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VIDEO WORKING INSTRUCTION SYSTEM

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Abstract: *The present paper presents a new working instruction system placed on the assembly line, composed by few synchronized video displays for providing interactive procedural instructions and a QR (Quick Response) code web-based application for gathering additional information and publishing comments, requests, and evaluation. This system helps operators memorize and perform operations correctly, respecting the recommended time at each workstation, ultimately increasing productivity and reducing scrapping on the assembly line. Two questionnaire based surveys were conducted in order to evaluate the proposed video working instruction system and to evaluate the work carried out within the workstations. Results indicate that the proposed system is more efficient, increases productivity, produces a lower level of waste and is accessible to users.*

Keywords: *Working Instructions, QR code, signage, assembly line, digitalization*.

1. INTRODUCTION

Digitalization is changing the conventional workplace to a flexible and customized workplace. Trends additionally point towards that the user's work assignments will change with the goal that progressively proactive work is performed and the user will also manage numerous different tasks and distinctive technologies. As far as technologies are concerned, the user will work together intimately with a higher level of automation, for example, cobots (collaborative robots) and support systems. This will expand the complexity level in production and create the requirement to understand user's views on such a framework. Complexity in a system is something that is hard to comprehend, depict, foresee or control [1]. Assembly work is complex because of the methodology to have mass-customized products and also due to the multitude of similar products, of several customers, that can be assembled within a period of time on the same production line. There could be different brands which represents similar products for assembly, but which requires quiet different procedures on the assembly lines: products could be almost similar but the operations are slightly different and also the customer demand and requirements could differ. One example: assembling windscreens for different car brands that have different features and components.

To support a multi-variation production, it is vital for operators to be able to deal with high demands from a cognitive workload perspective. In such circumstances, work directions can bolster operators cognitively. Work instructions are often not entirely used or insufficient in final assembly. The operator execution regarding apparent cognitive task and quality of data are influenced by the existing content of information inside the work instructions. With a growing quantity of product variants in final assembly, operators perceive an increase in the complexity of work. Human work, which remains inseparable from automated production systems, requires cognitive support to deal with the subjective difficulties of multi-variant production. Human work can benefit from external assistance, thus improving both the quality of the provided information and the strategies to give said data.

Visual and digital presentation, improved data sharing techniques together with the availability of data make it simpler for the operators to discover the vital information [2]. A repetitive visual presentation (video presentation) in front of the operator can correct some mistakes or bad habits which he has during operations.

Certain studies state that video game players (who keep their eyes fixed and expand their focus) are more likely to distinguish objects in a video clip than those who do not play, meaning they have the ability to track more objects around them.

Studies also state that action games improve attention and multitasking capabilities, improve vision (despite rumors that the state long before the screen worsens vision) and that video images have an impact on the brain. The most important changes happen at the level of

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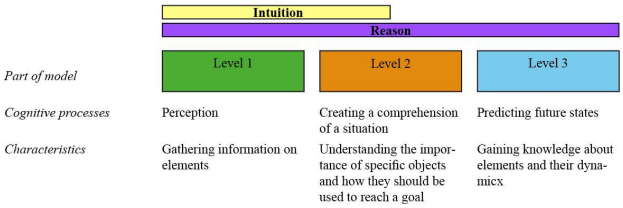

Fig. 1. Situation awareness - model described by separating intuition from reason (figure source: [4]).

the neural network that controls attention, making it more effective for people who play action games [5].

Today work guidelines are often message-based and not associated with the operators learning phase [3]. Despite the fact that reviews point towards that an expanded learning can be seen with advanced devices like digital tools (TV monitors, tablets or smartphones used for AR - Augmented Reality or QR scanning codes), learning is regularly done by guides of tutors or mentors at production companies.

According to J. Rasmussen, it is important to understand the operator's cognitive processes in order to support interaction and to optimize the performance [7]. Cognitive processes in complex final assembly can be depicted as natural for example quick, instinctive and easy. S. Mattsson et al. made a conceptual model in order to show the manner in which intuitive cognitive processes can be differentiated and portrayed in a complex context (Fig. 1).

2. THE RESEARCH

In order to simplify the information and to increase the retention of the information, a video-based information system was developed, using some real footages from operations, superimposed with text and graphical information based on the Learning Pyramid [6]. This solution is much effective than the existing text and picture-based instructions, being a combination of audio-visual and demonstration.

In Fig. 2 one can notice that simple Lecture or Reading give not such good results (10%) in teaching methods compared to Seeing/Visual (20%) or Demonstration (30%). According to J. Stanley, the visual center is much larger and stronger than the auditory center, while the demonstration is known to cause better recall, demonstration including seeing the instructor doing the process, seeing the physical procedure of the process, listening to the instructor as the process is explained. When watching someone, huge amounts of added information are interpret [6]. In the same time, Practice by Doing (the penultimate level in the pyramid – 75%) works better in the process of learning, like a participatory teaching method, because causing repetition engages the operator to create the memory he needs to perform all the needed operations.

Repetitive operations (Practice by Doing 75%) combined to repetitive looking at the visual demonstration (by Audio/Visual 20% + Demonstration 30%), all together can lead to the improvement and correction of operations as well as their memorization.

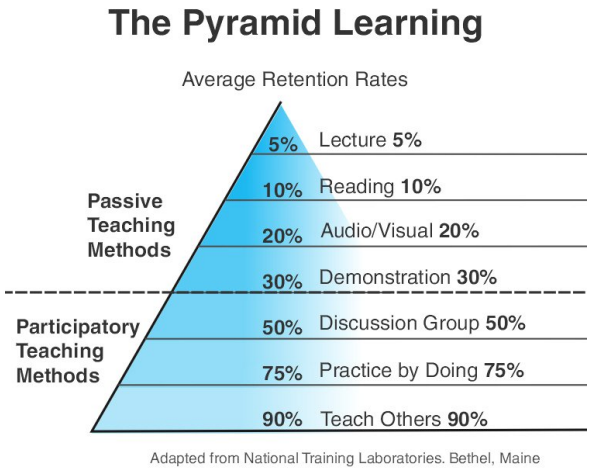

Fig. 2. Learning Pyramid (figure source: [6]).

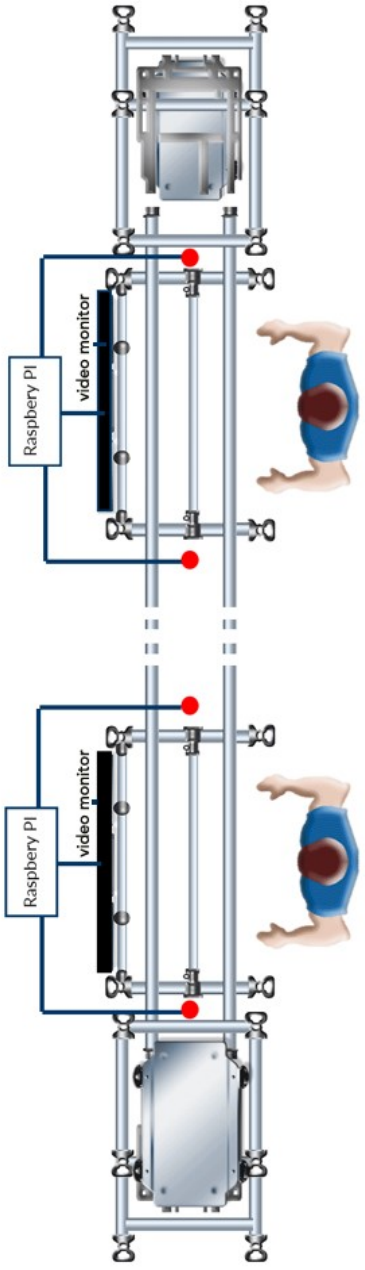

Fig. 3. Display systems on the assembly line.

The system is composed by a series of displaying systems one on each working place on the assembly line and includes a QR Code web-based application which will give additional information regarding the production line and allows to send comments and reviews regarding each working place.

The monitor which is displayed in front of the operator in each working place will guide him by displaying the correct operations in the recommended time of the execution. The operator working time is displayed in the right bottom corner of the display. The QR code web-based application allows visitors or supervisors of the assembly line to send comments and reviews about any workstation on it. By simply scanning the QR code with a smartphone, after being connected into the web application, they will be linked to a web page containing the comment-form related to that specific workstation that was scanned by the means of the code.

One display system is composed of a video monitor (Fig. 4) and a microcomputer (Raspberry PI).

At the entrance and exit of each working place, there are ultrasonic sensors that sense the entering and exit of the products on the working place online (Fig. 3).

Fig. 4. Video Monitor.

Fig. 5. QR Code placed on the working place.

Based on the time between entering and exiting of the product, the operation time can be counted. On each display videos with the operation instruction are found, that are created based on a perfect operation cycle. The time for operation on each workstation is equal to the video length and measures the recommended correct time that operator must fit in order to execute the operation.

By comparing these two times, video length (the recommended time) and counted time (the operator's working time) the play speed of the video is adjusted automatically to be in sync with the operator work speed.

Also, notifications are sent if the working speed is too low or too high, the notification being superimposed over the video. If the working speed is too low (the operator's working time is longer than the recommended time), the operator's time displayed in the right bottom corner becomes colored in red.

The QR codes (Fig. 6) are placed at each working place of the assembly line (Fig. 5) and contains the URL of the comment form. The QR code scanning is not depending on any external application for QR detection, like mobile QR scanning application, the scanning is directly done inside our web-based application. To do the scanning, java scripts were used inside the web application, based on HTML5 and WebRTC API, any webpage being served over HTTPS.

The supervisor opens the web application on the mobile or tablet and the first page displays the QR scanning interface which uses the backward camera of the device. The real-time webcam-driven HTML5 QR code scanner redirects to the evaluation/comment interface for that specific workplace where the QR code is located (Fig. 7).

Fig. 6. Example of QR Code.

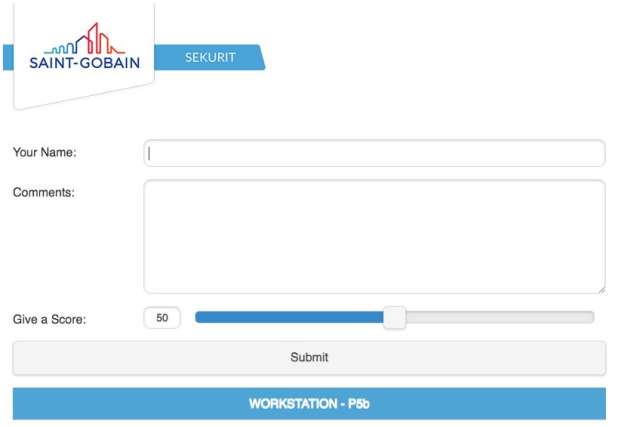

Fig. 7. Evaluation/Comments for P5b – user interface.

In this interface he will be able to address comments and create a star-based evaluation, also there is a button to return to the scanning interface.

The comments and rating are sent to a database on the server together with DateTime and working place ID.

Reports about comments and rating are available into the administration interface.

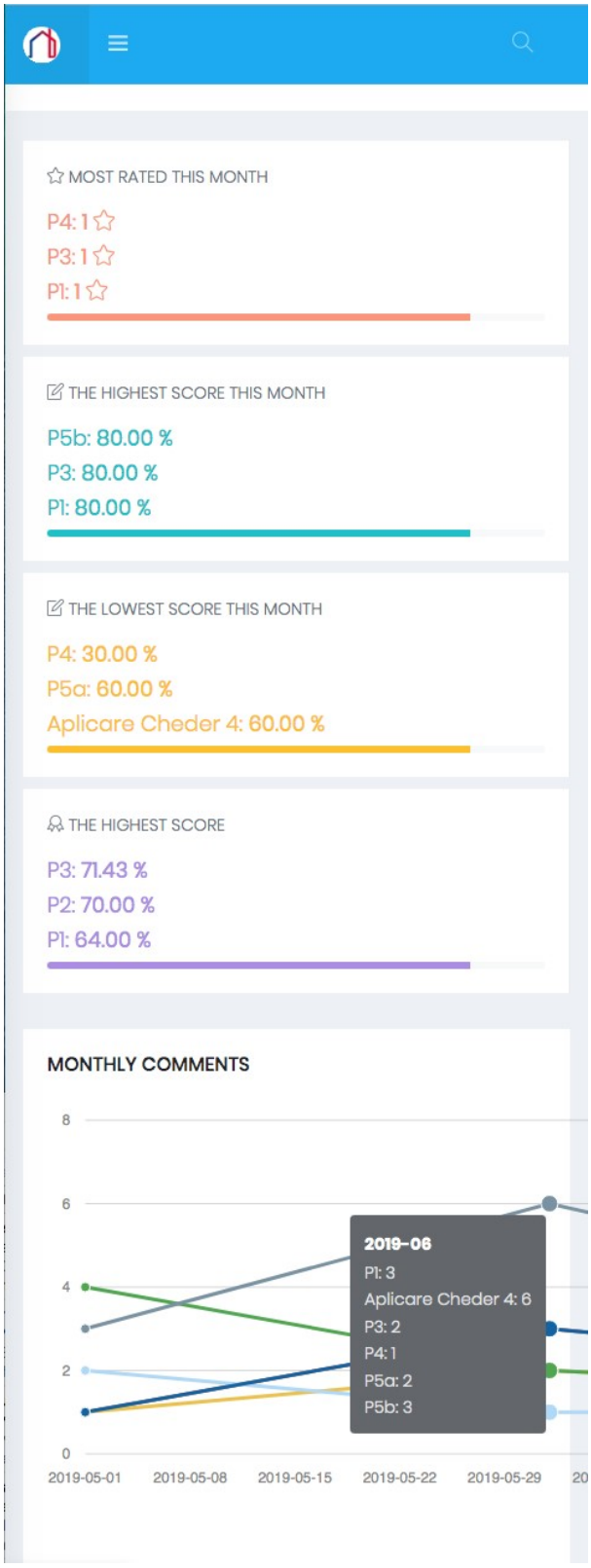

Fig. 8. Dashboard for Admin interface (mobile version).

In the dashboard administration, the administrator can see the report for the most rated workstations in the current month, the highest score and the lowest score in the current month and the workstations rated with the highest score over the entire period of the current year.

Also, it contains a graphical illustration of monthly comments – the number of comments for every workstation (Fig. 8), recent comments and a comments overview per month containing the least rated workstations (having a score <=50) (Fig. 9).

The administrator is able to display user comments between time intervals on one or all workstations, print data (Name of the initiator of the comment, Date of the post, Workstation and the Comment description) or search after relevant words (Fig. 10).

Also, data can be displayed in the timeline (Fig. 11). In the same time, it allows getting the average rating for each workstation between time intervals. Operators' competencies can be assessed at each workstation.

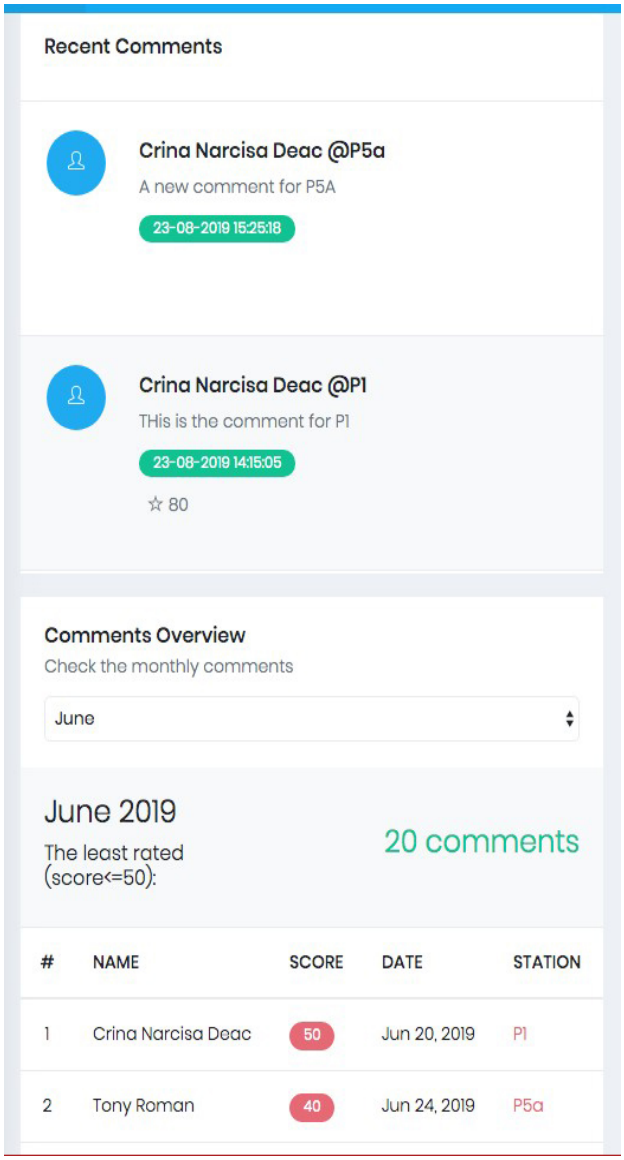

Fig. 9. Dashboard section for Admin interface containing Recent Comments and Comments Overview for the least rated workstations.

