ČVUT
ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

THESIS SUPERVISOR'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**AcouMan — Acoustophoretic Manipulation Platform**
Author's name:	**Josef Matouš**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis reviewer:	Martin Gurtner
Reviewer's department:	Department of Control Engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment — **extraordinarily challenging**

How demanding was the assigned project?

From the very beginning, it was unclear whether all the goals posed in the assignment could be met or not. What is more, it was unclear what tools (optimization and control algorithms) one should start with. The topic of the thesis is new, and thus there was no source from which one could take some inspiration.

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.

All goals set in the assignment are met.

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.

During consultations, Josef Matouš typically presented me with the problems he stumbled upon from the last time and right away proposed solutions to them. He worked very independently and mostly without my help.

Technical level — **A - excellent.**

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?

To meet the goals set in the assignment, Josef had to invoke rather sophisticated tools like *Linear Quadratic Regulator*, *Kalman filter*, *Model Predictive Control*, and *Particle Swarm Optimization*. All used methods and achieved results are clearly presented.

Formal level and language level, scope of thesis — **A - excellent.**

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 text in the thesis is well structured. Mathematical expressions are properly typeset. The text is mostly brief, yet clear.

Selection of sources, citation correctness — **Choose an item.**

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 thesis has a good selection of sources. All sources are properly cited.

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.

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THESIS SUPERVISOR'S REPORT

Please insert your comments here.

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

Josef Matouš chose a rather challenging topic for his master's thesis. He proved his theoretical and practical skills by solving all the problems he encountered throughout working on the thesis. The results presented in the thesis are impressive and will probably be submitted as a research article to a peer-reviewed journal. For these reasons, I have no other option than giving the thesis the highest possible grade.

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

Date: **28.5.2020**

Signature:

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REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**AcouMan — akustoforetická manipulační platforma**
Author's name:	**Matouš Josef (457195)**
Type of thesis :	master
Faculty/Institute:	Faculty of Mechanical Engineering (FME)
Department:	Department of Control Engineering
Thesis reviewer:	Asier Marzo
Reviewer's department:	External – Computer Science, Public University of Navarre (Spain)

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

Evaluation of thesis difficulty of assignment.

The difficulty of the task is considerable, especially for a master's level. I think a PhD would have problems solving it. At least the objects are floating on water, so the control system does not need to be ultra-fast.

Satisfaction of assignment **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

I think the presented thesis addresses all the problems of this multi-faceted problem. It has electronics, computer vision, control algorithms, modelling, optimization. It is a very complete and satisfactory thesis.

Method of conception **outstanding**

Assess that student has chosen correct approach or solution methods.

The methods seem beyond the basic tools used by engineers. I am not an expert on control algorithms (beyond basic PID).

Technical level **A - excellent.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

Not many references are used, but the ones included are used by the student as inspiration. I like seeing the thesis as an evolution of previous work to achieve a significant result that goes beyond what was previously achieved. The assembly of the triangles is really nice.

Formal and language level, scope of thesis **A - excellent.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

I have not detected a single typo; it is well written and very understandable.

Selection of sources, citation correctness **A - excellent.**

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The reference section seems good, the main references from the field are included.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

Please insert your commentary (voluntary evaluation).

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REVIEWER'S OPINION OF FINAL THESIS

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

I really enjoy the thesis. It is very complete: electronics, microcontrollers, FPGAs, RPi, computer vision, control systems, radiation forces, acoustics... what else could be there? And all the aspects are combined towards a novel application. The assembly example is the perfect culmination of the thesis. Not much to add, just keep on with the good work.

I attach some questions:

- "I have built a pool with 3D-printed walls"
Why not buying an acrylic container? or building one with acrylic cement. How is it transparent if it is 3d printed?

- "which are then amplified to 16 Vpp by the shield."
What was the IC employed for this?

- Now you are only changing the phase. Do you think adding also amplitude control would provide any benefit?

- "The phase of the acoustic pressure has no observable effect on objects placed in the field. It is, therefore, sufficient to consider only the amplitude."
For regular focal points or twin-traps, phase does not do much. But acoustic vortices can transfer orbital angular momentum. Perhaps could be a future research direction for you, using vortices to rotate the objects.

- "Figure 3.4: Results of algorithm benchmarking. The dashed lines go through medians, the error bars span from minima to maxima."
LM is faster than BFGS, but perhaps BFGS gives larger amplitudes? I mean, execution time is an important metric, but the main metric could be amplitude at the focal points. Anyway, perhaps you may enjoy IBP which is a simple and fast method for generating multiple focal points (or other shapes) https://www.pnas.org/content/116/1/84

I evaluate handed thesis with classification grade **A - excellent.**

Date: **31.5.2020** Signature: