Virtual Aircraft Environment to Evaluate Modification Proposal

Mr. Devender Sharma,
Research Scholar, GD Goenka University
Gurgaon, India
sharma_dev@hotmail.com

Dr.Sudeep Sharma
Dean, S of E, GD Goenka University
Gurgaon, India

***Abstract*- Both the military and civil aviation sectors in India comprise of foreign aircraft, designed, developed and manufactured by foreign OEMs. To modify these platforms to suit Indian requirements or integrate an indigenous sub system involves lengthy and expensive experimentation process using physical prototypes and time consuming procedures. Besides non reversible modification/ adaptation procedures to evaluate/ integrate subsystems on an old aircraft, expensive platform also suffers the risk of getting damaged during the integration process. The research paper outlines methodology to develop a virtual environment of an aircraft for evaluating modification proposals in an efficient manner thereby saving cost, time and effort. This research work shall facilitate visualization and immersion into a virtual aircraft along with modification scheme for subjective assessment of functional aspects like ease of operation, interference with the existing design, maintainability and aesthetics along with quantitative evaluation of engineering parameters affecting safety, performance, stability and control of the aircraft as a result of the modification.**

Keywords: - Virtual reality (VR), EMI/EMC, CAD.

I. INTRODUCTION

A. *Aircraft Modifications* the modification proposal to an aircraft can be subdivided into minor and major changes. Minor changes are those which do not appreciably affect weight, balance, structural strength, reliability, operational characteristics, airworthiness characteristics, power and noise characteristics, or emissions. Major modifications however involve altering its dynamic characteristics during flight ultimately affecting its attitude and resulting flight path. Notwithstanding the nature of modification being minor or major, all these need to be tested and evaluated for optimal performance and various options to suit functional requirements and other associated factors like power supply availability, EMI/EMC, floor loading, structural strength, maintenance requirements and aesthetics. Weight and CG are two major factors directly affecting the aircraft operation in terms of performance, stability and control. Combination of weight and CG also affect stick forces experienced by the pilot. To relieve the pilot of heavy stick force, the aircraft is trimmed in all the three directions. In a way, feasibility of a modification proposal can be evaluated by calculating the trim condition for a given set of flight conditions which is a direct indication of the controllability and flying characteristics of the aircraft.

B. *Virtual Reality* Virtual reality (VR) is a technology, which allows a user to interact with a computer-simulated environment, be it real or imagined one. Users can interact with a virtual environment either through the use of standard input devices such as a keyboard and mouse, or

through multimodal devices such as a wired glove, the boom arm, and an omni directional treadmill. For advanced engineering applications, simulated environment need to be similar to the real world, for example, simulation for pilot for combat training.

C. *Application of VR in Aeronautics*
Technological breakthrough and consequent development in the field of Virtual Reality have seen large scale applications in diverse fields. In the aeronautics sector, the documented research has been mainly concentrated in the area of flight simulators and training aids. There has been preliminary effort to design and develop aeronautics products using virtual reality mainly by the world's major aeronautics OEM M/S Boeing. The VR technology has not been exploited for analysing and evaluating modification proposals on an aircraft which are essential part of customisation and enhancement of operational capabilities of a bought out aircraft by a developing country like us.

II. SCOPE

The broad scope of the research paper is to design and develop a virtual environment for testing / evaluating modification proposals on Airbus A 320 aircraft. This involves

1) Conversion of a downloaded 3 D CAD model of Airbus A 320 aircraft to VR format to enable its loading in the virtual environment.
2) Design and development of Virtual environment for evaluating Integration of Modification units (generated virtually) with the 3D aircraft model.
3) Displaying feasible mod options considering trim conditions for various flight parameters including stability and control characteristics in the visualized aircraft model.

III. LITERATURE REVIEW

The literature review exercise was undertaken to understand the current technological state of Virtual Reality and its utilization in various research areas related to the aspects involved in the aircraft modification process. Feasibility work on using virtual reality for design of asemblability and designing of virtual assembly environment has been undertaken by Sankar Jayaram, et al. The virtual environment aids the mechanical engineering design process for assembly, design for maintainability and assembly planning. Useful research on Creation of concept shape designs via a virtual reality interface has been aptly described by Tushar H Dani and Rajit Gadh. Another relevant paper published is Prototyping and Design for Assembly analysis using Multimodal virtual Environments by Rakesh Gupta, Daniel Whitneyt and David Zeltzert. X. Wang, S.K. Ong and A.Y.C. Nee in their research paper present a novel assembly simulation system incorporating real-virtual components interaction in an augmented-reality based environment. Another useful piece of research for this project is the study on virtual manipulation technology in virtual reality systems undertaken by Xiaoyong Lei, Shuling Dai, Jihong Mei and Jin Zhang. In the conference CIRPe 2015, Adelaide Marzano et al have presented a paper describing a unique environment whose features are able to satisfy requirements for both virtual maintenance and virtual manufacturing through the conception of original virtual reality (VR) architecture.

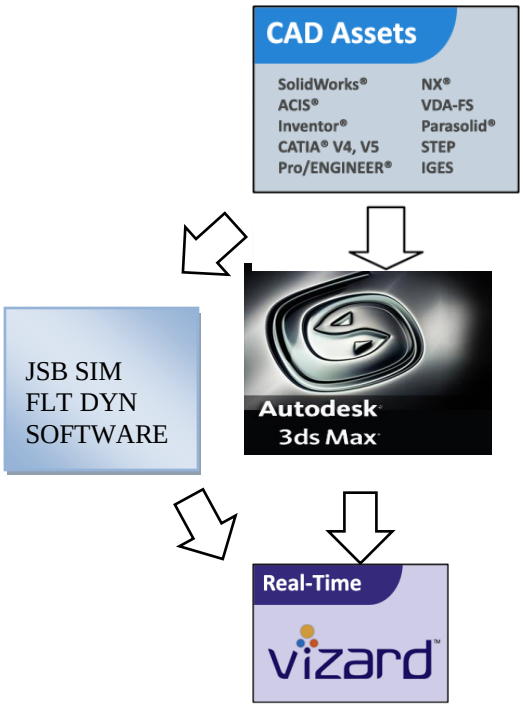
IV. TEST & EVALUATION OF MODIFICATION PROPOSAL

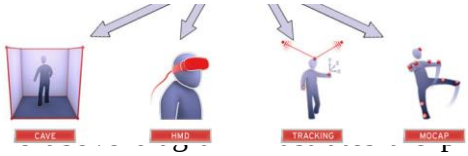
The process of testing and evaluation of a modification proposal for an aircraft can be broadly divided into following two distinct categories of assessments:-

A. Subjective assessment in terms of compatibility of the new system / design change with the existing system of systems. The aspects to be examined include physical interference, ease of operation, space requirements for functioning / maintenance, aesthetics, availability of power supply, floor loading constraints.

B. Quantitative assessment to verify likely changes in the flight dynamics of the aircraft due to introduction of the modification.

V. RESEARCH METHODOLOGY





posed methodology of the complete software at a high-level. Development of a virtual aircraft involves creation of a 3D model of aircraft in CAD software (or one can also use openly available free models like the A 320 model being used in the instant project), Conversion of model from CAD format to VR format (3D Studio Max or similar), simplification of 3D model as well as creation of multiple levels of detail for efficient rendering and suitable texturing and lighting of the model for realistic visual appearance real time virtual environment. The subsequent sections describe the three softwares being utilised for development of the Virtual aircraft environment for evaluating modification proposals.

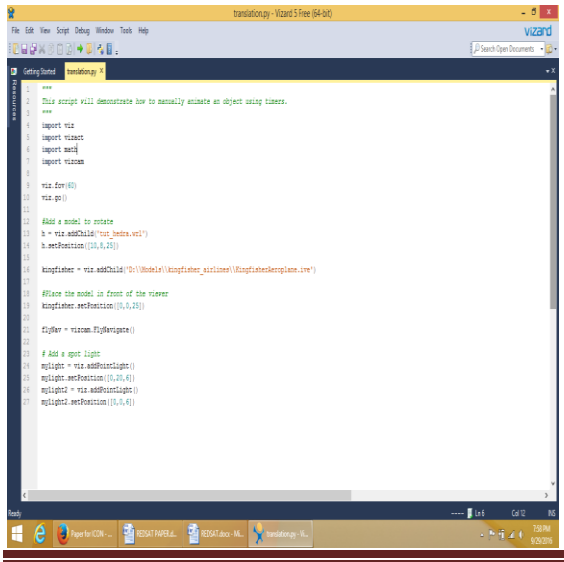
VI. 3 DS Max.

Aircraft models available in various CAD formats are very accurate and typically used for manufacturing. For interactive visualization and simulation; lower level of details are sufficient. For easy interpretation and operation for virtual reality, the CAD models are simplified and converted into a format suitable for interactive operation. Various tools are available which take CAD inputs and allow working on them. One such tools is Autodesk 3DS Max. This software has lot of functionality to edit and modify the base geometry imported from CAD models. Another advantage of using 3DS Max is that the visual fidelity of models can be improved by overlaying the base geometry with textures/images; which provide it a realistic interpretation. It also supports import of multiple CAD formats and export to VR suitable platforms like

WorldViz Vizard being utilized in this research project to create virtual aircraft environment.

VII. World Viz Vizard

The WorldViz Vizard software is an ideal software platform for developing VR applications especially for research applications. Available for free online along with features for Virtual Reality interactions, Physics, 3D Modelling, etc., the Vizard has lot of inbuilt tools to create powerful customized VR applications. Some of the features include import of 3D models, physics, VR interaction devices, data import, export from simulation models etc. The software also provides a powerful python interface to quickly program complex applications; and see the results on the fly.
Due to its simplicity and availability of default functionality it is used by various research applications. The following screenshots show the example codes in Python, for translation of the model and the Airbus A 320 of the King Fisher Airlines loaded into the software.



