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IMPLEMENTATION TECHNOLOGY OF AUGMENTED REALITY IN RAILWAY FREIGHT TRANSPORT IN SLOVAKIA

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Abstract

The technology of augmented reality is often confused with virtual reality and differs fundamentally. While augmented reality complements the real environment with virtual elements, virtual reality completely replaces this environment. Complicating the currently used technological process due to incorrectly or "violently" augmented reality can result in a primary prolongation or overpricing of the process, and secondarily also a reduction in the safety of employees performing the technological procedure operations in the track. The analysis of technological procedures in transport and logistics with the aim of innovating established procedures is an ongoing process not only in the present. Innovation can result in lower operating costs, increased transport speeds and adaptation to the needs of customers so that the rail sector remains competitive compared to other modes of transport. With the development of information technology in recent decades, new and new opportunities for innovative practices are gaining ground, while innovation itself is not proceeding as fast as development allows. This is for various reasons, whether in terms of operational safety or the relevance of technological progress to rail transport issues. The aim of this paper is to assess the possibilities of implementing technology of augmented reality in terms of procedures for processing sets of wagons in freight transport based on the analysis of technological procedures in rail freight transport at the Žilina - Teplička marshalling yard and characteristics of augmented reality. The implementation options are assessed on the basis of their feasibility separately in the case of the carrier, separately in the case of the infrastructure manager and finally in the simultaneous implementation in both entities. The implementation of augmented reality is always rational, which means that it must always represent a simplification, acceleration or reduction of costs in the usual technological procedures.

Keywords: technological process, railway freight transport, augmented reality

1 Introduction

Augmented reality is a virtual-real space that combines a real environment. The user is physically located with a virtual environment, which consists of elements such as two-dimensional or three-dimensional images, videos, texts or soundtracks. The type and scope of the virtual environment varies according to the type of augmented reality and the purpose of its use by specific users [1]. According to this pair of criteria, suitable technical equipment is also selected, which is used to use augmented reality. The most common are devices equipped with a camera, such as smartphones, tablets and Smart Glasses. These are glasses that are equipped with semi-permeable glasses that allow the image of the space that the user is looking at. Therefore they differ from the glasses used, for example, in virtual reality [2].

Assessment technology of augmented reality analysed Smith [3], Hall, et al. [4], and Čujan, et al. [5]. They research the usefulness of augmented reality in rail transport to improve the quality of rail services. Fedorko [6], Braud, et al. [7], Brumerčíková and Šperka [8], Cirulis and Ginters [9], and also Stopka, et al. [10], also addressed this topic, focusing on the use of augmented reality with a link to logistics processes.

2 Use the technology of augmented reality in railway transport

Augmented Reality can support rail workers with real-time information, which is particularly useful when it comes to inspecting train cars. Augmented Reality software and head-mounted devices support workers by allowing them to work hands-free while documenting with pictures, video, and voice to text, which all generate automatically into reports. This technology allows the employee to perform routine matters related to working with wagons in the track faster, more aprecisely and more efficiently [11]. The artificial intelligence installed in the software is able to identify a particular wagon by recognizing its UIC number in a predefined format. After loading a specific wagon, it is possible to start the technical inspection itself. With the help of artificial intelligence, the detected facts are recorded directly into the component of a specific wagon. In addition to voice communication, the SPACE1 system also enables image transmission between devices. The employee in the office is able to display the field of view of the employee in the track on the monitor as well as share the screen of his computer with the employee in the track. With properly chosen hardware, it is possible to replace the classic hand-held transmitter, that it is worn by railway staff at work with a communication device that is integrated into augmented reality hardware. Acceleration of individual tasks is also possible thanks to voice control of hardware of augmented reality. In the case of preparing a train composition report, it is possible to choose a technological solution that allows the employee in the track to operate in "offline" mode. The data is updated using the private network [12]. Each technological procedure in rail freight transport consists of a series of consecutive operations. These operations are arranged chronologically to create a logical and safe procedure. This will allow the most economical possible solution for relocating wagons on a specific line. However, the freight flows, the rail network and the technical means used in rail transport are not constant over time. The technology of work and the resulting technical procedures need to be innovated. These innovations are divided into two groups. The first group is the improvement of the technological procedure in terms of technical means, aids and equipment used. These will increase the efficiency of the activity or facilitate human labour. The second group includes such improvements in the technological procedure that streamline it in terms of organization and management of work related to the assembly and planning of trains on the railway network. The two groups are closely related to each other, and innovating an element in one group will often allow the element to be innovated in another [13].

3 Assessment of implementation possibilities of augmented reality in the incoming train set processing technology

The technological procedures for processing of wagon loads at Žilina-Teplička marshalling yard can be divided into four main groups - incoming trains, departing trains, transit trains with processing and work with a local wagons [14]. As part of our article, we focused on the technological procedures of handling of incoming trains. The time standards for operations were proposed for the considered train consisting of 30 Eas wagons, which will be divided on a serious hill into 10 trailers of 3 wagons. As an example, we can mention the technological procedures of processing the incoming train, that the individual operations are described in the table 1.

Table 1 Technological procedures of handling of incoming train with time data of individual operations. Source: authors, according to [15].

No.	Operation	Begin [min.sec]	Duration [min.sec]	End [min.sec]	Execute
1	Notification of employees	0.00	0.51	0.51	Train dispatcher
2	Train ensure to the station	0.51	3.00	3.51	Locomotive driver
3	Submission of documentation	3.51	11.13	15.04	Technical office clerk
4	Safety of train set, Distance locomotive	3.51	16.11	20.02	Wagon inspector/ Locomotive driver
5	Technical inspection	20.02	100.48	120.50	Wagon inspector
6	Transportation inspection	20.02	45.00	65.02	Technical office clerk
7	Notification of end inspection	120.50	0.53	121.43	Operating supervisor
8	Inspection for ŽSR	121.43	22.43	144.26	Commercial inspectors
9	Create sorting list	121.43	31.48	153.31	Operating supervisor
10	Loosening screw coupling	153.31	38.30	192.01	Shunter-preparer
11	Suspension shunting locomotive	192.01	0.54	192.55	Shunter
12	Control and conclusion sorting list	192.55	1.05	194.00	Hump yard supervisor
Together 194.00 minutes					

Based on the analysis of the currently available technology of augmented reality and technological procedures of train sets on model examples in the Žilina-Teplička station, it is necessary to find such operations in the technological procedure that it is appropriate to innovate. The proposals only provide for safe modifications of technological procedures, as part of the protection of employees at work.

3.1 Proposal of technological procedures using augmented reality by carries

The first proposal is to modify the currently technological procedures by carriers (freight railway undertaking). For operations that have been identified as suitable for innovation, the observed benefit is primarily the saving of employees' working hours. The operations that were not affected by the implementation of technology of augmented reality were left in the proposal in its original wording and time-consuming to correspond to the initial state. In the technological procedures of processing the incoming train, it is possible to implement augmented reality in the case of technical and transport inspections, respectively by connecting them into a one inspection, which replaces two separate initial inspections. Table 2 shows technological procedures of handling of incoming train, when consideres of augmented reality by carriers.

The modified technical-transport inspection is in the proposal performed by the wagon inspector which is equipped with a device for creating augmented reality. In addition to the front surfaces of the rims and the wheelsets, it also checks the correct tag of the wagons. The wagon inspector also corrects the identified shortcomings in this proposal and ensures that in case of division of a group of wagons, the first and last wagon in the group continues to be marked. Taking this into account, a surcharge was modelled for the original duration of the technical inspection performed by the master for 0.15 minutes to axle. The mark-up was obtained by expert judgment in view of the fact that this procedure is not currently applied and there are no standards by which the mark-up would be precisely determined. We

consider the 45 minutes of the technical office clerk's work to be saved. However, due to the logical and technical consequences resulting from the technological process, the slowdown of the wagon inspector will increase the total processing time of the incoming train set by 18 minutes in the case of the modelled set, which may negatively affect the performance of the marshalling yard.

Table 2 Technological procedures of handling of incoming train when considered of augmented reality by carriers. Source: authors

No.	Operation	Begin [min.sec]	Duration [min.sec]	End [min.sec]	Execute
1	Notification of employees	0.00	0.51	0.51	Train dispatcher
2	Train ensure to the station	0.51	3.00	3.51	Locomotive driver
3	Submission of documentation	3.51	11.13	15.04	Technical office clerk
4	Safety of train set, Distance locomotive	3.51	16.11	20.02	Wagon inspector/ Locomotive driver
5	Technical – Transportation inspection	20.02	118.48	138.50	Wagon inspector
6	Notification of end inspection	138.50	0.53	139.43	Operating supervisor
7	Inspection for ŽSR	139.43	22.43	162.26	Commercial inspectors
8	Create sorting list	139.43	31.48	171.31	Operating supervisor
9	Loosening screw coupling	171.31	38.30	210.01	Shunter-preparer
10	Suspension shunting locomotive	210.01	0.54	210.55	Shunter
11	Control and conclusion sorting list	210.55	1.05	212.00	Hump yard supervisor
Together 212.00 minutes					

3.2 Proposal of technological procedures using augmented reality by the infrastructure manager

A suitable operation for the implementation of technology of augmented reality from the point of view of the infrastructure manager is the creation of a sorting unit in the procedure of handling of incoming trains, on the basis of which the set will be sorted. The planned innovation is the replacement of the PSION mobile device with an augmented reality device that will be used by the commercial inspector when inspecting the wagons for ŽSR. Technological process of handling of incoming train after the implementation of augmented reality at the infrastructure manager are shown in table 3.

Data on wagon numbers, respectively their routes are obtained already during this inspection by using a device that is able to record data faster than the currently used device. Another advantage over the currently used equipment is the free hands of the employee and the elimination of his mistake due to inattention. The considered savings are 30 minutes of commercial inspector work in the preparation of the ticket and will have a significant effect on the processing time of the destination train compared to the procedure proposed using augmented reality by the carrier and also the current situation. Compared to the current situation, the length of the proposed procedure is shorter by 4 minutes and 17 seconds.

Table 3 Technological process of handling of incoming train after the implementation of augmented reality at the infrastructure manager. Source: authors

No.	Operation	Begin [min.sec]	Duration [min.sec]	End [min.sec]	Execute
1	Notification of employees	0.00	0.51	0.51	Train dispatcher
2	Train ensure to the station	0.51	3.00	3.51	Locomotive driver
3	Submission of documentation	3.51	11.13	15.04	Technical office clerk
4	Safety of train set, Distance locomotive	3.51	16.11	20.02	Wagon inspector/ Locomotive driver
5	Technical inspection	20.02	100.48	120.50	Wagon inspector
6	Transportation inspection	20.02	45.00	65.02	Technical office clerk
7	Notification of end inspection	120.50	0.53	121.43	Operating supervisor
8	Inspection for ŽSR	121.43	22.43	144.26	Commercial inspectors
9	Create sorting list	144.26	4.48	149.14	Operating supervisor
10	Loosening screw coupling	149.14	38.30	187.44	Shunter-preparer
11	Suspension shunting locomotive	187.44	0.54	188.38	Shunter
12	Control and conclusion sorting list	188.38	1.05	189.43	Hump yard supervisor
Together 189.43 minutes					

3.3 Proposal of technological procedures using augmented reality by the carrier and the infrastructure manager at the same time

The third proposal is aimed at the simultaneous implementation of all the measures proposed in the previous two points so that it is possible to achieve even higher savings in standard hours of staff work, in this case with the infrastructure manager.
The inspection for ŽSR, which is performed in the initial state after the inspections of the wagons by the carrier, is replaced in this proposal by the technical-transport inspection of the carrier. Table 4 shows Technological process of handling of incoming train with data of operations after the implementation of augmented reality by the carrier and at the infrastructure manager at the same time.

Table 4 Technological process of handling of incoming train with data of operations after the implementation of augmented reality by the carrier and at the infrastructure manager at the same time. Source: authors

No.	Operation	Begin [min.sec]	Duration [min.sec]	End [min.sec]	Execute
1	Notification of employees	0.00	0.51	0.51	Train dispatcher
2	Train ensure to the station	0.51	3.00	3.51	Locomotive driver
3	Submission of documentation	3.51	11.13	15.04	Technical office clerk
4	Safety of train set, Distance locomotive	3.51	16.11	20.02	Wagon inspector/ Locomotive driver
5	Technical – Transportation inspection	20.02	118.48	138.50	Wagon inspector
6	Notification of end inspection	138.50	0.53	139.43	Operating supervisor
7	Create sorting list	139.43	4.48	144.31	Operating supervisor
8	Loosening screw coupling	144.31	38.30	183.01	Shunter-preparer
9	Suspension shunting locomotive	183.01	0.54	183.55	Shunter
12	Control and conclusion sorting list	183.55	1.05	185.00	Hump yard supervisor
Together 185.00 minutes					

As a condition for the possible recognition of the technical-transport inspection of the carrier, the proposal provides for the production of a record of this inspection by means of a device that creates augmented reality. In the case of a technical-transport inspection of the destination train, at least 12 hours, resp. until all wagons inspected during this inspection have undergone another inspection from which a record has been made. The replacement of the inspection by ŽSR with a technical-transport inspection of the carrier presupposes at the same time the creation of a sorting center on the basis of the data obtained during this inspection. The considered savings compared to the initial variant are 45 minutes of working time of the technical office clerk during the transport inspection, 30 minutes of commercial inspector during the creation of the sorting plant and 22 minutes and 43 seconds during the inspection for ŽSR. Together with labor savings, the time required for the technological procedure is reduced by 9 minutes.

4 Conclusion

Based on the performed analyses of technology of augmented reality and technological procedures in rail freight operations were selected that are by their nature suitable for the implementation technology of augmented reality. From the point of view of the overall evaluation of individual proposals, the monitored criterion was, above all, saving labor in order to reduce the costs incurred in the processing of wagons at the assembly station. The reduction of the required workforce was achieved by adjusting technological procedures using an innovated technical tool - augmented reality. The disadvantage in all proposals is the addition of operation to the workload of the wagon inspector, which increases the time required for the inspections he performs on the wagons. In the first proposal, technology of augmented reality was implemented in the operations performed by the carrier. In the case of processing the incoming train the technological procedure was extended by 18 minutes. The labor savings of the technical office clerk were 45 minutes for the incoming train and 85 minutes 23 seconds for the departing train. With regard to the extension of the overall duration of technological procedures as well as relatively low labor savings, the author does not recommend implementing technology of augmented reality at the carrier without implementation at the infrastructure manager. In the second proposal, the considered saving of 30 minutes of commercial inspector, it was possible to shorten the technological procedure by 4 minutes and 17 seconds, given the faster recording of wagon numbers in the case of create sorting list by augmented reality than the currently used PSION equipment. However, due to the fact that other technological procedures do not include operations suitable for the implementation of augmented reality, authors does not recommend implementing technology of augmented reality in the infrastructure manager due to the high purchase price when used in a minority of technological procedures performed at the establishment. In the third proposal, a synthesis of previous proposals was proposed, resp. implementation technology of augmented reality simultaneously in the actions performed by the carrier and the infrastructure manager. By modifying the technological procedures, the total duration of the technological process of processing the target trains was shortened by 9 minutes, saving 92 minutes and 43 seconds of staff work. With regard to the highest labor savings and shortening 2/3 of the technological procedures in which augmented reality was implemented, the author recommends the implementation of this variant, respectively considers its implementation to be the most rational. In order to specify the duration of individual new proposed operations, it is recommended to perform additional measurements directly in the field and also to make a call for a price offer to specify the considered return on investment. In the case of the certification technology of augmented reality in practice, it is possible to consider implementation into other operations, while in the future it will be possible to achieve, for example, the abolition of paper wagon label by augmented reality, which may be beneficial.

Continuous innovation and improvement of technological procedures (in the barriers of existing legislation and occupational safety) is a very important element for maintaining the competitiveness of rail transport compared to other modes of transport, which can have positive effects on reducing the environment.

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