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Cost Savings Analysis Through Predictive Maintenance Of Industrial Materials Using Augmented Reality In The Electronics Industry Of Tijuana, Baja California, Mexico

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Abstract - A study was made to assess the cost savings that can be generated in predictive maintenance processes in industrial operations of an electronics industry located in Tijuana, Baja California, Mexico, which city is located in the northwest area of the Mexican Republic. This is based on the function of predictive maintenance that was developed through Augmented Reality (AR) technology, by overlaying numerical information digitally in real time over physical equipment, in the operation of five industrial devices and five industrial machines used in a production line of this electronics industry, which allowed the scientific study to be conducted. This investigation was made in 2025. Costs were saved through predictive maintenance with AR.

Keywords: Electronics industry, costs, augmented reality, predictive maintenance.

1. INTRODUCTION

The use of augmented reality in industrial processes is changing the way equipment and industrial machinery are evaluated in manufacturing areas, to analyze their operation and thus be able to predict possible electrical, mechanical, pneumatic, hydraulic, electromechanical, electropneumatic, and electrohydraulic failures[1]. This is highly relevant because through AR, we can observe in real time the likelihood of a potential failure occurring and predict this situation, which can sometimes be simple or at other times complex, and it can even stop the production flow in industrial lines of this evaluated industrial company or in any other industry worldwide[2]. The use of AR, in this scientific study, focuses on the application of predictive maintenance on five industrial pieces of equipment and five industrial machines analyzed in this electronics industry, and thus be able to know as accurately as possible in real time with AR simulation, any potential electrical failures of those mentioned above[3]. This scientific study is part of the electronics industry that manufactures cell phones.

1.1 Electronic Industry

It is a type of industry that manufactures a large number of electronic products, which are widely used in everyday life by countless people around the world[4]. The main electronic products that are most manufactured include the following[5]:

- Communications area. Computers, tablets, and cell phones.

- Industrial area. Equipment and industrial machinery used for product manufacturing (production and quality control).
- Home appliances area. Electronic stoves, microwave ovens, electronic refrigerators, and other automated appliances.

1.2 Predictive Maintenance

It is a function elaborated in industrial operations, especially in equipment and industrial machinery, to detect possible faults, and thereby prevent complex situations and the possibility of a production line shutdown[6]. This action is very important because, based on the predictive analyses was made, information can be obtained about a mechanical or electrical part that causes the electrical and mechanical failures[8]. This is very helpful because you will need to have such parts in storage for industrial equipment and machinery, those kinds of parts that tend to fail more frequently so you can have them ready to avoid downtime of equipment and industrial machines, thus maintaining the industrial flow in manufacturing areas of industrial companies. Figure 1 shows a predictive maintenance action[9].



Fig -1: Evaluation of predictive maintenance
Source: El Rol del Mantenimiento Predictivo en la Industria Moderna

1.3 Augmented Reality for Industrial Predictive Maintenance

The use of AR for industrial predictive maintenance is very important in industrial processes, because technical or engineering staff can observe through special glasses or lenses how the equipment and industrial machines of the evaluated electronics industry, or any other industrial company, are operating, allowing them to predict possible failures in real time[6]. Figure 2 shows technical staff evaluating industrial equipment and machines through special glasses, using augmented reality as a predictive maintenance action, which helps prevent failures in the mentioned equipment and industrial machinery[3]. This is very important to avoid any critical situation in industrial processes that could stop the production flow, causing delays in manufacturing processes and in delivering to customers[10].

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Fig -2: Analysis of predictive maintenance using augmented reality
Source: Mantenimiento Industrial con Realidad Aumentada

2. METHODOLOGY

In this investigation, various activities were made, which are mentioned below, to determine that the use of augmented reality in the function of predictive maintenance for actions on industrial equipment and machinery is of great importance. These activities are detailed as follows:

a) Analysis of productive performance, productivity, and quality of products manufactured based on the operation of five pieces of equipment and five industrial machines from this evaluated electronics industry.

b) Comparative evaluation of not using and using augmented reality in the function of predictive maintenance for five industrial pieces of equipment and five industrial machines from this industry, which made it possible to carry out this scientific study.

