Dissertations in Computer Engineering at TU Vienna

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Criteria for Dissertations

In the following we explain essential criteria that have to be fulfilled by dissertations in Computer Engineering at TU Vienna. We further list the methods that are typically applied in this area.

At the beginning of a dissertation project, one has to define the topic and the research questions of the project, including the hypotheses to be verified and/or falsified in the dissertation. Depending on the particular topic of the thesis, research questions could range from primarily scientific (say, concerning the power of a new modelling technique) or primarily technological (say, concerning the features of a new architecture). The distinguishing feature of a dissertation is, however, that all research questions are answered by applying sound scientific methods. Depending on the context of the dissertation project, the particular topic and the research questions may be defined from the very beginning (e.g., if the topic to be worked on is part of a larger project) or may be worked out and pinned down in the initial phase of the dissertation work (usually this involves lots of discussions between the student and his or her supervisor).

In parallel with the definition of the goal or research question the following points have to be addressed:

- A *motivation* for the choice of the research question has to be given. This motivation must be based on/linked with the following issues as well.
- A critical *investigation of the state of the art* as presented in *related work*. The deficiencies of the related work and the relation of the current work to the related work have to be clearly described.
- The *scope* of the current work has to be clearly defined.
- The *objectives* of the work have to be stated. Objectives must be given in a way that facilitates an evaluation of whether they have been met or not.
- The research work has to be *original*, i.e., the novel scientific aspects of the work have to be emphasized. Original contributions may consist in the creation of new artefacts (e.g., physical systems, algorithms, concepts, formal statements) as well as the application and evaluation of novel methods or existing methods in novel ways or new contexts.
- The *relevance* of the planned research has to be demonstrated, i.e., it should be argued why the planned work is interesting and to whom it is of interest. Note that relevance means either relevance for (future) applications or relevance for developing science here.

As a piece of scientific work, a dissertation thesis should be readable with moderate efforts by its targeted readership, i.e., researchers and PhD students that would publish in the same area (in the journals or at the same conferences) as the author of the dissertation. The thesis should be *self-contained*, i.e., all prerequisites and formalisms that are necessary for understanding the contribution of the thesis have to be introduced, a rationale for the choice of methods used in the thesis has to be given, all results have to be presented in detail, and an evaluation and interpretation of all results, including a discussion of the conclusions and consequences have to be given.

Regarding the focus of the research work, we distinguish between (1) theses that combine a construction of new artefacts (architectures, algorithms, concepts, etc.) with an evaluation of these artefacts, and (2) theses that focus on the argumentation about a set of hypotheses about existing artefacts or scientific knowledge. The research work may employ one or more of the following scientific methods:

- A formal proof (conducted either manually or automatically – e.g., by theorem proving, model checking, etc.),
- Systematic experiments based on a proof-of-concept implementation, or
- Systematic simulation experiments.

Whatever method is used, the choice of the selected evaluation method must be backed by rational argument and discussed in the thesis. Experiments and simulations must be conducted in a way that they provide sufficient *evidence* that the results are trustworthy (i.e., investigated cases must explore relevant scenarios with sufficient coverage and include rare event scenarios to certify the robustness of the evaluation process; the confidence level of results must be high enough to justify the acceptance or rejection of a hypothesis). Further, the *documentation* of the experiments or simulations (including the archival of the experiment setup, tools, data, etc.) must be provided in sufficient detail to allow for a repetition of the experiments (resp. simulations) and for checking the results for correctness.

Training objectives: It is our objective to lead dissertation candidates to become experts in their particular research area (in their core research area, they should even be top-level internationally) and to conduct internationally competitive research. The way to accomplish this is a permanent cycle of the following activities: do research – publish – review.
To ensure the quality of the research work, dissertations should be reviewed by at least one international reviewer. Dissertation candidates should publish a minimum of three papers. At least one of these publications should be a journal paper (published or accepted for publication)[1].

Scientific Practice versus Engineering Practice

Note: A clear-cut distinction between the two types of working practices is not always possible ...

The difference between scientific work and engineering work can be characterized by the diverging criteria for success in the two areas.

- Reproduction versus originality: An engineer typically reproduces or uses existing technology. In science the primary goal is to extend the state of the art, by exploring new problem areas.

[1] The latter is an aim rather than a requirement.

Example: In a lawsuit about an accident caused by the failure of technical equipment the engineer has to prove that the equipment has been in accordance to state-of-the-art.

- Special versus general solution: For the engineer working out a general solution is not of primary interest (though it might be advantageous if a solution can be re-used in-house). A scientist is interested in producing general solutions that are of interest to a wider target group.

- New insights versus economical interest: In science the primary goal is to find new insights that extend the state of the art. In an engineering context the driving force in the search for solutions is the economic benefit. As a consequence, the evaluation methods employed in scientific and engineering work are usually different in aims and scope: In an engineering context, a thorough scientific evaluation is typically replaced by a sufficiently "good practice" engineering standard for economic reasons.

On the Role of Scientific Concepts in Computer Engineering Research

Creating new concepts and investigating concepts is a central part of the scientific research in computer engineering. We use these concepts to describe and model phenomena of the real world and to build computer systems that interact with the real world (examples: time-triggered model of computation, system models for distributed algorithms).

Our work on concepts is complemented by the implementation of proof-of-concept prototypes and by evaluations. Proof-of-concept prototypes close the gap between theoretical artefacts and their realization under real-world constraints. Experiments, simulations, and formal proofs aim at the verification respectively falsification of scientific hypotheses by means of accepted scientific methods. For all experiments and simulations special care has to be taken that the applied methods are sound. In particular, a given hypothesis can only be verified by demonstrating that it cannot be falsified by any means.