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# Improvement of Realization Quality of Aerospace Products Using Augmented Reality Technology

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***Abstract*—**In the aviation industry, many faults may occur frequently during the maintenance processes and assembly operations of complex structured aircrafts because of their high dependencies of components. These faults affect the quality of aircraft parts or developed modules adversely.

Technical employee requires long time and high labor force while checking the correctness of each component. In addition, the person must be trained regularly because of the ever-growing and changing technology. Generally, the cost of this training is very high. Augmented Reality (AR) technology reduces the cost of training radically and improves the effectiveness of the training.

In this study, the usage of AR technology in the aviation industry has been investigated and the effectiveness of AR with heads-up display glasses has been examined. An application has been developed for comparison of production process with AR and manual one.

***Keywords*—**Aerospace, assembly quality, augmented reality, heads-up display.

## I. Introduction

AUGMENTED reality means that enrich of information which in our world for a purpose with combining image and / or data which are obtained by a machine and Augmented Reality is a simultaneous presentation of live footage and material or drawing which are prepared before. Developed software compile these combined images and show to the users [1], [2].

Under favor of Augmented Reality, any desired object could be positioned and made been functional in real world via a mobile device, a computer that integrated with a camera or heads-up display glasses [2], [3].

Today, the AR has been come in to use in numerous areas, particularly education and defense technologies.

If we look from the viewpoint of aviation industry, technical employees have to be very experienced at areas of system design, implementation and assembly inspection. These employees trying to make their work faultless with help of inspection period of system and user or technical guides. Because of being always obliged to consult to external resources such as digital mock ups (DMU), employees cannot concentrate to their job effectively. This problem scaling up to serious level at modern airplanes and complicated machines due to Aircraft products are becoming more complex and vary depending on design. Although prepared some interactive technical guide for these systems, consulting to external resource is still necessary.

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## II. Manufacturing Processes Cycle

### A. Product Design and Development

With rapidly developing technologies in industries, product design processes are being assisted with computer based utilities. In current use we can define these utilities as Computer Aided Design (CAD). Congruently in manufacturing process it can be named Computer Aided Manufacturing (CAM). In aviation industry, usage of these tools takes an important place for design and manufacturing. CATIA is most preferred tool in this context for aircraft designers [2], [3]. To make these process more efficient and beneficial, researchers and process management experts have begun to do research on the availability of virtual reality and augmented reality in these areas. Augmented Reality and Virtual Reality and also Mixed Reality are applicable to improve and make more effective CAD process.

Sabine Webel et al. presented an AR based tool-chain which allows matching the CAD data with real mock-ups. In their solution, the CAD model and the physical mock-up are aligned in a live video sequence. The user compares the two models by visually of the real and virtual geometry [4].

### B. Design Review

Revision of a design is realized with physical mock-ups. Some of them are developed to enable the review of the form of a product by its designer, while some are developed with partially realized functions for applicability objects.

VR and AR technologies are used to enable effective design applicability in terms of usability and design. However, physical quality of the design of product such as weight is not easy for the user to discern in design systems based on virtual reality. To overcome this problem AR based design systems were developed for the designers and experts to review the designs depending upon concrete mock-ups [2].

Aoyama et al. used ARToolKit marker and magnetic sensors on the physical mockup to make easier the rendering of the appearance of product and responses of the product which is interactive with the buttons on it [5].

### C. Assembly Inspection and Discrepancy Check

Throughout the design and production is completed smoothly and efficiently, in assembly line many faults might occur: the components might be missing or on incorrect position or might be not tightened.

In industries, the most common for checking these assembled items is to take manual visual inspection and measurements.

To achieve an optimal assembly duration, it is aimed to reduce the assembly completion time and workforce cost with minimum material loss.

AR technology facilitates the assembly sequence planning and validation as it saves the time and material needed to produce the real assembly sequence design for product re-use or reverse engineering. For this purpose, CAD models of real objects should be reproduced in real time.

We can define the procedure of validating the model as discrepancy check. In this context, AR technology enables the user to procure a solution in order to find differences or discrepancies between the designed and developed model and the assembled items. AR software could be used as a detection and failure notice system whether the produced item is different from the planned one.

In the next section, we proposed that based on this improvement awareness, we will introduce the details of developed augmented reality based solution which aims at facilitating our aircraft assembly inspection processes.

## III. Assembly Inspection Processes

In the factory, we have a department that controls and inspects all aircraft production units and their assembly processes which includes pipes, brackets, cable-racks, electrical bounding, and control boxes in accordance with the technical procedures.

