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Enhancing Performance Evaluation Through Augmented Reality Smart Glasses for Industrial Operators

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Abstract. Monitoring operator compliance with work instructions is critical to ensuring that product quality is maintained, safety requirements are fulfilled, rules are followed, efficiency is enhanced, and suitable training is provided. Various industries employ different tools to manage operator performance, such as Standard Operating Procedures, Checklists, Performance metrics, Audits or Inspections. Due to the requirements for infrastructure, manpower, training, maintenance, integration, and privacy issues, the process of monitoring operators' performance can be costly for industry. On the other hand, the advantages of a well-designed monitoring system can offset these cost expenses by increasing productivity, quality, and safety, resulting in long-term cost savings and better competitiveness. This paper reports a research project that transferred Hololens 2 with Microsoft Dynamics Guide to a tool that simultaneously guides and monitors operators' real-time performance. The new technology can assist industry in identifying areas where operators may require more training or support and optimising workflow to increase overall efficiency. Furthermore, the data gathered by this technology may be utilised to enhance future trainings and modify ongoing production processes.

Keywords. Performance Evaluation, Human-Computer Interaction, Augmented Reality Smart Glasses, Real-Time Monitoring

1. Introduction

Using enabling technologies in the industrial setting necessitates new interactions between operators and equipment, which reshape the industrial workforce and have substantial repercussions for the nature of the work. The forthcoming generation of smart operators are comprised of intelligent and trained operators that conduct tasks with the assistance of machines, communicate with Cobots and sophisticated systems, and utilise technologies like augmented and virtual reality [1]. Industry and manufacturing enabling tools are software, hardware, and other technologies that assist companies in improving their operations, cutting costs, and boosting profitability. Among these technologies are automation systems, robots, artificial intelligence, software for supply chain management, and sophisticated analytics. By automating repetitive jobs, simplifying procedures, and lowering the time and effort necessary to execute particular tasks, companies may save costs, boost productivity, and enhance overall performance. Improved product quality is another significant effect of enabling technologies. Quality

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control software, inspection equipment, and other tools can detect issues early in the manufacturing process, reducing product recalls and improving customer satisfaction. In addition, sophisticated analytics tools may assist businesses in processing large volumes of data to uncover trends, patterns, and improvement possibilities, helping them to make data-driven choices and optimise their operations. Manufacturing enabling tools have a tremendous influence on companies, allowing them to increase their efficiency, productivity, and profitability, as well as their product quality. As technology continues to grow and new tools become available, firms that use these technologies will have a market edge and be better positioned for long-term success.

In many industries, operator-tool interaction is crucial to productivity and output. Automating repetitive tasks allows operators to focus on more complex tasks, improving performance and job satisfaction. Enabling technologies can also provide operators with real-time performance data to help them improve and adjust their technique. Using sensors and monitoring systems, manufacturing companies can check equipment performance, identify faults, and adjust machine settings to maximise production and reduce downtime. Similarly, Supply chain management software can track delivery times, optimise routes, and improve logistics performance.

Augmented Reality (AR) is one of the most current enabling technologies that has begun to be used in developing industrial applications as it provides operators with information, visualisation, and instructions that are superimposed into their actual surroundings in real-time. This can improve the precision and competence of industrial processes, allowing operators to perform their duties more efficiently and safely. AR may also be utilised for remote collaboration, enabling specialists to give real-time instruction and assisting operators from any location [2]. AR is distinguished by its capacity to boost operator performance (OP), minimise mistakes and accidents, and raise industrial processes' productivity and efficiency. By incorporating augmented reality into their operations, companies may achieve considerable cost savings, enhance product quality, and remain competitive. Phones, tablets, and smart glasses are all examples of AR tools. One of the key benefits of smart glasses over other AR devices is that they offer an immersive experience, allowing operators to concentrate on their tasks while still having access to relevant information. Smart glasses can enhance worker safety by giving real-time information about possible dangers and safety practices [3]. They may also assist employees in identifying and resolving issues faster, minimising downtime and enhancing productivity. Also, the industry is more accepting of smart glasses for their sturdiness, and durability. They also have speech recognition and gesture control, making them simpler to use and more efficient than other AR technologies.

Evaluating is crucial in manufacturing since it directly influences product quality, production efficiency, and overall profitability. Yet, monitoring OP may be difficult in many sectors. The complex and dynamic character of the manufacturing environment is one of the key reasons behind this. Manufacturing processes include many variables, and adjustments in one variable can greatly influence OP and product quality. Moreover, OP can be difficult to quantify accurately since it frequently requires subjective judgments about the quality of work [4]. Lastly, the lack of a standardised method to monitor OP across sectors can make comparing performance data and identifying best practices challenging.

2. *Research Methodology*

To identify industry-wide OP assessment methods, a comprehensive literature analysis was conducted. The search terms employed in the review included "operator performance evaluation", "operator assessment", and "operator training". The review was carried out utilising diverse online databases, including Scopus, Web of Science, and Google Scholar. Additionally, a manual search of pertinent journals and conference proceedings was conducted to supplement the findings.

2.1. Evaluation of the traditional operator evaluation methods/tools

A survey was carried out in the industrial sector with the aim of obtaining valuable insights into the practices, challenges, and prospects for enhancing the evaluation of OP. A purposeful group of industry professionals with experience evaluating OP was chosen, and a web-based survey was used to collect their responses. The survey comprised of a combination of open-ended and closed-ended questions, with the aim of gathering data on existing practices and viewpoints regarding potential ways for enhancement. The data collected from the survey was subjected to descriptive qualitative analysis to analyse their answers. Subsequent to the survey, the results were utilised to guide the creation of the suggested approach to evaluating the efficacy of OP. Furthermore, an assessment of the existing AR applications was carried out to ascertain their appropriateness for implementation in the proposed approach. The study centred on examining software programmes that have the potential to offer instantaneous evaluations of operator proficiency and augment the instructional process. Various applications were assessed according to their characteristics, user-friendliness, and ability to integrate with current systems. Upon thorough evaluation, the Microsoft Dynamics Guide (MDG) was deemed as the optimal resolution owing to its comprehensive functionalities, user-friendly interface, and effortless integration with pre-existing frameworks.

2.2. Integrating AR in evaluating operator performance

The proposed solution seeks to utilise AR technology for assessing OP during task execution. According to the findings of the industrial survey, the parameters of output per hour/day/shift, along with defect rate, were frequently employed as the primary benchmarks for assessing the efficacy of OP. AR technology has the potential to offer a system, as shown in Figure 1, for real-time data collection and analysis. A comparative analysis between the conventional approach and AR for assessing an operator's proficiency reveals several significant differences and benefits. The conventional method of evaluation might be biased and time consuming due to the manual data collector's subjectiveness. On the other hand, AR facilitates the automation of the data collection process, thereby allowing for the instantaneous acquisition of performance metrics while the operator performs their regular duties. The utilisation of automated data collection methods serves to improve the objectivity and accuracy of the evaluation process. An additional benefit of AR is that it gives operators quick feedback. By means of AR-enabled devices, operators are provided with visual cues, instructions, and performance indicators superimposed on their field of view, which enables them to make instantaneous adjustments and enhancements. The prompt feedback mechanism enables prompt improvement of skills and enhancement of performance. Furthermore, AR enables the establishment of uniformity and objectivity in assessments. Through the

utilisation of predetermined metrics and guidelines, AR systems guarantee uniform evaluation criteria across diverse operators and tasks. This consistency eliminates subjectivity and ensures objective and fair evaluations. The educational advantages of augmented reality surpass mere assessment. This practise diminishes the necessity for distinct evaluation sessions, resulting in time and resource conservation. Although the implementation of AR technology may necessitate an initial investment and training, its academic benefits, such as heightened objectivity, instantaneous feedback, uniform evaluations, improved training, and increased efficiency, establish it as a promising instrument for assessing an operator's academic proficiency.

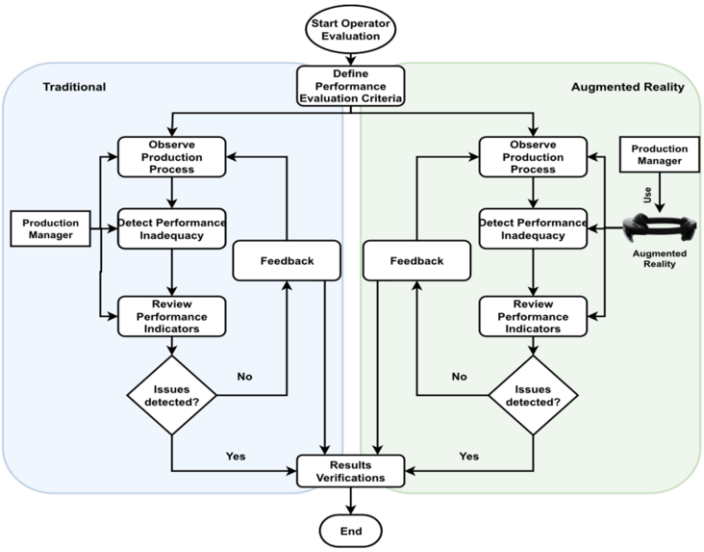

Figure 1. A Flowchart Comparison of AR and Traditional Operator Performance Evaluation.

