The use of real-time location system in hybrid assembly

Milan Martinkovič [1], Branislav Mičieta [1], Vladimíra Biňasová [1]

[1] University of Žilina, Faculty of Mechanical Engineering, Department of Industrial Engineering
Univerzitná 1, 010 26 Žilina, Slovakia
milan.martinkovic@fstroj.uniza.sk
branislav.micieta@fstroj.uniza.sk
vladimira.binasova@fstroj.uniza.sk

Annotation: Industry 4.0, known as the Digital Revolution, aims to transform traditional manufacturing systems by integrating physical and virtual worlds. In these systems, everything is connected to machines, tools, and workers to products and customers. This will be achieved by Industry 4.0's transformation technologies. One of these technologies is the Industrial Internet of Things (IIoT), which is based on the support technology - Real-Time Locating Systems (RTLS). This system is used for automatic identification and tracking of objects that are marked with tags. The combinations of the RTLS with the control computer and the mobile collaborative robot are created new possibilities in hybrid assembly.

1 Introduction

Currently, the Industry 4.0 is being implemented in practice, which refers to a new phase of the Industrial Revolution that focuses in particular on the interconnection of automation, machine learning and real-time data. Industry 4.0 comes with technologies such as the Internet of Things (IoT), virtual and augmented reality, autonomous robotics, which allow us to create a seamless human-machine, machine-machine connection and take production to a whole new level of possibilities. One of the pillars of Industry 4.0 is the Industrial Internet of Things (IIoT), which links production resources to communicate with each other or communicate with applications or services by information networks. IIoT impacts on the creation of a digital manufacturing workplace. By creating such a workplace is required an intelligent system that can collect data from these production sources. This system is called Real-Time Location System (RTLS) and is used to map, track and collect factory data.

RTLS is based on radio frequency identification (RFID) and Ultra Wide Band (UWB) to precisely locate and identify forklifts, AGVs (Automated Guided Vehicles), mobile robots and operators in real-time throughout the production hall. Using sensors (IIoT) is collected data, and the RTLS analyses the operation to identify and eliminate workflow weaknesses, resulting in time and financial savings [1,2]. The RTLS system shows a great application perspective in every area, especially in the supply chain, manufacturing,

https://doi.org/10.24132/PI.2019.08948.101-108

business processes and warehouse operations. This platform is mainly used in manufacturing, internal logistics and warehouses. The reason for creating this intelligent system is the concept of Industry 4.0 and Smart Factory because it collects, processes and evaluates data in real-time [2].

2 Transformation Technologies in Industry 4.0

The new Industry 4.0 (digital concept) is a transformation that allows data to be collected and analysed across machines. This creates faster, more flexible and efficient production processes and the results are quality products, reduced costs. This manufacturing revolution will increase productivity, change the economy, boost industrial growth and change the workforce profile, that ultimately change the competitiveness of the market. Advanced digital technology is already used in manufacturing, but with Industry 4.0, manufacturing is transforming. This will lead to greater efficiency and a change in traditional production relationships between suppliers, manufacturers and customers, as well as between human and machine. Nine transformation technologies are the basic pillars of Industry 4.0, which are shown in Figure 1 [3,4].

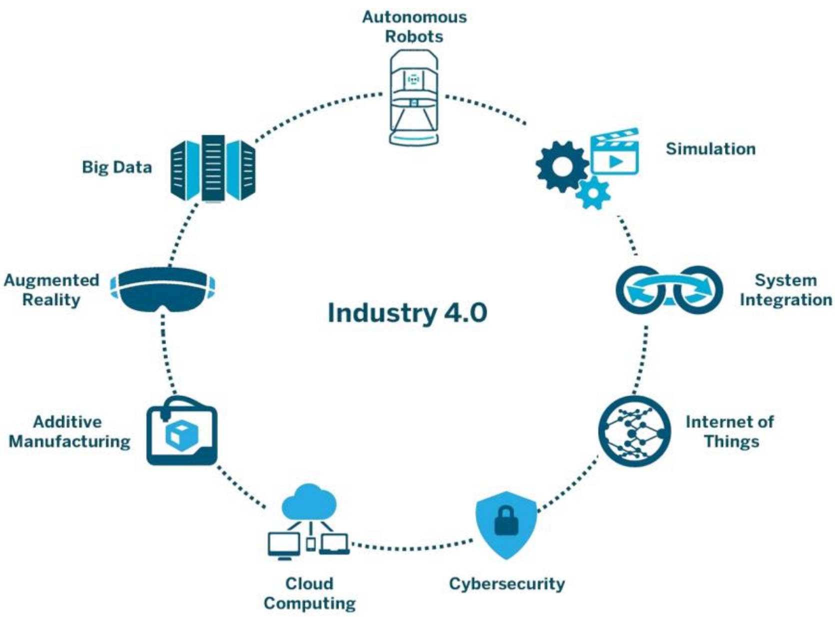

Figure 1 – Nine transformation technologies

2.1 Industrial Internet of Things (IIoT)

IIoT refers to billions of industrial equipment, from factory machines to aircraft engines, which are filled with sensors connected to wireless networks to collect and share data. The application of small, low-cost sensors and high-bandwidth wireless networks means that even the smallest devices can be connected in order to the level of digital intelligence. This intelligence allows devices to be tracked and monitored, and they can also share their status and communicate with other devices.

All this data can then be collected and analysed to streamline business processes. The use of IIoT can significantly improve connectivity, efficiency, scalability, time and cost savings for industrial companies. Companies are already taking advantage of IIoT through cost savings due to predictive maintenance, increased safety and other operational effects. Intelligent IIoT networks allow industry companies to break open data silos and connect all of their people, data and processes from the factory to executive offices. Manager can use the IIoT data to get a full and accurate overview of how their business is doing, which will help them make better decisions [5]. When creating a workplace using IIoT, you need an intelligent system that will collect data from anything that has been labelled with sensors. This is used by the support technology of RTLS.

3 RTLS as support technology for IIoT

As described in the introduction, RTLS provides knowledge of the exact position of all equipment in the manufacturing facility and, based on previously collected data, enables analysis, identification and correction of work process shortcomings, what can save time and costs. This platform consists of active UWB tags, UWB anchors and RTLS server in which running positional software (Figure 2) [6].

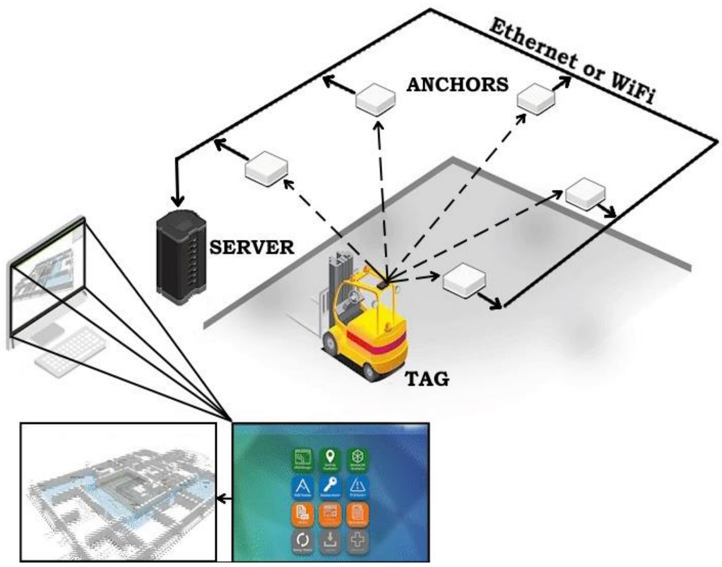

Figure 2 – The RTLS system

The individual elements (RTLS parts) are as follows:

- **UWB -** is ultra-wideband impulse digital transmission and it is a wireless technology that is used to transfer large amounts of digital data over a wide spectrum of frequency bands with low power for a short distance. UWB utilization is possible in positioning using the signal arrival time difference, thereby obtaining the distance between the reference point and the end point. The advantage of UWB is the transfer of a huge amount of data over a distance of up to about 70 meters at low power. Another advantage is the ability to transmit signals through doors, walls and other obstacles that have the ability to reflect the signal [6].

- **UWB anchors -** placed mostly on walls and represent the coordination system needed for accurate position estimation. The coordination system is present in RTLS servers and contains three coordinates (X, Y, Z), with the anchors being installed in a group and the recommended distance between them is 20 meters (depending on the particular company). Putting the anchors into service is easy thanks to the possibility of setting the IP address. Also, these devices are accessible via the HTTP interface, allowing their functionality and parameters to be checked (anchors are installed) [7].
- **UWB tags -** at regular intervals, these tags carry the UWB packet that is received by the surrounding anchors. Tags can be powered by battery or external power. The signal transmitted by the tag penetrates through non-metallic materials but in the case of concrete walls or floors it may be impacted or absorbed. Direct visibility between tags and anchors is required for proper operation. The UWB tag has a range of approximately 30 meters. Tags are broken down by use into traffic, personal and active [8].