The main job descriptions of this department are:

- Determine and apply the examination of in-process or final inspection / testing / acceptance functions for all manufactured that main assembly or sub-assembly parts.
- Engineering related to the contract with the main components and sub-assemblies manufactured documents and ensure that the correct configuration in accordance with the procedures.

Fig. 1 shows the application area. During the assembly inspection, technical controller team checks:

- Whether is there any missing parts or not,
- Whether brackets are on right position/direction or not.

Also if a bracket has electrical bounding, they should check it too. If all components on aircraft panel have true configuration according to technical design documents, examination process is finalized successfully.

Part and/or system deployment are being made by quality control technically with drawing and blue prints. This process is taken for not only bracket control but also complicated system or harness deployment at lately examination phase. 2D/3D technical drawing control is rising 100 percent by DMU image and bracket control before system integration and harness deployment.

## IV. Developed Application

The geometric positioning of the virtual objects on the real environment provides a basis for AR applications. This positioning is supported by text messages, image boxes or navigations. Proper localization allows the implementer to accept virtual content as improvement of the real objects instead of a separated or overlaid layer of data. This could be done for every object by means of applying some transformations and detections like feature, corner or blob of object.

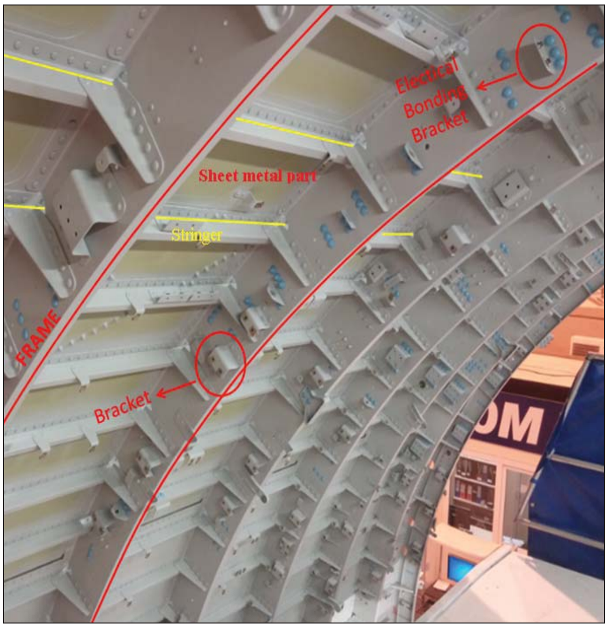


Fig. 1 An aircraft upper shell examined for assembly inspection

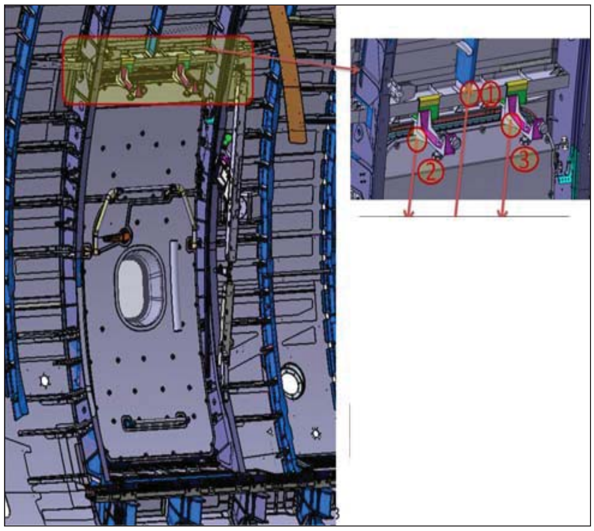

Fig. 2 Aircraft panel digital mockup with stringers, brackets, pipes and cable-racks

### A. Computer Vision (CV) Based Tracking

Computer vision based tracking should be separated from marker based tracking. Marker based tracking uses fiducial markers which can be used to determine and detect camera pose in relation to each marker, so it also causes some disadvantages. For example, with this method, attachment to the objects which are going to be augmented is so difficult. While this problem might be solved by using more than one camera, overall tracking quality and success of localization reduces significantly. If we talk about applying this to an aircraft panel, it requires that markers should be used on all locations, so it means that quite time-consuming, large number of markers and control difficulties. Because of these difficulties, marker less tracking methods using natural features of the environment to be augmented for tracking is encouraging approach for industrial systems.