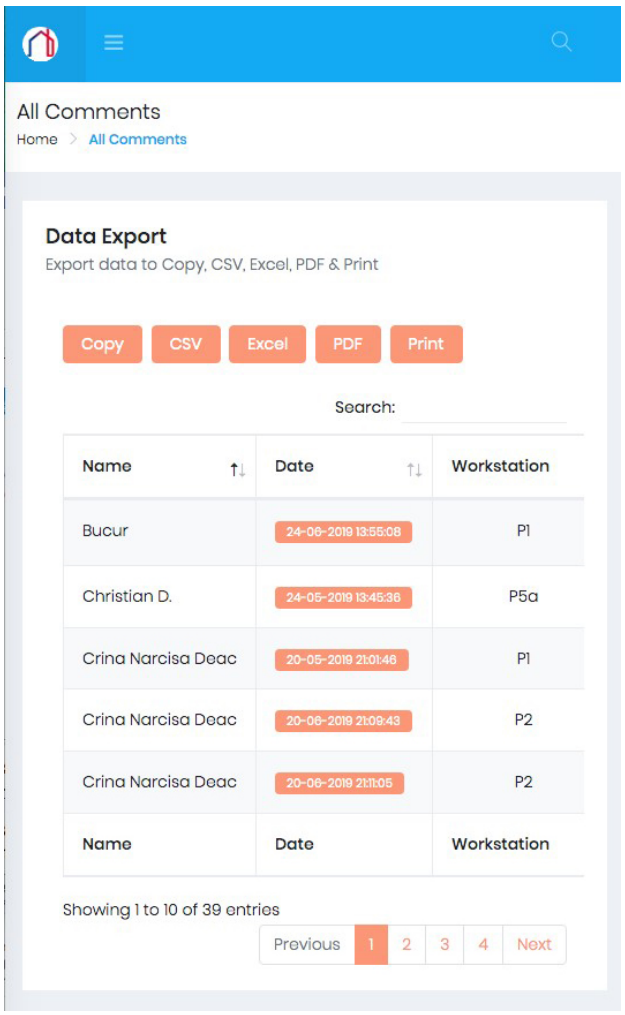

Fig. 10. View / Search / Print (csv, xls, pdf) Comments over all workstations inside Admin interface.

To evaluate the efficiency of this system, a questionnaire was used, on a sample of 45 people who are part of three work teams (three shifts of 15 people):

1) Do you use the video working instructions display tool?

Yes | No

2) Do you think it is annoying to have a continuous video display in front of you?

No | Yes

3) How do you evaluate the presentation of the sequence of operations at your workstation in this video system?

Poor | Good | Very Good

4) How do you evaluate the graphic information displayed in the video material?

Useless | Useful | Very Useful

5) How do you evaluate the timing of the clip with the operations performed?

Almost Synchronized | Phase Shift | In Real-Time

6) By constantly reviewing the procedures, do you manage to improve your work process?

No | Yes

Weaker | About equal | More efficient

7) Do you consider that by implementing the system, the number of waste and errors has been reduced?

No | Yes

8) Do you consider that the implementation of the system has led to an increase in labor productivity?

No | Yes

9) How many views of video / graphic instructions do you think you need in the case of a new product to learn the working procedures correctly?

number

10) How easy do you consider to be the learning of new procedures using this system?

Heavy | Normal | Easy

As noticed in Table 1 here above, 94% of respondents consider the video method learning to be more efficient when compared to the classical text one, while 80% of them consider that this system has led to an increase in productivity and 100% of respondents appreciate that the number of waste and errors has been reduced. It is observed that a large percentage of 20% do not appreciate the graphic information and text superimposed over the video, preferring only the video images. Respondents unanimously agree that they manage to improve their work process by constantly reviewing the procedures.

Another questionnaire was used for the staff of the company which evaluates and comments on the work carried out within the workstations, by scanning QR codes and for the administrators of the application, a total of 11 respondents:

1) Do you use the QR app frequently?

No | Yes

2) How easy is the assessment based on scanning QR codes?

Table 1

Survey regarding system efficiency

1)	Yes: 96%	No: 4%	
2)	Yes: 11%	No: 89%	
3)	Poor: 0%	Good: 23%	Very Good: 77%
4)	Useless: 20%	Useful: 44,44%	Very Useful: 35,55%
5)	Almost Synchronized: 0%	Phase Shift: 62,22%	In Real Time: 37,77%
6)	Yes: 100%	No: 0%	
7)	Weaker: 0%	About equal: 6%	More efficient: 94%
8)	Yes: 100%	No: 0%	
9)	Yes: 80%	No: 20%	
10)	<=3 times 33,33%	3-5 times 55,55%	>5 times 11,11%
11)	Heavy: 0%	Normal: 6,66%	Easy: 93,33%

Poor | Normal | Very Easy

3) Evaluate the functionality of the application's graphical interface.

Poor | Good | Very Good

4) How do you assess the quality of the reports generated?

Poor | Normal | Very Good

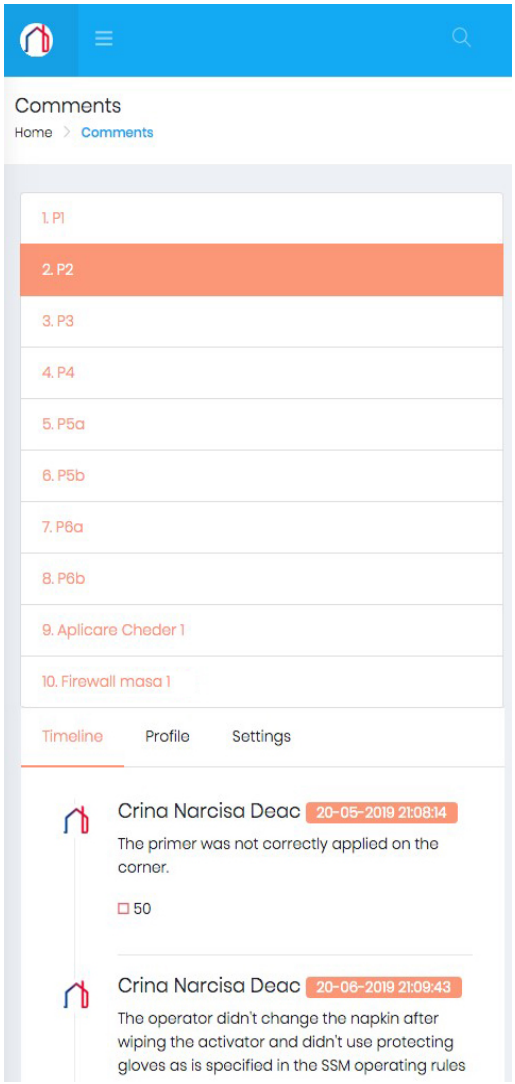

Fig. 11. View comments and score in the timeline.

Table 2

Survey for evaluation of work with the workstations

1)	Yes: 36,36%	No: 63,64%	
2)	Poor: 0%	Normal: 0%	Very easy: 100%
3)	Poor: 0%	Good: 18,18%	Very Good: 81,82%
4)	Useless: 0%	Useful: 72,72%	Very Useful: 27,28%

The answers of staff, as observed in Table 2, confirm the ease of assessment based on QR codes scanning in a proportion of 100% and also that the reports generated can be further improved. The system was most appreciated for its ease of use.

3. CONCLUSIONS

Using a combination of video, superimposed texts and graphics synchronized with the operation time and additional information provided by the QR code web-based application, a versatile and easy to use information system was implemented, a system that will help operators to perform their operations more properly, fitting the necessary time, by reducing the number of errors and increasing the productivity on the assembly line. The proposed video working instruction system was tested using an assembly line from Saint Gobain Sekurit company. This application will be implemented, tested and further developed in production on other assembly lines of Saint Gobain Sekurit company.

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