tray utilization. Creo 6.0 provides an extended support to the 3MF standard.

Creo 6.0 can provide productivity enhancing development in several fields. The user interface has been further refined and optimized. The use of the mini toolbars has been extended to the establishment and modification of the building elements, work became faster with the modernized building element console, and the use of the model tree became even more flexible. Moreover, significant developments have taken place in the field of designing frame structures and screwed joints, 3D drawing, caballing and basic modelling.

6. The BOSCH SAP ERP

The BOSCH company enabled students educated in the Laboratory to access the sharp BOSCH SAP ERP that can provide a fantastic learning environment. The first step is to become acquainted with the R/3 interface to the use the MM, PP modules, and the preparation of reports.

Material Master

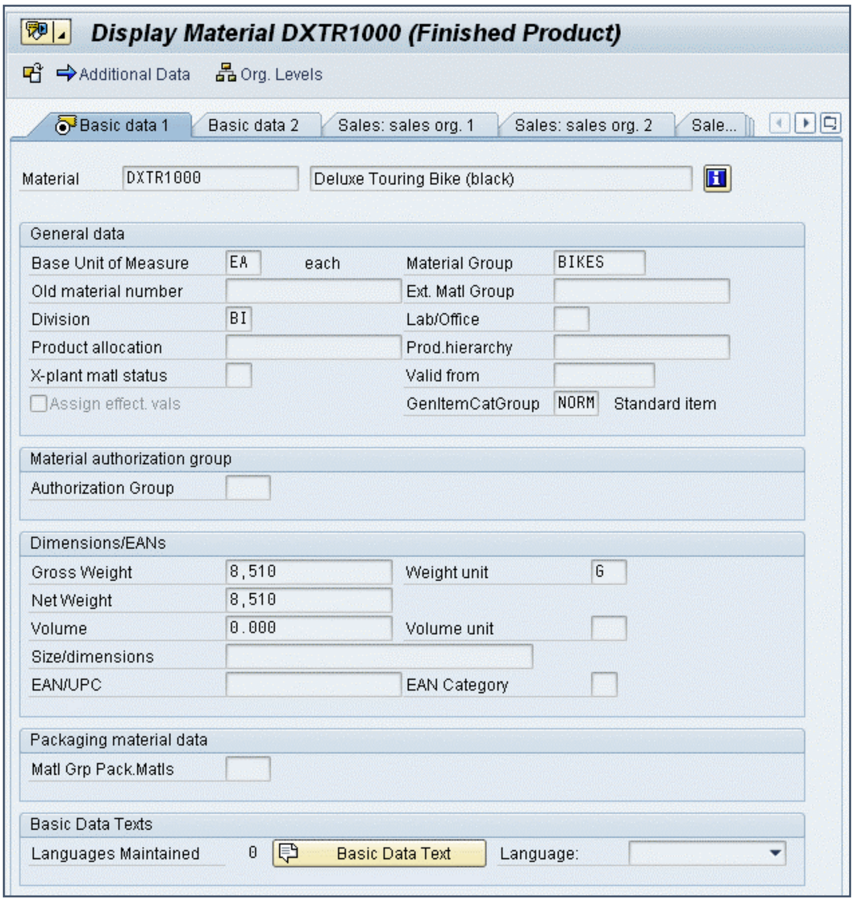
Contains all the information a company needs to manage about a material.

It is used by most components within the SAP system

- Sales and Distribution;
- Materials Management;
- Production;
- Plant Maintenance;
- Accounting/Controlling;
- Quality Management.

Material master data is stored in functional segments called Views.

Figure 16:
SAP material master record



Source: own illustration

The students work first in MM module: create, change and display raw material master records, which we will work with in the production line.

7. Production Line

By the time the students start to work on the work stations of the production line simulation, they have already learnt the above-mentioned application, adaptation of the methods, tools successfully including the operation concept of the industry 4.0 factories, technological implementations and the confident management of the SAP ERP relevant modules.

The production line of the Laboratory consists of 7 workstations and supermarkets each. Each workstation has a work description, i.e., what to do with the semi-finished product and the raw materials they received.

From the removal storage supermarket, the raw materials get to the first workstation with RFID bracelet. From here, RFID and XDK sensors can be found among each work station which watch the activities, movements of the students and, in addition, automatically register the pieces of information into the SAP ERP the data they received they are suitable for the assessment, analysis of the students' production simulation works and drawing conclusions from them (e.g. controlling the cycle times, accomplishing KPI-s, data visualizations, etc.) From the last workstation, the finished products get into the storing supermarket which we also register in the

Prod'Action system, on the slot level. On the monitor of each workstation, the students can see the pieces of information in connection with the current production on the SAP interface and other data visualization interfaces. At the end of the production cycles there is an evaluation. Then the product-number undertaking the next production cycle will be displayed on the Board. The students can make optional modifications on the production line: they can stop, fuse workstations, regroup the labor force, etc. Their main duty is to optimize the production process. The initial task is to manufacture even more from a product within a given time, optimization in three production circles. A further development is the manufacturing of several products in parallel with the lean approach and optimal fulfilment of the acute customers' requirements. Afterwards, some industrial case studies will be discussed with the involvement of the production line.

Some words about the i4.0 technological implementation:

7.1. BraceID

With more and more UHF RFID applications in today's logistics processes, an increasing number of RFID tags have to be scanned. Using traditional handheld scanners is not always an optimal solution. Many devices are bulky and require at least one free hand for operation. With the BraceID RFID Bracelet from metraTec there is an alternative that doesn't stop the work process. With this wearable device you can scan UHF RFID transponders seamlessly during normal handling operations. With a weight of less than 120g you can carry this device on your arm without operator fatigue. The RFID scan is activated via an integrated touch sensor or can be completely controlled from the software side. The bracelet has an integrated UHF RFID module and an energy efficient wireless communication module that transmits all scan data to a nearby gateway station. This keeps your WiFi network free from IoT data and lets the battery run for more than 2.000 scanning events. Besides the pure scanning functionality, the bracelet can provide users with instant feedback after each action via three color LEDs, a vibration alarm or an integrated buzzer for acoustic feedback. The main module of the device can be separated from the base, so multiple users can share the same device. Applications:

- Identification of boxes in short time;
- Controlling picking steps;
- Optimization of warehouse processes.

7.2. RFID

The point of the RFID technology is the communication of the radio transceiver unit with the RFID labels on the observed object. The communication happens automatically, even without human intervention.

This way, it is unnecessary to read every single package, the system can read the labels of the products crossing the reading gate all at once and upload them into the data base. The labels can be used again which increases the economical character of the RFID identification system, too.

There are three versions of the RFID label, also known as RFID tag or RFID transponder:

The passive RFID label without own power supply unit receives the energy that is necessary to the operation from the electromagnetic space generated by the reading device. This is the smallest and easiest RFID label type.

The partially passive RFID label has the minimal power supply unit and is able to collect the data continuously and then to convey them to the identification points. For example, measurement of the environmental temperature.

The active RFID label operates with a battery, and its signaler is able to send and receive information even from a big distance. The battery can even keep its working ability for 5 years, depending on the reading frequency.

The RFID label can be placed on the product directly or on the package, although we can find this type of labels in the plastic cards of the entering control system, too. The RFID reading unit communicates with the labels through radio waves. The RFID reading unit is connected to the computer or in the IP network to the server that is responsible for the control of the system which filters and transmits the data received in the data base. The data can finally get into the company control or logistics system.

The application or server that controls the RFID system usually performs the following operations:

- Identifies the content of the consignment;
- Controls the number of pieces;
- Compares the pieces ordered and those that were read;
- Filters out the faulty items;
- Indicates, if any item ordered is missing from the package;
- Transmits the data for invoicing.

The number of uses is endless.

Owing to their complexity the RFID systems take important positions on many professional areas. Each professional area has its own requirements, solutions. The RFID systems can perfectly be adjusted to the operation processes.

7.3. XDK

With the new XDK sensor platform, Bosch can offer a complex hardware and software platform with different types of sensors and Bluetooth and WLAN connections. An acceleration and rotation sensor, a magneto meter and sensors that are suitable for the measurement of volume, humidity, air pressure, air temperature and light are all components. The companies can develop their own big or small IoT-solutions by using the data.

7.4. Active Cockpit

Processing and visualization of production data in real time

Efficient production processes require continuous improvement. It is essential for error prevention and improvements to provide quick access to consistent data. This allows rapid reaction with minimal effort on the production line at the company.

With ActiveCockpit for production you have all the relevant data directly on the line

As an interactive communication platform ActiveCockpit processed and visualized production data in real time. ActiveCockpit networked IT applications such as production planning, quality data management and e-mailing with the software functionality of machines and plants. The information is the basis for decisions and process improvements.

