

I. IDENTIFICATION DATA

Thesis title:	Development of a Human-Robot Control System Based on Virtual Reality for Swarms of Unmanned Aerial Vehicles (UAVs)
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Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Daniel Bonilla Licea
Reviewer's department:	Department of Cybernetics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	ordinarily challenging
<i>How demanding was the assigned project?</i>	
<p>The goal of the assignment was to design and implement a system for controlling swarms of Unmanned aerial vehicles (UAVs) using Robot Operating System (ROS), Unity, and a virtual reality headset (Meta Quest 2). In addition, the control system was to be tested experimentally on real and virtual UAVs.</p> <p>This work involved mainly the integration of different existing technologies, and implementation tasks. Although, the integration and implementation tasks had challenges of their own, these challenges were of ordinary difficulty for a bachelor's student.</p>	

Fulfilment of assignment	fulfilled with minor objectives
<i>How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.</i>	
<p>There were a total of six goals in the assigned task:</p> <p>1. Review of at least 20 scientific papers related to human-robot interaction for swarms, at least 5 of which must deal with the use of virtual reality. The review must include references [1]-[12].</p> <p>The review is included in chapter 2 of the thesis, it covers 20 scientific papers as shown in Table 2.1, also 5 of those papers deal with virtual reality (see section 2.4). The asked references [1]-[12] are present in the thesis but with a different reference number, see first 12 entries of the Table 2.1. This task was completely fulfilled.</p> <p>2. Development of an environment in the Unity game engine capable of two-way communication with UAVs, providing the robot's state to the environment and, in return, sending control commands to the swarm.</p> <p>This development is described in section 3.1.2. Figs. 3.4-3.8 show the environment developed in Unity. The environment developed has a two way communication with the UAVs: 1) the motion of the virtual and real UAVs is sent to Unity and the UAV models shown in the environment move accordingly; 2) simultaneously walls and objects created in the Unity environment are perceived by the real and virtual UAVs. This task was completely fulfilled.</p> <p>3. Integration of the environment/simulator with a virtual reality headset, to give a more intuitive control to the user of the system similar to the system in [2]. The control will be executed using the headset's controllers, and different methods like artificial force fields and static meshes will be used to influence the swarm's behaviour.</p> <p>The integration of the environment with the virtual reality headset and the development of the user interface and control system is fully described in chapter 3, with various diagrams that describe the interaction between the different software</p>	

and hardware components.

The control system developed by the student allows the creation of virtual walls, implemented using static meshes, that are perceived as real walls by the UAVs, also repulsive and attractive forces. These tools allow the user to control the motion of swarms of UAVs. The system runs in the virtual reality headset selected, i.e. Meta Quest 2. This task was completely fulfilled.

4. (Optional) Creation of a method to translate the hand movement of the user to control commands that can be used to alter the goal of the members of the swarm dynamically.

This optional task was not performed.

5. Experimental verification of the system and comparison with existing methods for Human-swarm interaction [1] to validate the system's advantages.

The system was first tested with swarms of virtual UAVs with success, see chapter 3 and section 4.2. Then, the system was tested experimentally with a real UAV, but the results of that test were not fully satisfactory, see section 4.3. The real UAV did not behave as expected.

The comparison of the developed system with other systems is presented in chapter 5.

This task was completely fulfilled. But, the results of the experimental validation of the system were deficient.

6. (Optional) Utilization of the PrimeX Haptic gloves as an input method to the simulator to allow for a more comprehensive set of possible actions and enable the user to execute multiple commands simultaneously

This optional task was not performed.

Overall, the mandatory tasks were all completed, but the experimental validation was unsuccessful, and the optional tasks were not executed.

Activity and independence when creating final thesis

D - satisfactory

Assess whether the student had a positive approach, whether the time limits were met, whether the conception was regularly consulted and whether the student was well prepared for the consultations. Assess the student's ability to work independently.

The student had a positive attitude towards his work most of the time. But, the supervisor feels that the student could have done a greater effort during the experimental verification of the system to make the implementation fully successful.

Technical level

B - very good.

Is the thesis technically sound? How well did the student employ expertise in his/her field of study? Does the student explain clearly what he/she has done?

The technical level of the thesis is in general fine, the description of the system is mostly clear.

Formal level and language level, scope of thesis

C - good.

Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?

The organization of the thesis is appropriate is clearly describe the work done in a logical manner that makes it easy to understand. The presentation of the thesis including images, diagrams and tables is of good quality. The English is satisfactory. But, since the experimental validation was not completely successful the corresponding section was too short.

Selection of sources, citation correctness

B - very good.

Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?

Most of the references included in the thesis are adequate and recent.

Additional commentary and evaluation (optional)

Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.

Please insert your comments here.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading.

The grade that I award for the thesis is C - good.

Date: 31/05/2023

Signature: