Work Plan
Pesquisador Visitante I

Analysis and Modeling of Rotorcraft Dynamics

Grupo de Pesquisa
Visão Computacional e Aplicações

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1. Introduction

Brazil, the largest country in Latin America both in area and in population is also the largest operator of aircraft, especially rotorcraft operating in Brazil since executive transport and support for remote Amazonian regions to transport personnel and machinery in Continental Shelf, the national demand for qualified and well-trained pilots is increasing every day.

The rapid pace of technological change, especially in aerospace, necessitates a change also in the process of teaching and learning of aircraft pilots. Recent aviation accidents revealed in the press with both fixed-wing aircraft [1] and with rotary wing aircraft [2] provide more than enough reason for the development of new systems and processes for pilot training.

In major airlines, usually when a new driver is admitted it must be trained on land, in order to obtain the necessary familiarity with the control systems of the aircraft cabin. This training is called "ground school" being held from conventional classes in class where an instructor, usually an experienced pilot, with the support of a poster with the picture (or drawing) of cockpit instruments have all subsystems aircraft and its routine operating procedures, and emergency procedures.

![Fennec helicopter from Brazilian Army.](image)

**Figure 1.** Fennec helicopter from Brazilian Army.
The "ground school" is of paramount importance since it during the flight, pilot error in an emergency situation can be fatal. Fig. 1 shows the cockpit of a helicopter and its various controls.

Most systems use pilot training capabilities Multimedia, since it is believed that the more senses are used by the student, the learning of a particular subject, the better your advantage, especially for the novice rider. Thus, the following characteristics [3] are common in training systems:

- Presentation of tutorials about the functioning and operation of the major subsystems of the aircraft.
- Simulation of flight conditions (normal and unstable), student interaction in order to act on the cockpit instruments, aimed at monitoring the operation or the correction of instability.
- Joint assessment of the tutorials and simulations.
- Presentation of the external environment of the aircraft, such as cities, mountains, rivers, lakes etc.
- Exhibit the behavior of the aircraft during flight in terms of instrument readings and attitude of the aircraft according to the commands given by the pilot.

Several research works and development [4,5,6,7,8,9] has been presented touting systems training pilots, commercial or otherwise, in order to increase the development of training procedures of the pilot in the cabin of the aircraft. Fig. 2 shows an aspect of the Simulator for Pilot Training Helicopter developed in the
Laboratory of Multimedia and Interactivity - LMI UNIFEI and now used in the Centro de Instrução da Aviação do Exército – CIAvEx, in Taubaté city.

Despite the research, little has been done for the case of simulation events (normal or emergency) for pilot training rotorcraft contemplating the simulation of the flight of the aircraft and its attitude to commands cabin. This is because of the little knowledge about the equations and algorithms to simulate the behavior of this aircraft type, especially in emergency situations.

2. Objectives

2.1 Study the differential equations that represent the behavior of rotary-wing aircraft.
2.2 To study the limitations of these equations to represent the flight on a particular set of situations and emergencies instabilities.
2.3 Exploit the multi-physics energetic modeling of the helicopter, to simulate the dynamic behavior of the system and the instabilities such as “Air Resonance” (AR), “Ground Resonance” (GR) and “Rotorcraft Pilot Coupling” (RPC).
2.4 Develop algorithms that with the use of methods, techniques and tools of Artificial Intelligence, can realize representation of the behavior of both the control systems of aircraft attitude as that set for emergency and instability known.

3. Justificatives

This Work Plan Postdoctoral is closely placed in the context of research projects that have been developed in recent years in the Institute of Mathematics and Computer Science, Federal University of Itajubá, particularly in projects developed in the LMI associated with Computer Vision Research Group Applied - VISCAP.

Another justificative for this Work Plan is strengthening partnerships with centers of excellence, such as the Helicopteros do Brasil SA. - Helibras at Itajubá, MG, the Ecole Nationale de l'Aviation Civile - ENAC at Toulouse, FR, and the Centro de Instrução da Aviação do Exército – CIAvEx at Taubaté, SP.

This Work Plan collaborate, especially now, with the implementation of the Graduate course of Aeronautic Engineering and the Master degree course in Systems and Computer Technology, which has as one of its focus areas Mathematics of Computation covering the theoretical and practical aspects of computing models and simulation and in particular its line of Artificial Intelligence which is characterized by the research and development of new neural models as well as computational systems which are based on Artificial Intelligence.
4. Activities

The activities to be developed are basically those that lead us naturally to the aims set out above:

4.1 Study of differential equations which represent the behavior of the rotary-wing aircraft.
4.2 Study limitations of these equations to represent the flight on a particular set of situations of instability and emergencies.
4.3 Study of the application of rule-based systems for the production of knowledge storage situations of instability and in-flight emergencies known.
4.4 Study of the application of neural networks algorithms for the simulation of the behavior of control systems and aircraft for a set of instabilities and emergencies unknown.
4.5 Development of a system that, from the studies developed, represents the behavior of rotary-wing aircraft in emergencies and instabilities in a simulator to train pilots.
4.6 Integration of the system developed for the Simulator Helicopter Pilot Training - STH, existing at the Laboratory of Multimedia and Interactivity.

A previous study of the equations that define the basic behavior of the flight of rotary wing aircraft, items 4.1 and 4.2, is already being done in the last two years by a team of researchers UNIFEI together with researchers from ENAC, with results released two opportunities for interaction between these teams in Brazil on campus UNIFEI.

However, these studies have demonstrated the need to use unconventional methods provided by the use of AI [10,11] for representing instability situations and emergencies. For this case, it is expected that the activities suggested in items 4.3 to 4.5 will minimize the deficiencies of flight equations known to date. The end result of the study should be applicable to the Simulator for Pilot Training already at an advanced stage of development in LMI UNIFEI [12, 13].

5. Metodology and Expected Results

All activities described above will be developed through the systematic study of subjects proposed based on the bibliographic references listed at the end of this Work Plan as well as new works and studies that will be published after the publication of this and that represent the state of the art in field.

The expected results involve total or partial understanding of the issues described above and consequently the publication and presentation of results in journals, conference proceedings, and national and international seminars.
6. Schedule of Activities

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7. References


