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EVALUATION OF THE USE OF SMART GLASSES IN IRS LOGISTICS

Summary. To effectively transport materials through different means of transport, it is essential to have an optimized warehouse logistics first. Thanks to the Industry 4.0 platform, there are several ways to accomplish the delivery of materials from a warehouse through transport by road, rail or air. This paper deals with a primary warehouse problem, which is the fast and accurate search and selection of required items in the stock. For this issue, the use of smart glass technology and its implementation in the logistic processes of warehouses could help. In a particular way, an IRS (Integrated Rescue System) warehouse was selected as an example. The augmented reality (AR) type of glasses was selected. The introductory part of this paper deals with the current situation in the warehouse and logistic processes, where the problem of lack of qualified staff and material supply is prevalent, particularly during different crisis situations, such as pandemics or high employee turnovers. The use of smart glasses is one of the many possible problem-solving variants in this field. Further, a basic description of smart glasses, possible uses and sorting are presented in this paper. For the experiment, it was necessary to choose several different commercially available models of smart

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glasses. An evaluation was provided by the Simple comparative method, Saaty's method and Linear partial utility function method and the best options were identified. Also, there is an example of smart glasses application for picking a particular component in an IRS warehouse in the last part of this paper.

Keywords: smart glasses, warehouse logistics, Saaty's method, IRS logistics

1. INTRODUCTION

Logistics is a key factor for the function, progress and development of companies and organizations. The term itself incorporates several connected operations to ensure that the necessary and correct material, as well as goods, is in the required quantity and quality at the right place and time. Thus, logistics processes are constantly being improved and made more efficient. This involves the implementation of new technologies, their gradual modernization and automation. In the civil sector, logistics processes are organized by the companies on their own; however, in contrast, the state sector has to follow legislation as it is about handling the property of a state with a specific character [1, 2].

The warehouse sector has several significant problems, which slow down the whole logistic process. Because storage facilities often include individual storage halls with thousands or even tens of thousands of different items in individual aisles and multi-level shelves, storekeepers with excellent orientation are required. The high turnover of employees is another problem concerning the frequent training of new workers nowadays. From the abovementioned, it follows that in some cases, very lengthy processes can occur, and it is necessary to give increased attention to precise performance and ensure safety during the handling of materials or goods [1, 2].

Modern technologies of Industry 4.0, including automatic storage systems, automated guided vehicles (AGV), drones, augmented reality and smart glasses, can offer certain solutions to many everyday logistics problems. Smart glasses with augmented reality are common in civilian logistics these days; however, they are less used in military and humanitarian organizations for now. This article aims to show the use of smart glasses in these fields as well. For quick orientation and handling with a stock material, it is advantageous for warehouse keepers to have all necessary information, tasks and instructions in front of them, in their visual field at all times. Smart glasses will provide them with constant support on everything they need for work. They can easily handle the material with both hands; even a novice can become completely familiar with the warehouse in a short time. In addition, the glasses offer an easy solution to supply problems in crisis situations and pandemics, such as the recent situation with the Covid-19 disease [1, 2].

2. BASIC DESCRIPTION, USE AND SORTING OF SMART GLASSES

Smart glasses belong to the wearable device category. These are small intelligent electronic devices for detection, analysis and data transfer, suitable for wearing directly on or close to a person. In logistics, they are used in warehouse operations and material handling, remote cooperation of workers during installations and repairing of various devices, training of new employees and their remote support, and inventory checks as well. However, smart glasses can also be used in various industries like healthcare, sports, education and many others, including the gaming and entertainment industries. In addition to smart glasses, smart bracelets and

watches, as well as smart clothes or shoes, can also be included among the most frequently used wearable devices. These days smart glasses are easily obtainable at major electronics suppliers. Although the first versions of smart glasses caused headaches to users after being worn for a long time; however, this problem has been adequately addressed in current models. Thus, workers can work with the glasses for an entire work shift without any health complications or discomfort. Smart glasses can be sorted into two basic categories - Virtual Reality (VR) and Augmented Reality (AR) basis [3].

For this article, the second type of smart glasses has been selected; however, for complete information, it is necessary to describe the first type as well. In the case of Virtual Reality (VR), the entertainment industry has a significant share in its development, especially in filmography and video games, where VR glasses are gaining increasing attention lately. The concept of Virtual Reality can be considered as a three-dimensional, computer-created environment, which is perceived realistically by human senses, but completely cuts off the user from external reality. This happens because VR smart glasses have non-transparent displays, so the user only perceives the reality created by the glasses. Thus, the person becomes a complete part of a virtual world where he can explore space, manipulate and communicate with objects, and has the opportunity to try every activity in the so-called "rough outlines" without unnecessary costs and danger [3].

On the contrary, AR smart glasses have transparent displays so the user can be in constant eye contact with the real environment around him through his field of vision. The point is that the real environment is enriched with virtual elements expanding the real image which the user can see. The worker can wear the glasses always as it does not limit him in any way. He can see all the information directly from a computer or tablet and has both hands free at the same time, so he is not limited to manipulating the device. AR glasses are the current trend, especially in large companies, such as Coca-Cola, Volkswagen Group, DHL Supply Chain, etc. There are three main different ways to control the glasses. This could be either pure voice control of the glasses software through a microphone built into their frame (it has to be simple one-word passwords mostly), touch control using the settings on the side buttons or the touch sensor on the frame or a combination of these methods [3].

3. METHODS OF GLASSES SUITABLE TYPE EVALUATION

A model situation at a specific IRS warehouse was selected for this study. A suitable tool enables quick reactions to recent situations and should be simple and easy to use by less professional staff. Therefore, an acceptable variant of AR smart glasses could help to solve problems where there is a lack of qualified workers and speed up the receiving and expedition of the necessary material.

To determine the most suitable variant of glasses, the important selection criteria are first presented, after which the Simple comparative method, Saaty's method and Linear partial utility function method are used as multi-criterial methods for evaluating the variants. Based on market research, the following five variants of smart glasses (V1-V5, Figures 1-5), which offer a simple use and are commonly available in the market, were selected for comparison [4-8]:

- Google Glass Enterprise Edition 2 (Figure 1) - V1,
- Vuzix M4000 (Figure 2) - V2,
- Vuzix M400 (Figure 3) - V3,
- RealWear HMT-1 (Figure 4) - V4,
- RealWear Navigator™ 500 (Figure 5) - V5.

Fig. 1. Google Glass Enterprise Edition 2 [4]

Fig. 2. Vuzix M4000 [5]

Fig. 3. Vuzix M400 [6]

Fig. 4. RealWear HMT-1 [7]

Fig. 5. RealWear Navigator™ 500 [8]

To evaluate each variant, the following six important criteria (C1-C6) were determined:

- Integrated camera resolution - C1,
- Battery life - C2,
- Glasses weight - C3,
- Operating control and PPE (Personal Protective Equipment) compatibility - C4,
- Water, dust, fall and heat resistance - C5,
- Price - C6.

3.1. The simple comparative method

3.1.1. Integrated camera resolution (C1)

With the help of a video camera, videos and photos are transferred to a desktop computer, laptop, etc., through the camera. The operators thus can monitor whether a certain part is in stock or not in real-time. The resolution of the camera is important, particularly for carrying out repairs by a worker guided by an experienced workshop specialist remotely. The obtained values for comparison are in Table 1.

Tab. 1

Integrated camera resolution (C1)

Selected smart glasses	Resolution (Mpix)
Google Glass Enterprise Edition 2	8
Vuzix M4000	12.8
Vuzix M400	12.8
RealWear HMT-1	16
RealWear Navigator™ 500	48

From the above, it follows that the Realwear Navigator 500 glasses model completely dominates the other selected models. The value of 48 Mpix is highly above the standard, which undoubtedly guarantees the precise transfer of video and photos. The RealWear HMT-1 with 16 Mpix slightly exceeds the value of the Vuzix M400 and M4000 models, which both have the same 12.8 Mpix. The Enterprise Edition 2 model from Google Glass has the worst equipped integrated camera, with only 8 Mpix.

3.1.2. Battery life (C2)

Sufficient battery life is another aspect of the selection of a suitable model. It is, indeed, a desirable requirement that the glasses are in operation throughout the whole working shift and, therefore, always at hand. There should be no discharge of the battery during any activity in the warehouse during the work shift. The detected data are in Table 2.

Tab. 2

Battery life (C2)

Selected smart glasses	Battery life (h)
Google Glass Enterprise Edition 2	8
Vuzix M4000	7 (2-12)
Vuzix M400	7 (2-12)
RealWear HMT-1	8
RealWear Navigator™ 500	8

From the above, it can be seen that only the RealWear Navigator™ 500 and Google Glass Enterprise Edition 2 models last up to 8 hours on a single charge. For the RealWear HMT-1, 10 hours is considered. However, to be sure, at the RealWear models mentioned above, the spare "hot swap" battery can also be replaced during operation without unnecessary downtime. On the other hand, the M400 and M4000 models from the Vuzix company have a 2-12 hours battery life according to the battery type and working conditions. For our experiment, there was a mean value (7 hours) considered, which corresponds approximately with the other smart glasses battery lives.

3.1.3. Glasses weight (C3)

The glasses' weight is another critical aspect that affects the overall comfort during the wearing of the glasses. This is mainly affected because it is assumed that the smart glasses could be worn by the worker throughout the whole working shift. Ensuring the comfort and convenience of the operator is one of the main prerequisites for careful and faultless work. The data for the selected models of glasses is seen in Table 3.

Tab. 3

Glasses weight

Selected smart glasses	Weight (g)
Google Glass Enterprise Edition 2	51
Vuzix M4000	222
Vuzix M400	180
RealWear HMT-1	380
RealWear Navigator™ 500	272

From Table 3, it is clear that the Google Glass Enterprise Edition 2 model absolutely excels with its ultra-lightness of 51 g, surpassing the other glasses models. On the contrary, the heaviest model is the RealWear HMT-1, with a weight of 380 g. The other models are around the 200-300 g range.

3.1.4. Operating control and PPE (Personal Protective Equipment) compatibility (C4)

Operating control of smart glasses is closely related to compatibility with the worker's personal protective equipment (PPE), such as helmets and gloves. Table 4 shows a brief overview of the control method and the related compatibility of glasses models with PPE.

Tab. 4

Operating control and PPE (Personal Protective Equipment) compatibility (C4)

Selected smart glasses	Control method	PPE compatibility
Google Glass Enterprise Edition 2	Touchpad / Voice	Incompatible (C)
Vuzix M4000	Touchpad / Customizable voice / Control buttons	Partially compatible (B)
Vuzix M400	Touchpad / Customizable voice / Control buttons	Partially compatible (B)
RealWear HMT-1	Voice with partially interference suppression	Compatible (A)
RealWear Navigator™ 500	Voice with interference suppression	Compatible (A)

Among the selected smart glasses, only the Google Glass Enterprise Edition 2 was completely incompatible. The Vuzix models were partially compatible, while the RealWear glasses offered full compatibility with PPE.

3.1.5. Water, dust, fall and heat resistance (C5)

Another prerequisite of smart glasses for their correct and efficient functioning is a certain degree of protection, especially against falling, water, dust and temperature. These aspects essentially ensure trouble-free functionality under various circumstances. Considered aspects are shown in Table 5.

Tab. 5

Water, dust, fall and heat resistance (C5)

Selected smart glasses	IP Code	Dust resistance	Water resistance	Fall resistance	Working temperatures
Google Glass Enterprise Edition 2	IP 53	Limitedly protected against dust ingress	Protected against splashing water less than 60 degrees from vertical	No resistance guaranteed	0 up to +32 °C (C)
Vuzix M4000	IP 67	Fully protected against dust ingress	Protected against immersion to 15-100 cm depth	Resistance up to 1 m	-20 up to +45 °C (B)

Vuzix M400	IP 67	Fully protected against dust ingress	Protected against immersion to 15-100 cm depth	Resistance up to 2 m	-20 up to +45 °C (A)
RealWear HMT-1	IP 66	Fully protected against dust ingress	Protected against high pressure water jets from any direction	Resistance up to 2 m	-20 up to +50 °C (A)
RealWear Navigator ™ 500	IP 66	Fully protected against dust ingress	Protected against high pressure water jets from any direction	Resistance up to 2 m	-20 up to +50°C (A)

To compare the resistance of the models against the ingress of water and dust, a certified IP (Ingress Protection) code, according to an international standard IEC 60529, was used, which indicates the degree of protection against the ingress of water and dust. The standard provides more detailed information about the device's resistance than just the general word "waterproof or dustproof" when contact with water and dust happens. The first number of the code indicates the degree of dust resistance, and the second number, the degree of water resistance. Based on these codes, it is easy to compare individual models of glasses and their degree of protection. Table 5 shows that the selected models are divided into three categories of IP codes - 53, 66 and 67. Vuzix models are in the IP 67 category, RealWear models meet IP 66, and the Google Glass model belongs to IP 53. IP 66 and IP 67 certification offers an excellent degree of resistance, where the user can be sure that even in challenging weather conditions, these glasses can still function safely without any issues.

Another aspect which affects the durability of smart glasses is their impact resistance after falling from a certain height. This is also certified for various devices, which guarantees the functionality of the device when it falls to the ground. From Table 5, it is clear that only the Google Glass model does not guarantee any resistance. This is quite undesirable for working in warehouses because it is predictable that something may slip out of one's hand for instance, which can happen at any time and to anyone.

The last of the selected resistance criteria compared is the working range of temperature. Again, in Table 5, the particular values are shown. Google Glass has the smallest temperature range, with the lowest values, which do not reach below freezing point. This could cause problems, especially at lower warehouse temperatures and when working outside in winter. Other models of glasses have very similar values of temperature ranges, which increases their usability in different temperature conditions.

3.1.6. Price (C6)

The price of individual models was selected as the last criterion because price plays a crucial role in the overall economic evaluation. Only the commercial and publicly available price of each piece of the given models without accessories was considered, which can be seen in Table 6. All variants, except for the Google Glass model with only 1000 euros per piece, are approximately in the 2000-3000 euros per piece range.

Tab. 6

Price (C6)

Selected smart glasses	Price (EUR)
Google Glass Enterprise Edition 2	999
Vuzix M4000	2502
Vuzix M400	1802
RealWear HMT-1	2002
RealWear Navigator™ 500	2503

3.2. Saaty's method

Saaty's method is based on the principle of pair comparison and its output is made by weights of criterions determined according to the significance of the variant selection. Table 7 serves as an auxiliary table to Saaty's method, where the weights of individual criterions are listed according to their importance. In Table 8, individual variants are evaluated by using the determined weights and their geometric mean value for each criterion evaluation [10, 11].

Tab. 7

Saaty's method auxiliary table

Importance of the criterions	Score points if the statement is true	Score points if the statement is not true
Both compared criterions are significant equally	1	1
A criterion in the line is slightly more significant	3	1/3
A criterion in the line is quite more significant	5	1/5
A criterion in the line is provable more significant	7	1/7
The criterion in the line is absolutely more significant	9	1/9

The weights are calculated according to equation (1) [10, 11]:

$$v_i = \frac{G_i}{\sum_{i=1}^{n} G_i} \tag{1}$$

where G_i is geometric mean value.

Tab. 8

Individual variant evaluation

Individual criterions	C1	C2	C3	C4	C5	C6	Geometric mean value	Total weight
C1	1	1/3	7	3	1/5	5	1.3831	0.1534
C2	3	1	7	5	5	7	3.9283	0.4357
C3	1/7	1/7	1	1/3	1/5	1/3	0.2772	0.0307
C4	1/3	1/5	3	1	1/5	1/3	0.4870	0.0540
C5	5	1/5	5	5	1	7	2.3650	0.2623
C6	1/5	1/7	3	3	1/7	1	0.5766	0.0639
Total							9.0172	1.0000

For completeness, it is advised to check the validity of the table values using the Consistency Ratio (*CR*) according to equation (2). First, it is necessary to calculate the Consistency Index (*CI*) using equation(3), which comes from the largest value of the matrix λ_{max} and the total number of elements. Subsequently, a Random Index (*RI*) (Table 9) is added to the *CR* formula according to available sources [10, 11].

$$CR = \frac{CI}{RI} \tag{2}$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

Tab. 9

Consistency indices for a randomly generated matrix [10]

n	3	4	5	6
RI	0.58	0.90	1.12	1.24

Since this is a subjective evaluation, the calculated value of *CR* = 0.16 is slightly higher than the 0.1 value allowed by the standards. Although there are slight inconsistencies, they do not affect the overall rating.

3.3 Linear partial utility function method

This method is suitable for evaluating multi-criterions variants. Its biggest advantage is that quantitative and qualitative criterions can be compared. Table 10 shows individual criterions (C1-C6) and specific values for each variant, including the measurement unit in which the criterion is calculated. This is an auxiliary table needed for the actual calculation of the most suitable variant (V1-V5) [12, 13].

Tab. 10

Linear partial utility function method auxiliary table

Individual criterions	Measurement unit	Selected variants of the glasses				
		V1	V2	V3	V4	V5
C1	Mpix	8	12.8	12.8	16	48
C2	h	8	7	7	10	8
C3	g	51	222	180	380	272
C4	-	C	B	B	A	A
C5	-	C	B	A	A	A
C6	EUR	999	2502	1802	2002	2503

The overall rating of the selected variants is calculated according to equation (4) [12, 13].

$$H^j = \sum_{i=1}^{n} v_i \cdot h_i^j \tag{4}$$

where H_j - an overall evaluation of the j[th] variant, v_i - a weight of the i[th] criterion, n - a number of evaluated criterions, h_i^j - a partial evaluation of the j[th] variant for the i[th] criterion, which is calculated according to equation (5) [12, 13].

$$h_i^j = \frac{x_i^j - x_i^0}{x_i^1 - x_i^0} \tag{5}$$

where x_i^j - the value of the i[th] criterion of the j[th] variant, x_i^1 - the best value among all variants of the i[th] criterion (considering the quantitative criterions there is assigned the value 1), x_i^0 - the worst value among all variants of the i[th] criterion (considering the quantitative criterions there is assigned the value 0).

Table 11 shows the criterions and the selected variants. The weight values of the criterions obtained from Saaty's method in the previous case (Table 8) are also included. The final ranking is determined from the highest calculated H^j values to the lowest.

Tab. 11

Selected variant evaluation

Criterions	Weight v_i	The worst value	The best value	Selected variants h_i^j				
				V1	V2	V3	V4	V5
C1	0.1534	8	48	0	0.12	0.12	0.2	1
C2	0.4357	7	8	1	0	0	1	1
C3	0.0307	380	51	1	0.48	0.61	0	0.33
C4	0.0540	-	-	0.2	0.6	0.6	1	1
C5	0.2623	-	-	0.6	0.6	1	1	1
C6	0.0639	2503	999	1	0.0007	0.47	0.33	0
Total evaluation H^j (4)				0.6985	0.2229	0.3619	0.8037	0.9155
The final rankings				3	5	4	2	1

4. RESULTS AND DISCUSSION

4.1. The simple comparative method

This method showed that the models from RealWear stand out in almost all categories according to characteristics, except for the weight, where the Google Glass Enterprise Edition 2 glasses won, and the Vuzix M400 model came in second place. The weight of glasses has been the subject of various research [14-16]. According to Bergstrom et al., head-mounted displays supported by the nasal arch and held by the ears should have a light construction [15]. Bergstrom et al. [15] and Syberfeldt et al. [16] also suggested that these wearable devices should not weigh more than 100 g. Otherwise, they may cause excessive psychological stress.

The winning models weigh three times more, but considering the other parameters, this is still a good choice. In addition, they have good ergonomics and can be attached in different ways. As for the price, it usually corresponds to the quality and characteristics of the products in the field of other compared parameters.

4.2. Saaty's method

Saaty's method determined the weights of the individual criterion, with the C2 criterion (the battery life), and the C5 criterion (the overall resistance of the smart glasses), receiving the highest value. Based on the obtained values, selecting smart glasses from RealWear is a clear choice. Another vital criterion is C1 (the resolution of the integrated camera), which also clearly points to the RealWear Navigator™ 500 glasses. This method was also used as a base data research for the next method.

4.3. Linear partial utility function method

Based on the analysis of the most advantageous variant of the multi-criterion impact, variants V4 and V5 (both models of RealWear glasses) performed as the best again, while the variant V5 (RealWear Navigator™ 500) was slightly better placed with an overall rating of 0.9155 against value 0.8037. Due to its characteristics, likewise, after the analysis, it still appears to be the most suitable option for IRS warehouses, especially in more demanding conditions.

4.4. The winning model of smart glasses

From several analyses, it is clear that the RealWear Navigator™ 500 (Figures 5 and 6) is the winning model of the considered smart glasses. It is a recognized brand in the market, and this augmented reality model definitely has a lot to offer. This is a monocular type of smart glasses (glasses with a display for one eye).

The first advantage to mention is its voice control. According to available information, it is said to have the best voice control among smart glasses, and its noise-cancelling microphones can filter ambient noise up to 100 dB. Thus, its users are assured of full hands-free control and high-quality sound transmission even during a remote connection with experts, regardless of the ambient noise [8].

Fig. 6. RealWear Navigator™ 500 smart glasses [8]

High-quality transmission and recording are also guaranteed by the resolution of the front integrated camera, which is capable of taking pictures with a 48 Mpix resolution, a significantly higher value than the other compared variants and corresponds to the number of Mpix in professional cameras. The RealWear Navigator™ 500 model is adapted for use in the heavy industry, so its durability is not underestimated either. Because of its IP 66 certification, the device is highly protected against water and dust. At the same time, the glasses are tested for falling from a height of 2 m, and the temperature range from -20 to +50 °C, which is more than satisfactory [8].

These glasses support several different software applications suitable for logistics processes, including the TeamViewer Frontline software, which, according to an Ayes representative, is the most used in logistics. Among other things, the manufacturer enabled the development of customized software for even more efficient functions. The last notable advantage of the RealWear Navigator™ 500 glasses that should be mentioned is the battery life. The battery life on a single charge lasts up to 8 hours, and it also has an external "hot swap" replaceable battery, which allows battery change during operations, ensuring the possibility of continuous operation of the glasses. In addition, the RealWear Navigator™ 500 smart glasses can be combined with different headgear and is fully compatible with different PPE (Figure 7) [8].

Fig. 7. Different headgear equipment for RealWear Navigator™ 500 glasses [8]

5. ECONOMIC EVALUATION

An economic evaluation of smart glasses implementation is determined by defining and comparing the costs (Table 12) and benefits (Table 13) of the current state without smart glasses with one after the purchase of smart glasses.

5.1. Storage costs without and with smart glasses

It can be seen from Table 12 that the costs of storage and providing these processes can be significantly higher for the variant without smart glasses because when considering the purchase of smart glasses, the highest costs are only for their purchase, which from the above is not much of an investment.

Tab. 12

Storage costs without and with smart glasses

	Current state	State with smart glasses
Direct material costs	-	purchase of smart glasses and software, creation of documentation
Indirect material costs	compensation for material loss	-
Direct intangible costs	delay in delivery of materials, loss of time, excessive use of manpower	electricity for charging
Indirect intangible costs	-	-
Partial costs	-	maintenance and service
Final costs	-	spare parts and accessories
Internal costs	unnecessary material storage, lengthy warehouse logistics processes (issuance, receipt, inventory checks)	-
External costs	-	-

5.2. Storage benefits without and with smart glasses

It is clear from Table 13 that the current situation offers no benefits to the company, only more jobs for employees. On the other hand, there are several benefits to the purchase of smart glasses.

Tab. 13

Storage benefits without and with smart glasses

	Current state	State with smart glasses
Direct material benefits	-	manpower saving
Indirect material benefits	more job positions	financial savings, prevention of property damage, prevention of occupational accidents
Direct intangible benefits	-	saving time, easier orientation in the warehouse, error elimination, rapid training of new workers, faster supplying,

		modernization, better handling of crisis situations
Indirect intangible benefits	-	expanding the use of smart glasses in other processes (maintenance, repairs, etc.) and other sectors, gaining awareness of modern storage devices and augmented reality
Partial benefits	-	new experiences with progressive technology, modernization
Ultimate benefits	-	elimination of faults in storage processes, saving time and manpower, acceleration of storage processes
Internal benefits	-	increasing the safety and independence of warehouse workers
External benefits	-	improving the quality of logistic storage processes

6. PRACTICAL ILLUSTRATION OF A ONE STOCK ITEM PICKING USING SMART GLASSES

This section is dedicated to finding and picking one inventory item with smart glasses. The individual steps, including pictures (Figures 8-12) from the real point of view of the warehouse keeper, are listed below in a clear arrangement. Augmented reality elements of selected smart glasses are displayed in the field of view of the worker's glasses. All identifying information about the items listed here is fictitious and serves only as an illustration.

6.1. Step 1

The warehouse keeper searches for the given item in the system on his computer according to the relevant identification data, and the information about the location of the item is transmitted directly to his glasses. In the upper right corner of the field of vision, the item to be picked up and the task "Pick" (pick up with a confirmation window) are displayed.

When the task is completed, a confirmation “tick” of successful completion occurs; otherwise, an error cross will be displayed. In the centre of the field of view, the location of the item is shown as "Aisle" and "Shelf" with their numbers. In the case of multi-level racks, there would be an option to display an additional number that would show the exact rack floor. Following the arrows, the storekeeper is guided to the specific item (Figure 8).

6.2. Step 2

When the storekeeper reaches the desired item location, turn on the CAMERA function (using the touch control on the side of the glasses frame or the voice command "CAMERA"). The front camera and the glasses reader built into the camera are turned on. Now, he has to direct the glasses with his gaze to the warehouse ticket so that the cross in the middle of the field of view interface is on the warehouse ticket (in an ideal case, directly onto a QR code that the glasses reader scans - Figure 9).

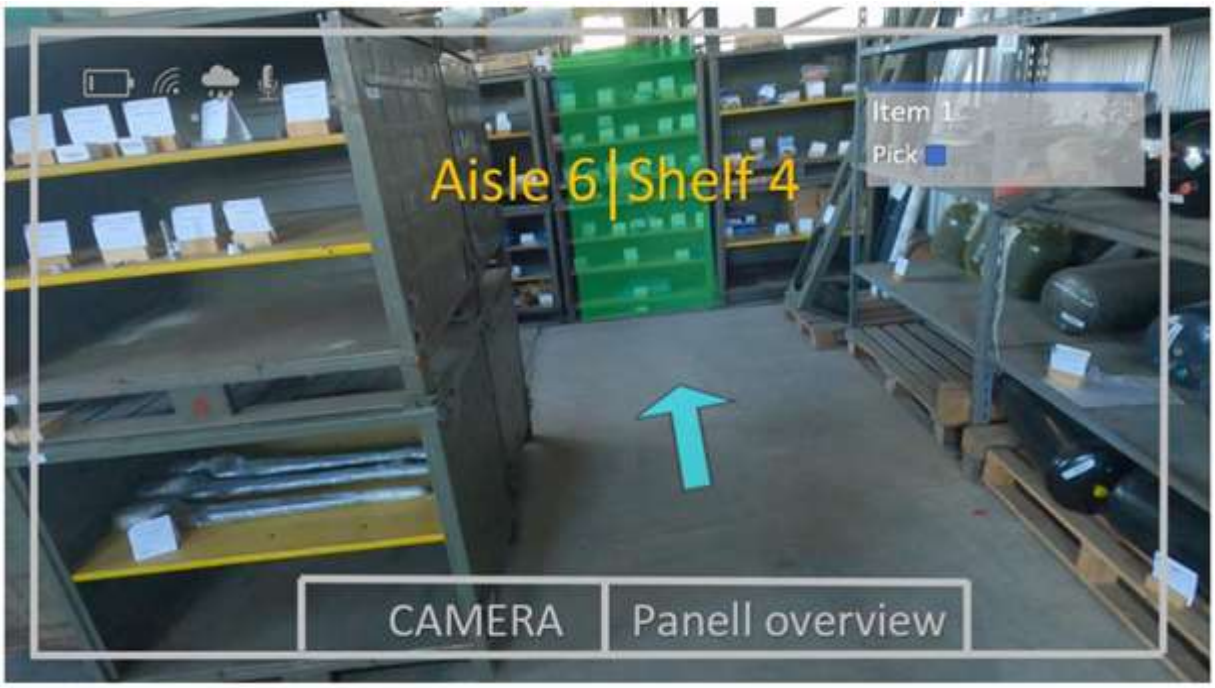

Fig. 8. Step 1

Fig. 9. Step 2

6.3. Step 3

After pointing the camera at the storage ticket, the scanned ticket will be displayed on the glasses, including the standard storage information and the identification data about the searched item (Figure 10).

Fig. 10. Step 3

6.4. Step 4

To verify that the picked up item is the correct one, the voice command "PICTURE" is used (to display a photo of the given item from the system). Then, a preview of the item is displayed in the upper right corner of the field of view (Figure 11).

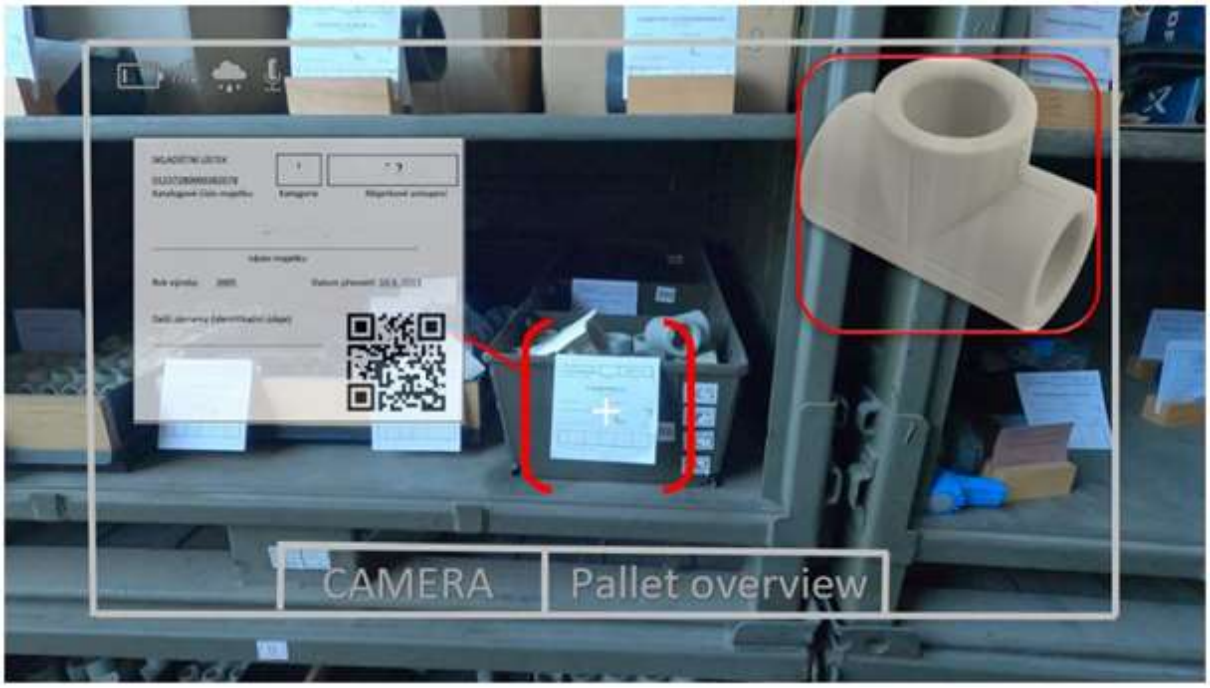

Fig. 11. Step 4

6.5. Step 5

The voice command "PICK" is used to confirm that the item has been picked up. In the right corner of the field of vision is the taskbar, where the completion of the task is confirmed by checking the blue box next to the "Pick" task, after which the item can be collected and taken away. After checking the box as a confirmation of the completed task, the number of pieces for the given item will be automatically reduced in the system (Figure 12).

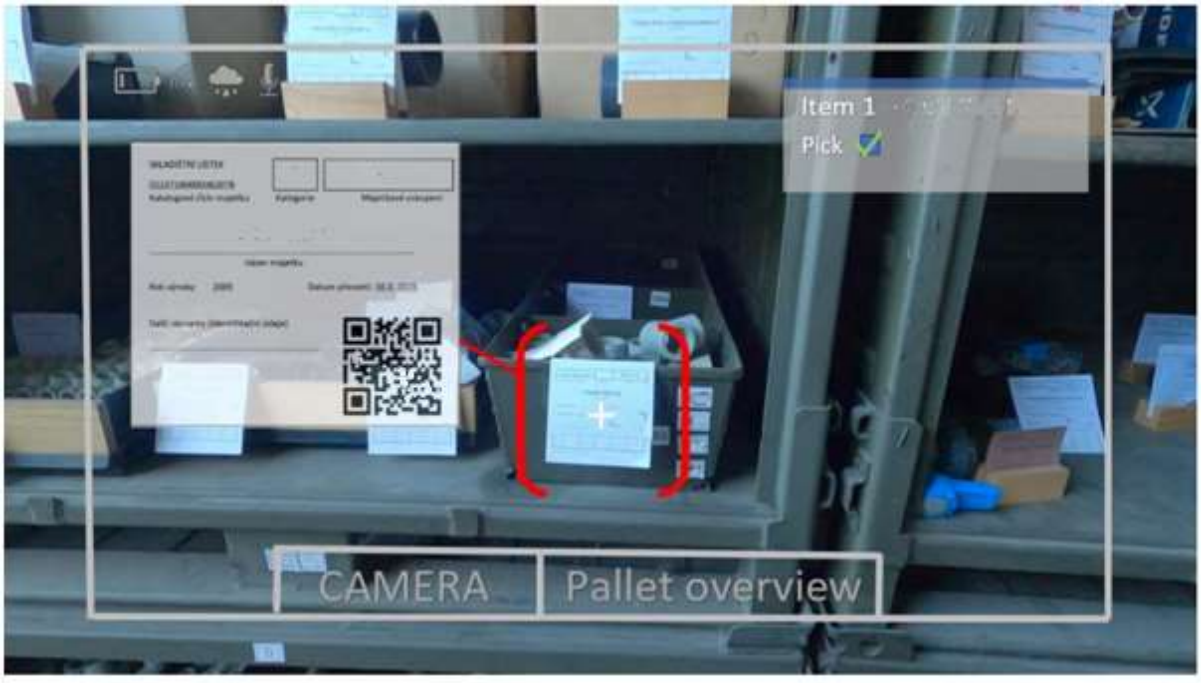

Fig. 12. Step 5

7 CONCLUSION

There are all kinds of smart tools and means to facilitate quality and efficiency improvement currently demanded under the "Industry 4.0" concept and its branches. The same situation is considered for smart glasses, which are becoming increasingly popular in both manufacturing companies and services. Also, their possible use is offering possibilities for IRS warehouses, which, especially in crisis situations, are full of confusion and problems with the lack of qualified workers and the rapid receiving and delivery of the necessary material. This article is focused on the selection of a suitable variant of smart glasses based on augmented reality for a specific IRS warehouse logistics, which could primarily help in resolving chaotic situations, especially crisis situations.

Based on market research, five different models of smart glasses were selected, and their evaluation was carried out using three scientific methods - A simple comparative method, Saaty's method and the Linear partial utility function method. Since this article is focused on the IZS warehouse, evaluation and selection of a suitable variant were carried out under all the working conditions expected there. Each of the abovementioned methods evaluated significant parameters for selecting suitable smart glasses, and the results showed that the clear winner was the Navigator™ 500 model from the RealWear company. The only issue is the weight of the

product, which exceeds the recommended value by three times. However, it is possible to clamp and hold these glasses in different ways, including on different head covers, so they offer comfort even with a relatively higher weight. The price parameters corresponded relatively to the characteristics of selected smart glasses.

The final part of this article details the use of smart glasses in searching for an item in a warehouse. Observably, the display of the smart glasses is very intelligible, and even a complete novice can quickly find his way around the warehouse. Conclusively, it is suitable to tell that the results of the experiment can be used not only for material warehouses of the integrated rescue systems but also as a basis for warehouse logistics in other fields and sectors.

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