THESIS SUPERVISOR'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**Uncertainty-aware Human-Robot Collaboration using scheduling and reactive control**
Author's name:	**Marina Ionova**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Dr.-Ing. Jan Kristof Behrens
Reviewer's department:	CIIRC CTU

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **extraordinarily challenging**

How demanding was the assigned project?

The thesis assignment was on the challenging end of the spectrum for several reasons. 1) The breadth of topics to be handled when designing this Human-Robot Collaboration system spanned from modeling the task and the actors for scheduling to working with a real robot using ROS. Dealing with humans (in scheduling) introduces a great amount of uncertainty. This means that the real system must be reactive for dealing with uncontrollable events. On the other hand, quantifying the system's performance must measure the behavior quality for an ensemble of situations. This is conceptually and computationally challenging, 3) Designing a system for humans must consider human factors.

Fulfilment of assignment **fulfilled**

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.

In total, the assignment was fulfilled. The thesis delivers more than I expected regarding the topic of human factors. The work regarding systematically testing the solution via probabilistic simulations could have been more extensive, but the assignment is also fulfilled here. Regarding the implementation of an uncertainty aware HRC planning method, several methods have been implemented and compared in simulation. The system has been shown to be working also in the real setup.

Activity and independence when creating final thesis **A - excellent.**

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 was working independently, with high motivation, great care, and took my suggestions seriously. She also brought her own ideas. The collaboration with the rest of the team was good.

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?

Overall, the thesis is on a really good level. Some design decisions should be evaluated more thoroughly. For example, the influence of the integration of the scheduling into the acting process could be compared more. Also, the influence of formulating preferences as part of the optimization criterion should be checked. I would have wished for a little more care regarding taking the uncertainty into account during the scheduling and in the evaluation. It would have been great to see if knowing the amount of uncertainty would lead to better expected results.

Formal level and language level, scope of thesis **B - very 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 thesis conveys a complex topic. The use of notations is good. The representations could be at some points more unified

(e.g., p. 16 vs 25). The thesis organization makes sense. The thesis' length is fine, but 5-10 pages more would allow to cover some extra evaluation.

Selection of sources, citation correctness	**A - excellent.**
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?	
The citation style and habit are good. The related work chapter is rather short with three pages. Nevertheless, the main works are covered, and the work of others is marked appropriately throughout the thesis. The student's contributions are clearly stated.	

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.
The thesis presents a novel approach to Human-Robot Collaboration using Constraint Programming based scheduling and reactive control. It is advancing the state-of-the-art in HRC. The results were already submitted to a workshop at the Robotics Science and Systems conference (RSS). The implementation on the real robot will be used for further experiments and as demo. The work has the potential to be presented at world-class conferences. For a journal publication, the experimental promising experiments need to be backed up by theoretical elaborations.

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

The thesis more than fulfills the expectations. The topic was wide and naturally allows for further research. The student managed to design, implement, and evaluate a meaningful non-trivial system. The student gained and demonstrated significant knowledge in robotics, human factors, and Constraint Programming,

Questions:

1) *How could the knowledge of the uncertainty distribution of task durations be considered in the scheduling? What are the problems of over and underestimating task durations?*
2) *Which class of tasks can the system handle? What are the assumptions on the agents, the tasks, the constraints? Which decisions are made by the system?*
3) *What are controllable and uncontrollable events in your system? Apart from not being under the control of the system, uncontrollable events are also challenging to register. Give some examples of how the system determines that an event has happened (e.g., the human finished a task) now. How could this be improved? How could this uncertainty (a task should be finished, but the system doesn't know it yet) affect the system and how should it be handled ideally?*

The grade that I award for the thesis is **A - excellent.**

Date: **7.6.2023** Signature: