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THE INTERIOR DESIGN OF A HELICOPTER. PILOT'S POSITION: MODELLING AND CONTROL

Abstract: *To this day, most means of transport, either objects or persons, are designed to be handled by a person on board. So the design of a means of transport must be an ergonomic one, taking into account the human factor (the person who will handle the machine). The ergonomic design of a pilot's workspace is about ensuring the state of comfort in the movements he must perform so that he can handle the means of transport safely. In the aviation sector, this rigor of design is more important because even the slightest human error can be fatal. Over time, it was realized the importance of creating the virtual human model in design in order to discover the problems of ergonomic nature. The virtual human model made in the Maya Autodesk software will be analyzed from the point of view of movements to see if the model complies with the restrictions of the human body and if it can perform the specific movements of a pilot in the helicopter cabin.*

Key words: *helicopter, design, ergonomics, human factor, human virtual model, control, Maya software.*

1. INTRODUCTION

The helicopter is a means of air transport for both objects and people.

Like other means of transport, helicopters are also maneuvered by a person or two on board. The persons on board these aircraft are the human factor to be taken into account both in the design of the aircraft and in its interior design.

Over time, the realization of human virtual models at the beginning of the design of the workstations and workspaces, but also of the products to be used by a person, proved effective in simulating and identifying the ergonomic problems that existed in the design or that could occur.

If when we are passengers in a means of transport we could help our position so that we were comfortable, when we think about the pilot, his state of comfort must be taken into account in the design of the helicopter.

Thus, the interior design of the cockpit must be ergonomically correct to facilitate the safe handling of the aircraft.

In this paper, we will analyze the movements of a virtual human model for a pilot using the Maya Autodesk software.

2. HUMAN DIGITAL MODELING - HISTORY

Over time, ergonomics specialists wanted a robust and analytical model that could simulate the physical and cognitive capabilities of different groups of people [1].

Three-dimensional human figure models apparently arose independently from at least six different applications [2]:

- Crash simulation;
- Motion analysis;
- Workplace assessment;
- Dance or movement notation;
- Entertainment;
- Motion understanding.

In the 1970s and 1980s, several models of human physical simulation were developed to help design workspaces where manual tasks had to be performed [1].

One of the first attempts to develop a computer model of human performance was in a doctoral thesis of Kerry Kilpatrick (1970). He developed a 3-D human graphic model at the University of Michigan to describe how a seated person would most likely be in position when performing touches and movements that constitute a manual task. Simulations with his model required the user to provide a list of hand movement requirements and a file describing where objects were located relative to the reference point of a simulated person's seat. The last file also contained the weight of the objects and how they were oriented for grabbing [1].

The Kilpatrick biokinematic model was one of the first such models to illustrate how anthropometric data, when combined with geometric data describing a work environment and a list of manual tasks, could help a job designer in conducting an assessment of the physical ergonomics of a workspace [1].

Perhaps the most notable original development of a digital human model to help ensure better ergonomics within a vehicle was offered by Ryan and Springer (1969) for the aircraft company Boeing. This effort was called the First Man program, and was later simply retitled Boeman. The goal was to provide an analytical tool to simulate the positions and capabilities of pilots while they were seated with a complete torso retention in various aerial aircraft. The motivation was to reduce the expenses and time for the construction and testing of the various prototype compartments of the crew in the advanced aircraft [1].

Boeman's basic structure was adopted in the early 1970s by the U.S. Air Force's Aerospace Medical Research Laboratory (AMRL). The interface division of the AMRL crew system simplified the posture prediction model to gain computing speed and then added the ability to simulate a variety of male and female anthropometric sizes of pilots seated in different types of aircraft. The data and algorithms used to refine the coverage as evaluation predictions were developed as part of a program called the Crew Coverage Assessment Program (CAR) at AMRL. The resulting model became known as COMBIMAN (Figure 1). AMRL provided the program to various federal agencies and contractors in the 1980s [1].

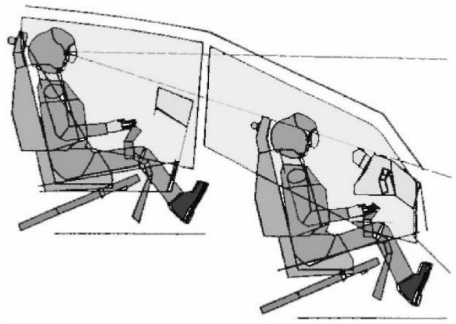


Figure 1 COMBIMAN being used to simulate the sight lines for a helicopter crew station.
Adapted from McDaniel (1998) [1].

During the same period of the 1970s and 1980s, Case, Porter and Bonney of the Universities of Nottingham and Loughborough in the United Kingdom developed SAMMIE (System for Aiding Man). SAMMIE was conceived in the late 1960s as a very general model of human kinematics for evaluating various problems of coverage, interference and line of sight presented by a designer [1].

Recently, the SAMMIE avatar has become a hominoid with solid segments and continues to be fully integrated into a CAD program that allows users to introduce the avatar in a graphic environment of interest and then visualize the potential effects of different workspace and vehicle models. Alternative postures can be selected from menus or by direct manipulations of the joints. Hidden line algorithms allow the avatar to appear in a 3D space, and mirrored view lines are provided as an additional feature for vehicle designers. The SAMMIE program has been formulated to represent different specific people, which improves the use of individual anthropometric attributes in a population [1].

In the late 1980s, another model, more generally, was developed at the Ecole Polytechnique in Montreal, Canada. Now known as SAFEWORK. The current version of SAFEWORK is supported as an application within the DELMIA software suite provided by Dassault Systemes and runs in a CATIA CAD environment [1].

Another model of general-purpose human physical simulation, JACK, began as a NASA supported effort in the Department of Computer Science and Information Science at the University of Pennsylvania in the mid-1980s (Badler et al., 1993). Several CAD software companies took over the development of JACK in the 1990s [1].

In the early 1990s, researchers at Aalborg University in Denmark proposed a new 3D biomechanical model which was based on the theory that the mechanical structure of the musculoskeletal system has a mathematical similarity to a solid articulated structure in which the load holder of which elements (bones, muscles and ligaments) are used to their full potential to stabilize the configuration of the structure. By 1997, they formed the AnyBody Research Group within the university, continued to build a more complex model for the whole body, and developed the optimization of ergonomics in design as an engineering discipline within mechanical engineering at their university [1].

One of the latest models of human body under development is SANTOS, from the University of Iowa. Although it has not yet been released to the public for independent testing and validation at the time of writing this, it promises future users that it can help carry out several types of ergonomic assessments [1].

Currently, Jack is the virtual human model designed to incorporate as many historical applications as possible into the foundation of an integrated and consistent software [3].

3. THE VIRTUAL HUMAN MODEL FROM MAYA AUTODESK

Autodesk Maya, commonly abbreviated to only Maya, is a 3D graphics application on your computer that runs on Windows, macOS, and Linux. It is used to create elements for interactive 3D applications (including video games), animated movies, TV series, and visual effects.

The virtual human model created in Maya is referred to as general character. In order to define a character, the following are required:

1. The modeled body – the physical appearance of the character;
2. Skeleton – an assembly of articulations that in correlation with the body will allow the character to move.

The HumanIK tools in Maya provide a complete key character framing environment with modes of manipulation of the whole body and manipulation of their body parts, auxiliary effectors and pivots, and fixation. HumanIK also offers a redirection engine that allows you to easily redirect animation between characters of different sizes, proportions and skeletal hierarchies.

The HumanIK tool allows:

- Creating a skeleton for an already existing body;
- Creating a body for an already existing skeleton;
- Creating controls for an already existing body and skeleton;
- Creating a dummy character.

The dummy character is the virtual human model made available by the software (Figure 2). A Control Rig is also created for the character. As can be seen in Figure 3, the control installation appears on the character as the skeleton where rigid human joints (wrists of hands and feet, head, shoulders, hips) appear fenced. The Lattice function assigned to these joints turns them into rigid joints, which will not allow the unnatural deformation of the body when moving [4].

The menu of the control installation helps to move the character. If we press on one side of the body, it will not move. For the movement of that part it is necessary to select the appropriate joint, represented by the nodes in the menu. The view in that menu indicates

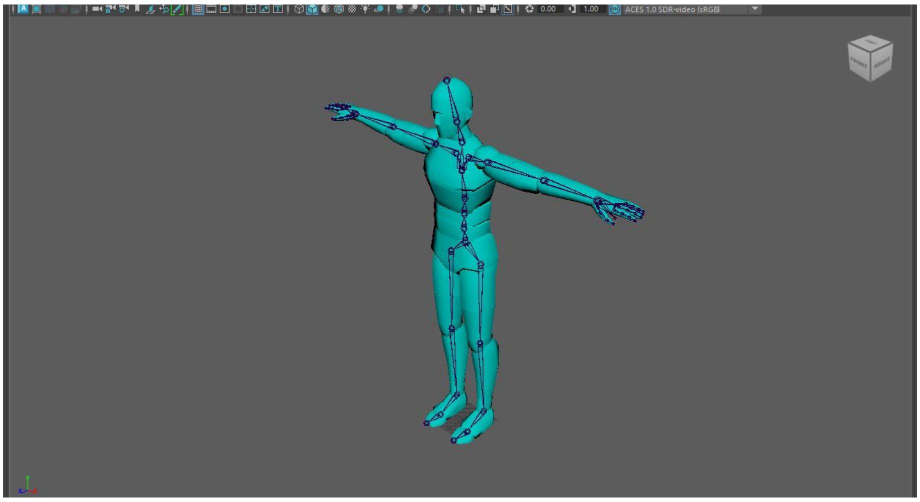
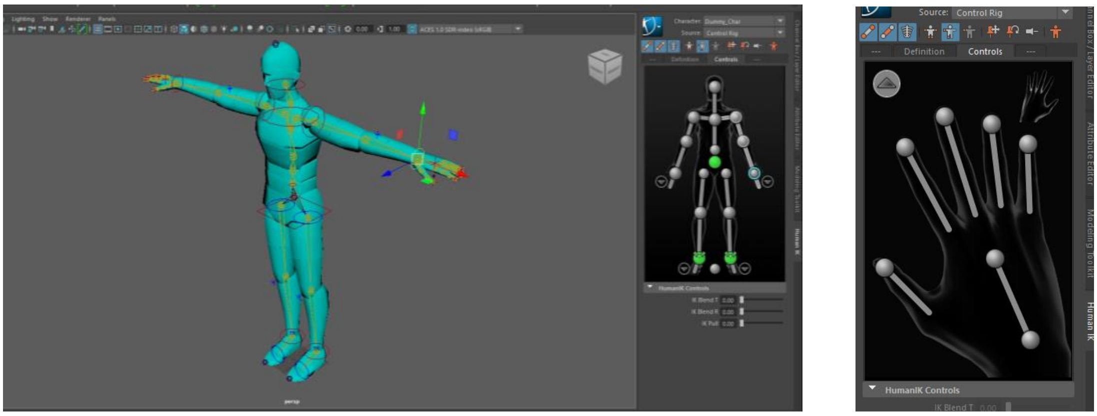


Figure 2 Dummy character created in Maya Autodesk. X-Ray view to be able to see the inner skeleton of the body.



a) b)

Figure 3 a) Dummy character with the control rig and its menu;
b) The control system of the skeleton of the doll character hand.

the selected member to select more easily then the required joint.

4. WORKSPACE

Previously we tested the virtual human model to see the degrees of freedom but also those of rigidity.

To see if the model can be used for the future interior design of a helicopter, it must be seen if it looks natural from a human point of view in the helicopter cockpit.

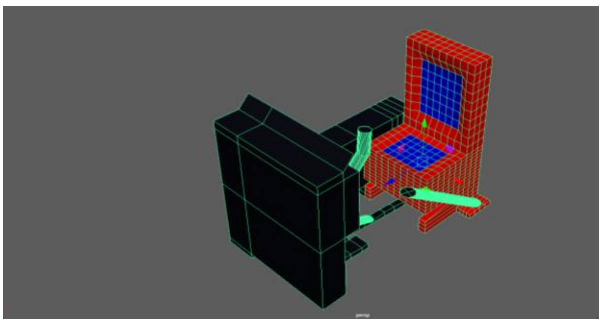


Figure 4 Minimalist modeling of helicopter cockpit interior in Autodesk Maya.

For this we tried minimalist modeling of the interior of the helicopter cockpit (Figure 4). This modeling will include: the seat, the cyclic pilot, the collective pilot, the pedals and the board that would include the digital devices.

5. POSITIONING THE HUMAN MODEL IN THE WORKSPACE

Having now created both the human model and the approximate model of the workspace, it remains to be seen how well we can place the pilot (Figures 5-8).

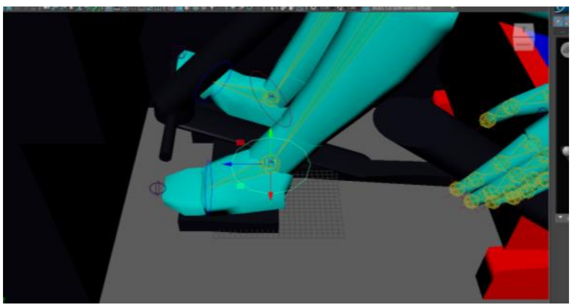


Figure 5 Positioning of the feet on the pedals.

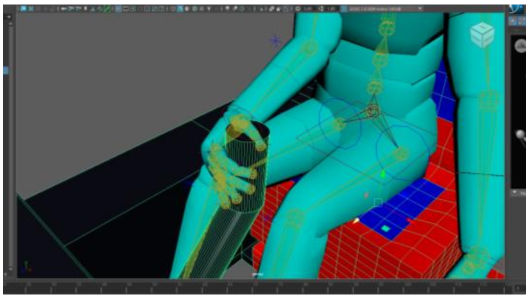


Figure 6 Positioning the hand at the cyclic pilot.

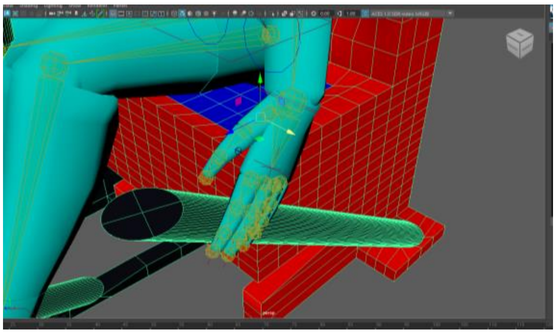
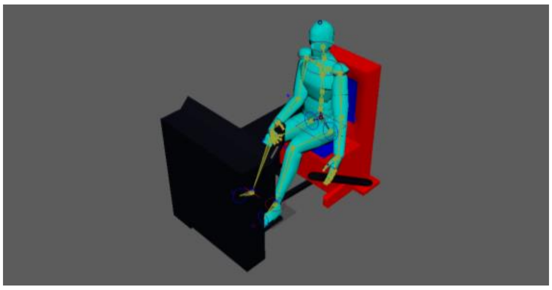
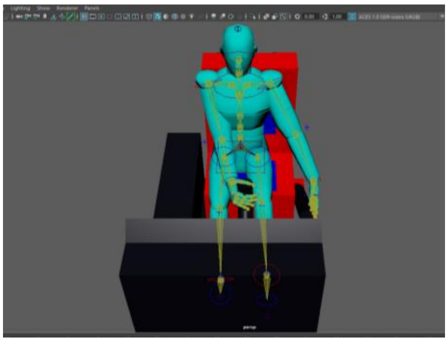


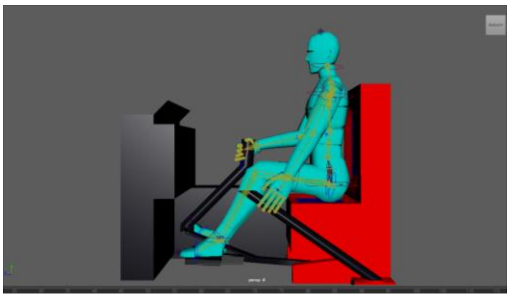
Figure 7 Positioning the hand at the collector pilot.



a)



b)



c)

Figure 8 Isometric (a), front (b) and side view (c) of the positioning of the virtual pilot model.

From what can be seen from the figures presented, the virtual human model of the Maya Autodesk can be used for the future design of a pilot's cabin.

This virtual human model is malleable enough to be easily positioned in the workspace and, at the same time, rigid enough. Rigidity is useful to maintain the shape and natural position of the human body.

6. CONCLUSIONS

The virtual model of the Maya is usable and realistic, however it needs to be dimensionally adjusted to create a model of the workspace closer to reality. The resizing is necessary to avoid a small overlap in the human model between the trunk and the arm on the cyclic pilot (Figure 8b) and to correct the too short arm that catches the collector pilot.

Therefore, it is ideal to design the workspace in a 3D modeling program that allows a good correlation of the dimensions of the human model with those of the interior of the helicopter cabin, dimensions that would then be imported into Autodesk Maya. If the dimensions of the projected space make the dummy character plausible, then it can be used, but if the dimensions differ too much, the human model must be recreated and assigned to the HumanIK skeleton only.

The HumanIK tools in Autodesk Maya provide a complete environment for framing key characters in a workspace, with full body and body part manipulation capabilities.

REFERENCES

[1] Don, B.C. (2008). *Digital Human Modeling for Workspace Design*, available at: http://rev.sagepub.com/content/4/1/41, *Accessed*: 2022-12-01.

[2] Karim, A.M., Timothy, M. (2006). *Towards a new generation of virtual humans*. International Journal of Human Factors Modelling and Simulation, Vol.1, No.1, pp. 2-39.

[3] Norman, I.B., Cary, B.P., Bonnie, L.W. (1999). *Simulating Humans: Computer Graphics, Animation and Control*, Oxford University Press, Online ISBN: 9780197560273.

[4] Nane, B. (2022). *Research Rapport No. 2*, University Politehnica of Bucharest, unpublished.

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