i-Tutoring with AR to Support Decisions in Assembly via Problem Solving for Aeronautical Transportation

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ABSTRACT

Advances in Problem Solving methodology focused in learning the assembly operation in terms of productivity, must certainly be exploited. This work proposes a congruent integration of ideas and procedures that will lead to determine a process solution. That is, in certain assembly cases it is possible to combine Intelligent Tutoring with Problem Solving to constitute a robust framework in order to support decisions for complex assemblage that do not have been reached by robotic systems. The challenge is a pool of critical thinking and creative thinking to connect a cause-effect analysis and decision making with process (or product) innovation. So Decision Making is fortified to get better or exceptional support. An assembly case aided by Augmented Reality is developed through the construction of a diagram that uses the format IF…THEN, which is a crucial issue in aeronautical transportation.

Keywords: problem solving, process innovation, aeronautical transportation, augmented reality (AR), complex assembly.

1. INTRODUCTION

It is fundamental to integrate Intelligent Tutoring with Problem Solving to establish a robust framework that supports decision making for complex assembly circumstances about which, in [1] and [2] it is demonstrated that these cases have not been settled for robots; so that it is promising to attempt to work for connecting cause-effect analysis, preventive planning and decision making as it is intended to elucidate latter.

This task claims to combine critical thinking (process questions for analyzing complex situations to separate and arrange into manageable concerns and so having separated and prioritized a major concern) with creative thinking (techniques for problem definition and idea generation and so getting several creative solutions to a major concern that requires an innovative approach).

Problem Solving has been used as a technique in automotive industry due to ISO standard has been demanding. Some principles and diagrams exist and constitute an important point about this. It can be primarily mentioned:

- Ishikawa or Cause-Effect diagram (or Fishbone),
- Pareto principle.

Consider a typical Ishikawa diagram in Fig. 1, including its causes which are signalized using eight words with letter M at the beginning; it is named 8 Ms Cause-Effect Diagram.

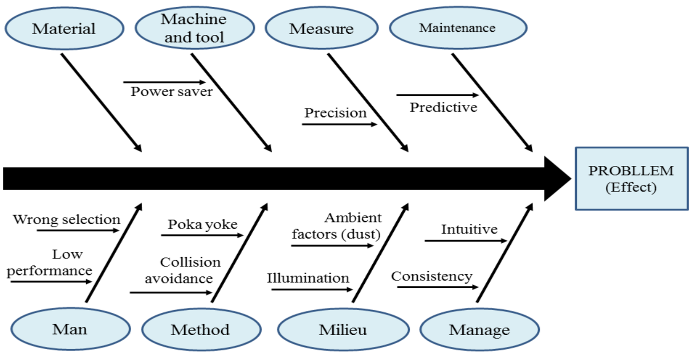

Figure 1. A typical Ishikawa diagram that reflects Cause-Effect action in a troublesome situation.

Albeit industrial engineers are dedicated to analyze causes for production problems related to Method, herein three types of Poka-yoke techniques are described, according to [3]:

- Contact type: shape, dimensions or other physical properties to detect the contact or non-contact of a particular feature, e.g.: case of only fitting one way to assembly.
- Constant number type: if a fixed number of movements are not made an error sign is triggered.
- Performance sequence type ensures steps are performed in the right order.

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Likewise method, other causes and sub-causes can be studied to entirely determine them as it shall deploy in Section 3 for an aeronautical component.

The outlined Fishbone shows eight causes (and many sub-causes) in this problem circumstance. Even so it is appropriate to assign weights ($w_1, w_2, \ldots, w_8$) to causes for pondering them according to their magnitudes and/or importance degrees to get a Pareto-based Cause-Effect diagram as it can be seen in Sections 2 and 3.

1.1 Related Work

Some papers have dealt with this theme however several of them are outstanding and related to this research.

In [4] is explored the knowledge related to processes and resources to support decision planning which are used to explore a manufacturing knowledge model structure to describe the plant capability.

In [1] is discussed about expert transfer systems by using AR and demonstrated the assemblage must be complex when Augmented Reality technology is utilized to assist the assembly process. And in [2] is affirmed that until now complex assembly has not been accomplished by robots. In [5] is anticipated that among diverse activities involved to produce AR technology, one is identifying the user case and planning the project, 3D modeling, texturizing and animating, and also developing software. Thus we shall need to use these elements to integrate a quality condition for achieving a correct effect.

1.2 Plan of the Article

This is the first stage with a few technical data of a work in progress; conversely more numeric fallouts will be reported in a future paper. In Section 2 a methodology is described while the concern descriptions and task are made in Section 3. Results and discussion are in Section 4 while conclusions and future work in Section 5.