In the following section, there is an overview of used present Simultaneous Localization and Mapping (SLAM) tracking methods and mechanism.

*B. Simultaneous Localization and Mapping (SLAM)*

Simultaneous localization and mapping (SLAM) is the computational problem of constructing or updating a map of an unknown environment while simultaneously keeping track of an agent's location within it [6].

It was originally developed by Hugh Durrant-Whyte and John J. Leonard [6] based on earlier work by Smith, Self and Cheeseman [7] Durrant-Whyte and Leonard originally termed it SMAL but it was later changed to give a better impact. SLAM is concerned with the problem of building a map of an unknown environment by a mobile robot while at the same time navigating the environment using the map [6]. SLAM consists of multiple parts; Landmark extraction, data association, state estimation, state update and landmark update. There are many ways to solve each of the smaller parts. This also means that some of the parts can be replaced by a new way of doing this [8].

The SLAM process consists of a number of steps. The goal of the process is to use the environment to update the position of the robot. This is accomplished by extracting features from the environment when the robot/tracker moves around. An Extended Kalman Filter [9], [10] is the center of process. It is responsible for updating where the robot thinks it is based on the features. These features are commonly called landmarks.

*C. Solution*

Augmented reality technology on behalf of the company to trial within Upper Shell bracket assembly line is selected.

Developed application is designed to reduce the assembly inspection time of tens of thousands brackets that may hold pipes, wire bundles, electrical bounding's in place in the aircraft part and find out wrongly positioned, damaged or missing brackets. Also, this application is intended to minimize the errors that can occur while mounting bracket of the aircraft panel frame, improve work performance efficiently, reduce workforce labor and cost due to defective parts. Adept at working the system used now, inspectors do their job as taking information from technical guides and mock-ups that which bracket and where and in what way to installation.

In the present system, the DMU superimposed to the real part of aircraft panel. Benefiting from the laths on the upper shell part, recognition of the product is provided (Fig. 3).

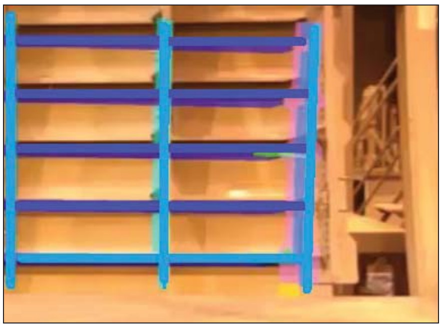

Fig. 3 Laths on the upper shell panel of aircraft

Following, brackets are displayed on the screen where should be located on.


Fig. 4 Located brackets on the screen

By touching the desired part of the touch screen, actual state of the image can be seen clearly (Fig. 5). In this project, one workstation PC, a camera and Metaio software is used. Established image transferred to the computer with a fixed camera system and presented to the user.

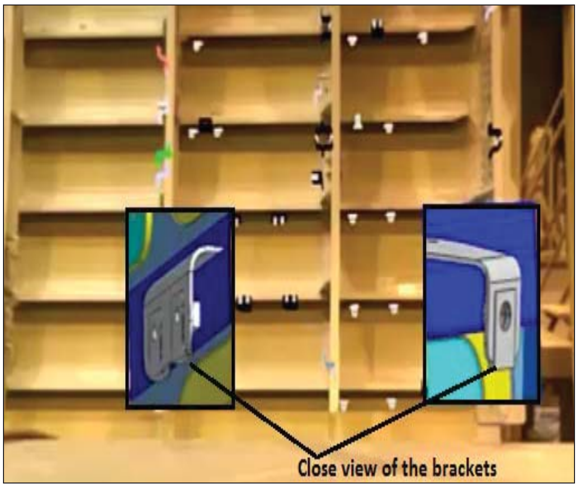


Fig. 5 Located brackets on the screen

## V. Conclusion

In this study, a system that helps the assembly inspectors by superimposing extracted CAD data and real part/panel of an aircraft product to check discrepancies and wrong configurations has been presented. The proposed solution gives the possibility to make as designed/as built comparison. With this comparison and assembly inspection, early production warning could be given. Depending on the aircraft type and work environment, it is intended to reduce the inspection time compared to normal manual inspection process. Also, through early detection of non-conformities, costly revisions that are performed later phases are avoided efficiently.

Instead of using a fixed camera, a heads-up display glasses can be integrated to the system. Also, linking this system with ERP system of the factory has been planned to develop an integrated industrial application.

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