3. Results

The objective of evaluating OP is to appraise and enhance operators' effectiveness and proficiency in executing their designated duties. This process is very important to the industry because it helps make sure that goods are always of high quality and are made in a safe and fast way. The evaluation of OP is a crucial process that can yield useful insights into potential areas for improvement [5]. This feedback can be leveraged to identify opportunities for enhancing operator skills or optimising production processes through measures such as supplementary training or equipment upgrades. Moreover, through the identification of areas where operators may be encountering difficulties, performance evaluation can serve as a preventive measure against accidents or errors that may lead to product defects or workplace injuries.

3.1. Traditional operator evaluation methods and tools

A typical approach is direct observation, in which a trained supervisor or manager watches and notes the operators' actions and performance. This can be measured in terms of how long it takes to perform tasks, how many mistakes are made, or how high the

quality of the final product is [6]. Another approach is using sensors and other automated tools, such as motion-tracking or eye-tracking technologies, to collect data on OP [7]. The data gathered by these technologies may then be evaluated to find improvement opportunities. Several sectors now analyse OP in a controlled environment using simulations or virtual reality systems [8]. Furthermore, Key performance indicators like production efficiency, quality, and safety are also used to evaluate OP in many companies. These methods help companies identify and track improvements. However, the cost of deploying and maintaining such tools and the need to ensure that all operators and teams use them equally present challenges. Braarud's research [9] took advantage of structured task-specific observation methods and scenario replay to assess operators' performance in an industrial environment. The study found that control room operators' team performance assessments matched the experts'. However, experts were better at identifying team performance improvements. Structured task-specific observation protocols and scenario replay were found to be effective at assessing team performance and identifying improvement opportunities.

3.2. Industrial investigation for operator performance evaluation

Current research has yielded significant findings related to the techniques utilised by companies to assess the operator's performance. Output per hour, day, and shift, followed by defect rate, were the most often used criteria for evaluating OP. The most commonly used data collection methods were manual data collection and peer-to-peer feedback. The results indicated that respondents utilised OP data primarily to make decisions regarding process enhancement, resource allocation, and the identification of training requirements for personal performance development. The findings showed that only a small percentage of respondents reported routine OP reviews, with the majority of evaluations being undertaken on an as-needed basis. Moreover, production managers and lead operators/supervisors were found to be predominantly accountable for conducting evaluations, with input from additional stakeholders, including experienced operators and production engineers. One-on-one meetings with administrators or supervisors were the most popular form of delivering feedback to operators, followed by written reports and training sessions. Moreover, the research identified various measures implemented by companies to tackle issues related to OP, such as providing additional guidance and training, adjusting job duties, and applying suitable disciplinary actions. In addition, the difficulties associated with assessing OP were highlighted, such as competing demands on time and priorities, collecting and analysing reliable data, and ensuring assessments are fair and objective.

3.3. Hololens 2 as a tool for operator performance evaluation

The operator's performance evaluation can be enhanced in a number of ways with AR smart glasses. First, the glasses provide real-time performance feedback to the operator. Managers can track the operator's progress and identify areas that need more training. Supervisors can give operators specific feedback to improve if they make mistakes or take too long. MDG enables the tracking of user progress and performance data [10]. This includes a worker's task completion time, precision, and rate. The above data can evaluate employee performance and identify areas that need improvement. Analytical tools on MDG platform help organisations evaluate performance metrics and

spot trends. MDG also helps companies create employee assessments which can assess employee proficiency and identify areas that need training.

Second, AR smart glasses can assist in making sure that operators are employing the proper protocols and resources. By displaying instructions and guidance in the operator's field of vision, smart glasses can reduce errors and ensure task accuracy. This can boost productivity while also enhancing workplace quality and safety. Third, AR smart glasses can make operator training more engaging. Augmented reality can show operators instructions and give them feedback as they complete tasks. This may result in better skill application and retention, which in turn may improve performance. MDG enables interactive guides with step-by-step procedures and best practices for companies. The guides can be tailored to the company's requirements, such as equipment, safety protocols, and related details [10]. MDG can aid in proper usage of protocols and resources by guiding operators. Moreover, MDG can integrate with other systems and resources to provide operators with necessary information and tools. The platform can integrate with inventory management systems to provide operators with the necessary parts and tools for a specific task. This can enhance workplace competence and minimise errors.

4. Conclusions

In conclusion, assessing OP is vital for ensuring the production of goods with high quality, safety, and efficiency. Companies use different methods to assess OP, such as direct observation, sensors, simulations, and key performance indicators. Yet, these methods have challenges, including deployment and maintenance expenses. The results of industrial investigations can be used to pinpoint knowledge gaps and make improvements to the existing methods for gauging OP. AR smart glasses like Hololens 2 can improve OP evaluation through real-time feedback, protocol adherence, and immersive training. The study suggests that Hololens 2 along with MDG has potential for assessing OP. This is because it can incorporate structured task-specific observation protocols and scenario replay. By leveraging these insights, businesses are able to identify opportunities for enhancing operator skills and optimising production processes through measures such as additional training or equipment enhancements, resulting in improved product quality and workplace safety.

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