  In addition to UWB, the following types of wireless technologies can be used for communication between anchors and tags: WiFi, GPS, Infrared interface, Bluetooth and RFID systems (active or passive). In companies, the most common use is WiFi, Bluetooth and the UWB described above (range 100 m). In the case of data collection from the whole enterprise, it is possible to divide the enterprise into parts and use the described technologies or use the Lora, Sigfox technologies, which range from 2 to 15 km [9].
- **RTLS server -** receives UWB packets using Ethernet or WiFi network, which were previously processed by UWB anchors. The server includes positioning software, which processes data and informs about the positions of objects in real time using a 3D model and stores the coordinates in a MySQL database [10].

4 Hybrid assembly

Hybrid assembly is a combination of manual assembly and automated assembly. Hybrid assembly is characterised as a close connection between human and robot in cooperative (in the future collaborative) assembly activities that exploit the strengths of both sides.

The classic automated assembly system has its specific advantages such as operation without breaks, fatigue, resulting in high productivity for simple assembly tasks. In the past, the flexibility of automated systems has been limited due to the complexity of programming, and capabilities in complex handling and assembly operations are also limited. However, with the gradual implementation of Industry 4.0, the flexibility of these systems increases. In terms of manual assembly, human provides incomparable sensorimotor capabilities in complex handling operations, adapts quickly to new assembly procedures, but is limited in performance and accuracy. Hybrid assembly uses human and robotic capabilities to the best possible extent in an assembly system in which tasks are gradually divided between human and robot [11, 12].

One of the main components of the hybrid assembly is a collaborative robot that manipulates objects in cooperation with humans. A collaborative robot performs tasks that cannot be fully automated (delivering components to a worker) and assists a person in challenging, complex and repetitive activities, protecting the worker from health problems and accidents at work. At present, hybrid assembly involves human-robot cooperation, which means that human and robot are working on their assembly tasks, but not on the same product or on the same part of the product [13]. In hybrid assembly, there are currently stationary collaborative robots that are placed where they are needed (moving products from one conveyor to another). The disadvantage of these robots is the lack of mobility. When it is necessary to use the robot in multiple positions of the assembly workplace, companies use mobile robots (Figure 3).

Figure 3 – Mobile robot

Mobile collaborative robots are a combination of AGV and collaborative robots. The advantage of these robots is that they can operate individually or in groups, have a high level of autonomy, shorter reconfiguration times and easier commissioning of the robot. Mobile robots move thanks to different kinds of navigation technologies (magnetic tape, laser navigation, visual navigation, natural navigation). These technologies ensure the safe and correct movement of the mobile robot in the assembly system. Also, the mobile robot is equipped with safety elements (sensors) that create a safety zone around the robot. If there is an obstacle in the safety zone, the robot slows down and then stops.

4.1 Use of RTLS in hybrid assembly

In hybrid assembly, the RTLS system is used to locate and identify robots, process pallets, components, products, tools, forklifts and in the near future, people, too. Companies that use RTLS to track production are beginning to use the RTLS concept associated with a control computer (brain placed in the AGV) as a new way of navigating AGV (mobile robots) or mobile collaborative robots.

Among the companies involved in the production and application of RTLS system is also the company Kinexon, which created the control computer Kinexon Brain. This “brain” in conjunction with RTLS allows the mobile robot to navigate freely and flexibly even in harsh industrial environments, allowing for dynamic material and workflow. This type of navigation is based on accurate and robust localisation using UWB (3 RTLS as a support technology for IIoT) and Kinexon sensor network, which provides integrated two-way communication and navigation with one system [14,15].

In hybrid assembly, tags are used to label assembled products, operators, mobile collaborative robots, tools or machines. Position software in the RTLS displays the position of all selected objects. Mobile collaborative robots are equipped with sensors, 3D cameras and navigate the assembly site using RTLS and the control computer. Sensors and 3D cameras monitor their surroundings for the occurrence of an obstacle that is not tagged;

The operator can program positions and routes for a mobile collaborative robot, or can send it to a position when it is necessary. In the software, the operator can see the 3D model of the assembly workplace and the positions of all selected objects. If it is necessary move the robot to the required position, the operator enters the name of the position and the robot uses software (data from UWB anchors), sensors and 3D cameras to navigate while checking the route it travels. 3D cameras also serve to identify an object (shape of an object) so that the robot can grab it. If sensors are used in assembly workplaces, the software can be used to check not only the position of the material, robots or machines but also the quality of the product to be assembled or tool wear and machine failure (maintenance).

5 Conclusion

In this paper, the theoretical knowledge from the area of RTLS (system elements and their functioning), manufacturers of RTLS and hybrid assembly (human-robot cooperation, collaborative robot, mobile collaborative robot) was processed.

It has been found that by combining the RTLS system with a control computer (Kinexon Brain), the AGV can navigate freely and flexibly even in challenging conditions. In terms of application, this technology could be used to navigate mobile collaborative robots in hybrid assembly, thus becoming autonomous and adaptive. The advantage would be to move safely around the assembly workplace and, using multiple sensors, it would be possible to monitor the position of the material, robots or machines, the quality of the assembled product or tool wear and machine failure (maintenance). This knowledge being used for the elaboration of the dissertation thesis, which deals with the research of possibilities of optimisation of assembly processes in connection to adaptive assembly.

Acknowledgement

This paper was created with support of project KEGA no. 022ŽU-4/2018.

References

[1] Real - time location system in industry [online]. Sewio Networks, 2019, [cit. 7. 8. 2019], https://www.sewio.net/rtls-in-logistics/

[2] Kocevar, E. Identec solutions is equipping 20 production facilities of one of the world's largest automotive suppliers with a real-time localisation solution [online]. IDENTEC SOLUTIONS AG, 2019, [cit. 7. 8. 2019], https://www.identecsolutions.com/home/products/newsroom/rtls-system-for-large-automotive-suppier/

[3] Embracing Industry 4.0 and Rediscovering Growth [online]. Boston Consulting Group, 2019, [cit. 10. 8. 2019], https://www.bcg.com/capabilities/operations/embracing-industry-4.0-rediscovering-growth.aspx

[4] Herčko, J., Fusko, M., Kotorová Slušná, Ľ. Concept of the Factories of the Future in Slovak industrial companies. In: *Mobility IoT 2018 – 5th EAI International Conference on Smart Cities within SmartCity360° Summit*, November, 2018, s. 21-23.

[5] What is IIoT? [online]. Inductive automation, 2018, [cit. 11. 8. 2019], https://inductiveautomation.com/resources/article/what-is-iiot#

[6] Rouse, M. Ultra wideband [online]. TechTarget, 2008, [cit. 11. 8. 2019], https://whatis.techtarget.com/definition/ultra-wideband

[7] UWB Anchors [online]. Sewio Network, 2019, [cit. 11. 8. 2019], https://www.sewio.net/uwb-anchors/

[8] Precise Indoor Positioning is finally here thanks to Ultra-wideband RTLS [online]. Locatify, 2017, [cit. 11. 8. 2019], https://locatify.com/blog/in-practice-precise-indoor-location-detection-with-uwb-ultra-wideband/

[9] Industry 4.0: Asset Track and Trace [online]. Advanced Solutions Nederland B.V., 2018, [cit. 11. 8. 2019], http://www.advsolned.com/industry-4-0-asset-track-and-trace/

[10] RTLS – Real Time Location System [online]. KODYS Slovensko, 2019, [cit. 11. 8. 2019], https://www.kodys.sk/rtls-real-time-location-system

[11] Krüger, J., Lien, T. K., Verl, A. Cooperation of human and machines in assembly lines. In: *CIRP Annals-Manufacturing Technology*, 2009, vol. 58, s. 628-646. ISSN 0007-8506.

[12] Tsarouchi, P. et al. On a human-robot collaboration in an assembly cell. In: *International Journal of Computer Integrated Manufacturing*, 2017, vol. 30, s. 580-589. ISSN 0951192X.

[13] Hohmann, CH. Cobots: more cooperation than collaboration [online]. Fraunhofer, 2017, [cit. 11. 8. 2019], https://hohmannchris.wordpress.com/2017/02/08/cobots-more-cooperation-than-collaboration/

[14] The Kinexon Brain: Intelligence for the smooth running of all intralogistics vehicles [online]. Kinexon Industries, 2019, [cit. 11. 8. 2019], https://kinexon-industries.com/product/brain/

[15] Krajčovič, M., Furmann, R. Navrhovanie výrobných a logistických systémov s podporou moderných počítačových technológií. In: *ProIN* 18–1a, 2017, s. 27–32. ISSN 1339-2271.