Advantages resulting from special product features:

- All relevant information available to everyone in real time directly on the production line;
- Intelligent networking saves information processing time;
- More efficient improvement processes through clear analysis and conclusive task definition with ActiveCockpit.

Industry 4.0:

- Real-time collection, processing and visualization of all relevant data of a manufacturing facility for the exchange of information between people, machines and production process on the shop floor;
- Interactive software for the diagnosis and optimization of machines and processes, and disorder management;
- Browser-based Internet standards and openness to third-party applications;
- Easy connection to back-end systems (MES / ERP).

Customer benefits and advantages

Higher productivity through continuous, digital supported process improvement, integrated disorder management and a higher resource efficiency through improved planning.

By current and consistent key figures, decisions can be made quickly and efficiently on the shop floor.

- Saving time and failure prevention by direct connection to any back-end systems (ERP, MES);
- Customer specific apps can be integrated as a widget;
- Communication and information tool for employees at all levels;
- Structured and recorded team meetings;
- Customer-oriented configuration thanks to an intuitive web application;
- Save time by automatic login function;
- Space-saving.

Basic functions

PUBLIC AREA

- All relevant data available digitally on site;
- Information from different file formats can be displayed (e.g. As Excel, PowerPoint, video);
- Available for all employees.

VIEWS

- Fast compilation of data and documents, for example for improving rounds;
- Individual user management, for example read, modify, delete;
- Information can be displayed and used across departments. Documents are updated by Desklink;
- Filtering and presentation of relevant information, without changing the original file.

MEETINGS

- Operators can assign own names for each plant;
- Meeting documentation with freely selectable elements and customizable structure;
- Automatic report generation with all relevant information and annexes to the discussed topics.

NOTE PAD, WHITEBOARD FUNCTIONALITY

- Note function for communicating with colleagues or for escalation in the round;
- Annotation function via touch screen to highlight, annotate directly to ActiveCockpit;
- Show and transmit relevant information. (In disorders e.g. a photo can be taken by tablet and forwarded directly to ActiveCockpit).

Q- AND S-WIDGET

- Register and manage quality and safety deviations;
- Displaying the current status with a large Q (for quality) or S (for safety);
- Overview Quality or Safety Status per year;
- Values can be transmitted via Industry 4.0 interface back in ERP MES.

Additional functions – Industry 4.0 interface

INDUSTY 4.0 INTERFACE

- networked in real-time with ERP and MES-backend-systems through standardized connection to your existing systems;
- Customer specific definition of relevant data and connection possibility for easy and safe access.

FUTURE-PROOF THROUGH APPS

Bosch Rexroth offers numerous additional functions apps such as:

- Deviation Management: Registration and processing of deviations. These measures are defined in the ActiveCockpit and passed on the industry 4.0 interface MES and ERP;
- Table: presents your data clearly and intuitive to track processes optimally and detect deviations at an early stage;
- Personal deviation: for interactive creation of employee capacity schedules on the assembly lines;
- Process Quality Manager: Detect and avoid deviations in the production process as soon as possible.

WEBFRAME

Fast integration of apps, even third-party apps.

CUSTOMER SPECIFIC SERVICE

Bosch Rexroth offers its customers project specific services, such as the creation of a value stream designs.

Data Security

- All data incl. E-mails are encrypted and transmitted via SSL;
- Application uses methods of "defensive programming", which checks all entries in advance;
- A defined role and authorization concept regulates the access to the system and prevents errors during data entry;
- All passwords are encrypted stored in the data base to prevent spying in the case of a compromised database. All user entries are checked for correctness and malicious code;
- Indirect database queries avoid possible attacks ("SQL injection").

8. AR Supported Workplace Environment

Not only simulation and finish-product design are realized with the AR technology in the Laboratory, but the university lecture notes belonging to the Laboratory are AR supported, too. This means that in case of the pages of the printed lecture notes the relevant pieces of information are underlined and clicking on the pictures the relevant videos can be played. If you look for certain expressions you can directly go to websites, diagrams, and numerous other objects are also available in AR environment in real-time.

Moreover, if you enter the Laboratory, numerous AR elements can also be found: the teaching posters on the wall come to life, arrows and superscriptions help the orientation in the Laboratory and the function of the device and the course of education can also be determined, so that the orientation in time and space takes place in AR, as in a Smart Warehouse, too.

All this shows the wide range of possibilities, which the AR technology can provide and, last but not least, it gives a strong motivation for the participating students.

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