For our application, the following functionalities would be suitable and are being incorporated:

1) Import of 3D models.
2) Interactive creation, editing and moving of sub systems inside the aircraft.
3) Programming of Physics parameters associated with the 3D models.
4) Virtual reality based navigation and manipulation of various parameters associated with modifications in internal configuration

The research project envisages use of the Head Mounted Display for visualization and navigation. The Joysticks would be used for interactive placement of objects inside the aircraft. The simulated environment shall also depict collision and visual depiction of unacceptable configuration. Based on the modification objects location; physics parameters would be computed and passed on to the appropriate mathematical simulation model (JSBSim). With the feedback coming from JSB Sim, the software shall facilitate visual depiction of simulated results and its effect on the aircraft.

VIII. JSB Sim

JSBSim is an open source Flight Dynamics Model (FDM) software library that models the flight dynamics of an aerospace vehicle. The software has a built in library of various aircraft including Airbus A 320 being virtually created as a part of this research project. JSB Sim is written in C++ and uses XML configuration files. For the purpose of this research project, JSBSim Trimming and Linearization GUI is planned to be integrated. This GUI provides trim conditions and linear models for various aircraft modeled in JSBSim. The trim conditions can be used to evaluate aircraft performance and determine the aircraft's flight envelope. The linearization of the aircraft dynamics can be used to evaluate the effect of aircraft modifications on its control systems.

IX. EXPECTED OUTCOMES

The key outcomes of the research activity

include the following:

(a) Design and development of a Virtual Reality based system that allows real-time modifications of a virtual aircraft model.
(b) Simultaneous availability of variation in relevant engineering parameters governing flight behaviour (like performance, stability and control derivatives etc) in quantitative form and subjective evaluation of related aspects (Aesthetic, functional, interference etc.) of various options of a proposed modification on an aircraft.
(c) Saving in cost, time and effort.

X. CONCLUSION

The need for Virtual Reality model of Aircraft is to visualize, model and simulate aircraft environment and to create installation/integration scenarios of various airborne systems on-board commercial jet class of aircraft. The aspects to be examined are constraints of aircraft weight, cg balancing, structural constraints (both within and outside fuselage), access for installation/ removal, maintenance and ergonomics. This research shall aid in user exploring the modification options available, visualize in the VR aircraft mock-up with situation awareness and act as a decision aid for finalizing the layout without actually cutting the metal.

REFERENCES

[1] Mario Lorenz, Michael Spranger & others, “CAD to VR – a methodology for the automated conversion of kinematic CAD models to Virtual Reality”, Technische Universitat Chemnitz, Germany, 2015

[2] Rakesh Gupta, Daniel Whitney & David, “Prototyping & Design for Assembly analysis using multimodal virtual environments,” MIT, Cambridge, USA, Oct 1996.

[3] Zhang Xiaogiang, Wangan & Li Jianzhong,” Design & application of VR system in fully mechanized mining face,” Taiyuan University of Technology, China, 2011.

[4] Sankar Jayaraman, Special Issue : Virtual Reality, Washington State university, 1997.

[5] Tusar H Dani & Rajit, “Creation of concept shape designs via a Virtual Reality Interface,” Dept of Mech Engg, University of Wisconsin, Madison, USA,Oct 1996.

[6] Zhi Ming Fang, Wei LV & others, "Modelling & Assessment of civil aircraft evacuation based on finer grid," Shanghai Key Laboratory of Engg structure, China, 2015.

[7] Adelaide Marzano, Inelda Frel & others, "Design of a VR framework for maintainability and assemblability test of complex systems," School of Mechanical & Aerospace Engineering, Queens University, North Ireland, 2015.

[8] X Wang, SK ong & AYC Nu,"Real Virtual components interaction for assembly simulation & planning," Mechanical Engg Dept, National University of Singapore, 2016.

[9] SN Trika, P Banerjee & RL Kashyap, "Virtual Reality Interfaces for feature based CAD systems," Dept of Mechanical Engg, University of Illinois, Chicago, Sep 1995.

[10] Xiaoyong Lei, Shuling Dai & others, "Study of virtual manipulation technology in Virtual Reality systems," Beijing University of Aeronautics & Astronautics, China, 2005,

[11] Sankar Jayaram, Hugh & Kevin Wlyons, "Virtual Assembly using Virtual Reality Techniques," School of Mechanical & Materials Engineering, Washington State University, 1997.

[12] Gabriel Zachmann, Dissertation on Virtual Reality in Assembly Simulation-collision, detection, simulation Algorithms & Interaction Techniques, July 2000.

[13] John Warren Barrus, "Virtual Workshop. A simulated environment for mechanical design, MIT, Sep 1993.