3. RESULTS

In this scientific study, numerical and percentage information was obtained regarding the operational performance of five industrial pieces of equipment and five industrial machines, which are an essential part of a production line in the manufacturing of cell products from this analyzed electronics industry. The results are shown in the following sections.

3.1 Evaluation of productive performance, productivity, and quality

An analysis was made of three main factors that are very important in achieving the manufacturing and sales goals of each industrial company, especially focused on this highly relevant electronics industry. The percentage of numerical information obtained is shown in Table 1.

Table -1: Comparative analysis of production factors in the electronics industry (2024-2025).

Production Factors	Operative Yielding, %		Productivity, %		Quality, %	
Months	BI	AI	BI	AI	BI	AI

January	56	83	48	80	54	81
February	58	84	50	83	50	80
March	61	85	51	82	48	84
April	63	88	54	84	53	82
May	66	86	53	81	56	88
Junie	68	88	56	80	58	85
July	67	89	57	88	60	87
August	65	90	60	86	62	88
September	66	92	58	87	63	85
October	68	94	63	85	61	89
November	69	90	64	88	64	90
December	66	92	61	90	66	92

BI. Before starting the investigation (2024), AI. After completing the investigation (2025)

The table above shows the percentage indices of the three production parameters evaluated in five industrial machines and five industrial devices, noting an increase from 2024 to 2025, where the comparative analysis is illustrated. Table 2 shows the operational performance of the evaluated industrial machines and devices. In both analyses, increases in the three evaluated production factors are shown.

Table -2: Operational performance evaluation of industrial machines and devices in the electronics industry (2024-2025)

Production Factors	Operative Yielding, %		Productivity, %		Quality, %	
	BI	AI	BI	AI	BI	AI
Equipment						
1	43	83	45	82	56	87
2	48	86	48	80	54	88
3	54	88	53	85	55	85
4	52	90	55	88	57	90
5	57	92	52	86	60	95
Machines						
1	52	84	57	85	53	85
2	50	86	55	88	56	88
3	55	88	58	84	57	83
4	53	90	54	89	60	88

5	56	94	59	90	62	90

BI. Before starting the investigation (2024), AI. After completing the investigation (2025)

3.2 Comparative analysis with and without augmented reality in predictive maintenance

This section of the scientific study was very relevant because specialized equipment was obtained (lenses and glasses for AR analysis), as well as a supercomputer to store numerical data and convert it into percentage levels, and Unity software to evaluate predictive maintenance actions with augmented reality in real time. Table 3 shows a comparative evaluation of using and not using AR for predictive maintenance functions, in relation to the three relevant production factors, presenting increases in the percentage indexes of each production parameter, indicating that the use of AR in predictive maintenance is very important. This represents reliability in manufacturing processes.

Table -3: Analysis of the use and non-use of AR in predictive maintenance in the electronics industry (2024-2025)

Production Factors	Operative Yielding, %		Productivity, %		Quality, %	
	AI	DI	AI	DI	AI	DI
Equipment						
1	32	88	38	85	48	87
2	36	90	43	86	53	89
3	47	94	46	89	57	93
4	54	96	50	93	60	94
5	60	98	56	95	67	96
Machines						
1	41	86	45	84	56	86
2	43	89	48	87	59	89
3	48	91	55	88	63	91
4	56	94	60	92	66	94
5	63	97	64	96	69	98

BI. Before starting the investigation (2024), AI. After completing the investigation (2025)

4. CONCLUSIONS

Research is crucial for implementing high technology, like augmented reality in predictive maintenance processes in manufacturing areas, highlighting the need to evaluate this action visually in real time and to be able to predict electrical failures in equipment and industrial machinery. It's necessary to apply this technology in all industry activities and in all industrial companies worldwide. Costs were saved thanks to predictive maintenance with AR.

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