2. METHODOLOGY

A beginning is intended by registering the causes that can generate a product, for example a wrong or right assembly aided by a technology, which is our concern we will try to describe.

Related to Fig. 2, it is possible to ask for the causes or a main cause that provoke collisions when the operator is going to assembly two parts for a component.

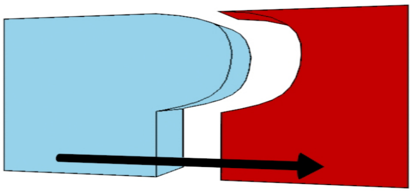

Figure 2. Alignment condition for a well-designed AR tracking.

Retaking the Ishikawa diagram of Fig. 1 which basically shows eight problem roots it is possible to constitute a method starting to assign weights ($w_1, w_2, \ldots, w_8$) to the causes for pondering according to their magnitudes.

It is convenient to fix these causes in descending order. Then it can be stated equation (1) and Table 1.

$$w_1 > w_2 > \ldots\ldots > w_8 \qquad (1)$$

This assigning task about importance degrees (made for experts) must be, accomplished for reflecting the weighted causes (on Table 1) and considered as an attainment of a priority set which serves for influencing the decision making process focused on problem solving.

Table 1. Causes weighted in descending order of priority.

CAUSES	WEIGHT	VALUE
Material	w_1	0.20
Machine and tool	w_2	0.17
Measure	w_3	0.15
Maintenance	w_4	0.12
Man	w_5	0.11
Method	w_6	0.10
Mileu	w_7	0.08
Manage	w_8	0.07
TOTAL	$\Sigma\, w_i$	1.00

The Tutoring leads to create a scheme to manifest logical interactions between the causes and correspondent typical actions.

So by considering the assigned weights ($w_1, w_2, \ldots, w_8$) of the causes we can ponder them. Next step is to outline the correspondent diagram in Section 4 including the statute IF…THEN of Artificial Intelligence. This shall be exploited to support decision making for assembly aided by AR.

3. CONCERN DESCRIPTIONS AND RESEARCH TASKS

The study task is related to a wing of an aeronautical RV-10 kit considered by [7]; this assembly involves drilling and riveting processes so it is needed the worker has some basic knowledge for operating the tools.

Basic marks for AR tracking are pasted on each piece (Fig. 3) to execute a Poka-yoke technique [8,9] where two pieces are posed to an AR system to verify they are the correct parts in this stage of the assisted assembly. Users are involved with animated models and depiction about how to accomplish the assemblage.

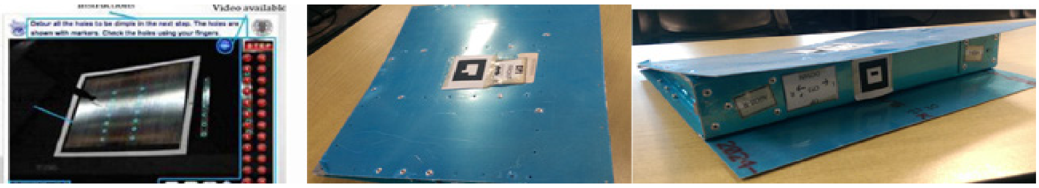

Figure 3. AR application and pieces of the assisted assembly of the RV-10 kit on Lab.

Causes that can affect an AR aided assembly are, Texture that determines the look of the 3D models; Content Design that defines the additional information for assembling (like images, tables, videos, and text); External Factors as ergonomic factors; Graphic user interface (GUI) for understanding about how to practice the AR application; and other elements like Animation, Model and Planning process defined by [5]. It must be listed the most important roots with theirs corresponding weight values on Table 2, which can lead to a right assembly assisted by augmented reality and be considered the Fishbone or Ishikawa diagram (Fig. 4). Eight causes that provoke a well aided assembly are deployed in Fig. 4; it represents how the visualization of each root at the Fishbone helps to conceive a prototype to simplify the design of process to, for example, detect collisions (Fig. 4) and so on to calculate a total assembly impact. Having the causes, they are encrusted on Fishbone diagram in Fig. 4 and weighted (Table 2) on descending order of their primacy to generate a right assembly. These values are gotten by studying AR aided assembly cases and participating in related projects.

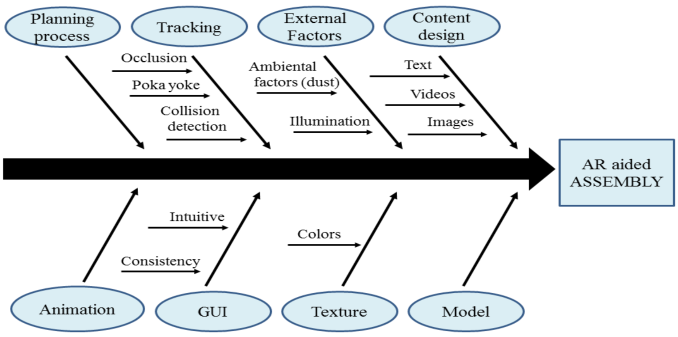

Figure 4. Ishikawa diagram that reflects Cause-Effect action for an AR assisted assembly.

Again causes are weighted and showed in Table 2, on descending order of selected roots.

Table 2. Weighted causes for an assembly assisted by AR.

CAUSES	WEIGHT	VALUE
Planning process	w_1	0.20
Tracking	w_2	0.17
External Factors	w_3	0.15
Content Design	w_4	0.12
Animation	w_5	0.11
GUI	w_6	0.10
Texture	w_7	0.08
Model	w_8	0.07
TOTAL	$\Sigma\, w_i$	1.00

Consequently by assigning weights (w_1, w_2, ….., w_8) to the causes it is attained the diagram (Fig. 5) in Section 4.

4. RESULTS AND DISCUSSION

Authors in [4] have argued that the UML tool (Unified Modeling Language) is useful in the creation of new structures detailing attributes for defined knowledge classes. Their experimental software system demonstrates the functionality of a model using object-oriented database environment and must be intended to select the best process based on IF…THEN rules, where the decision criteria involves some characteristics (dimensions and tolerances); so it allows definition of certain interactions after being populated with information instances. Analogously, it could be constructed a diagram in Fig. 5 for tutoring so that decision making may be reinforced.

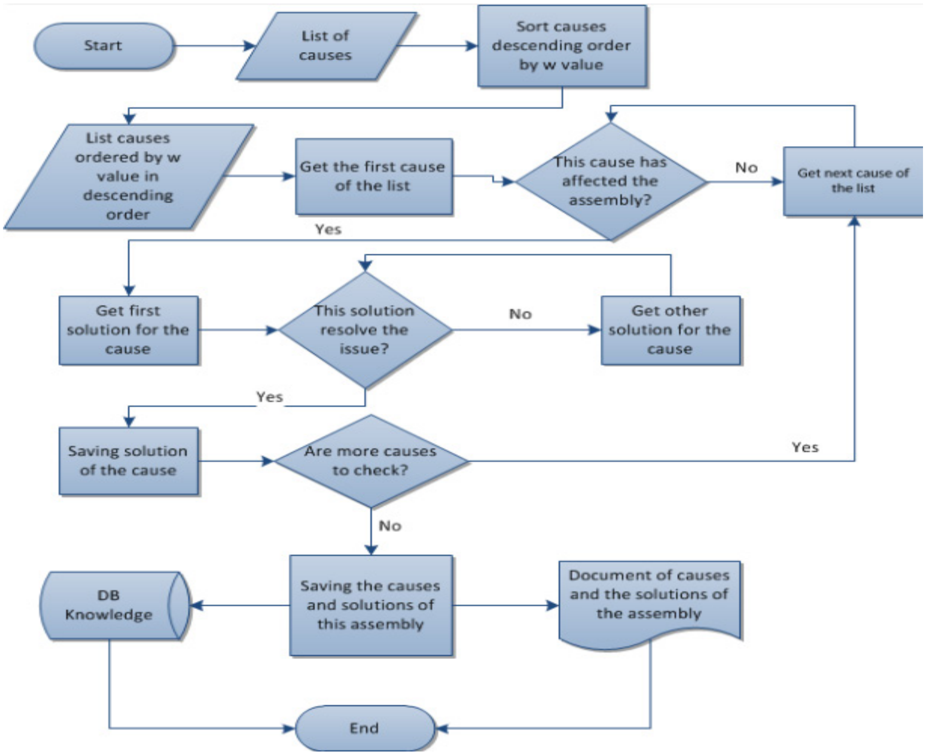

Figure 5. Flow diagram to support decision making via problem solving for complex assembly.

Following the described methodology, the main consequence is the diagram deployed in Fig. 5.

5. CONCLUSIONS AND FUTURE WORK

Eight causes for obtaining a correctly aided assembly are deployed representing how the visualization of each root at the Cause-Effect (Ishikawa) diagram helps to conceive a prototype to simplify the design for achieving a process innovation to, for example, detect collisions by supporting via Ishikawa diagrams which include collision detection and collision avoidance. And so on to calculate a total assembly impact. The main outcome of this work is a flow diagram that has been developed to support decision making via problem solving in assembly aided by Augmented Reality technology for aeronautical transportation.

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