Multidomain Design and Optimization based on COMSOL Multiphysics: Applications for Mechatronic Devices

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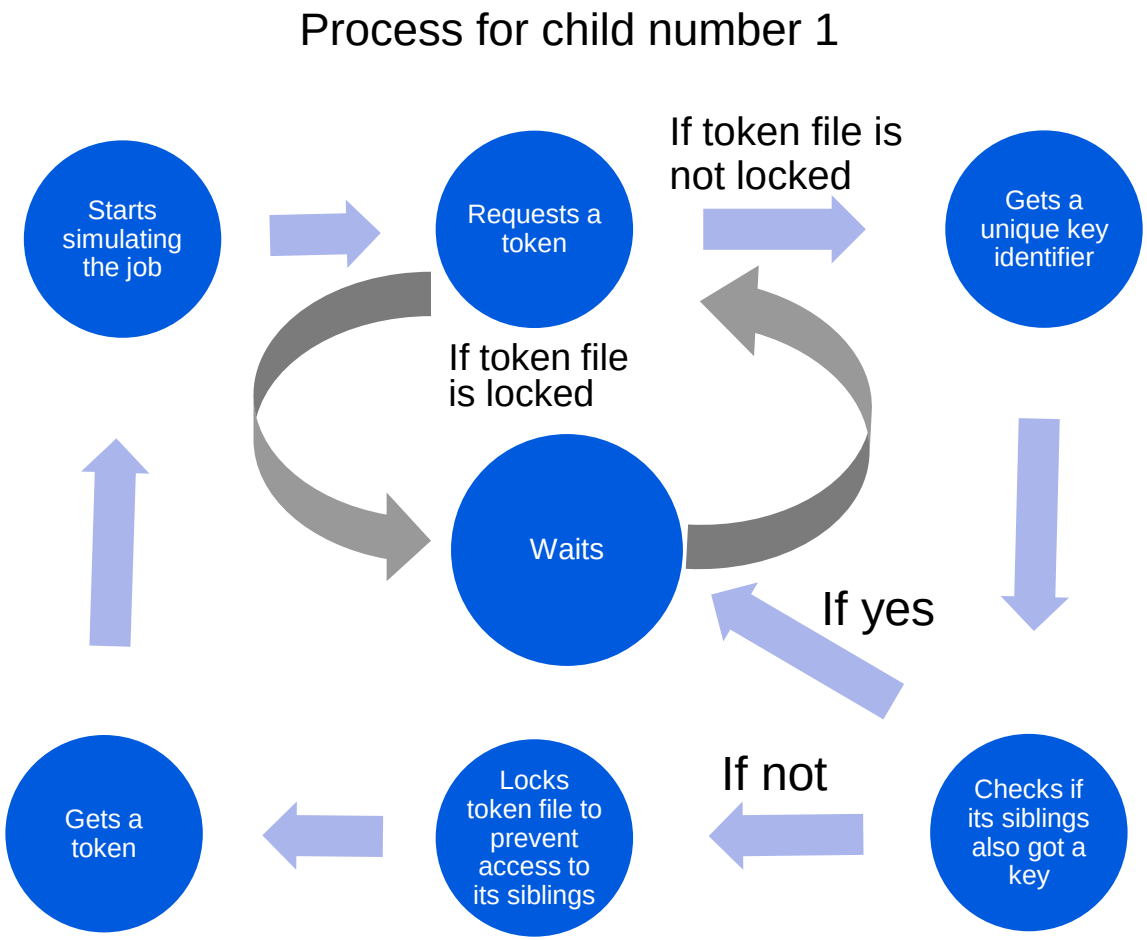
Introduction

- Due to recent advances in computers Finite Element Method (FEM) based simulations are becoming a standard prior to designing and prototyping.
- Although FEM is very accurate it has several limitations.
- COMSOL Multiphysics is an excellent tool that can be used to carry out Multiphysics simulations.
- However, due to the limitation of the FEM, it is a challenge to guarantee convergent for large parametric studies especial in the presence of nonlinear and or time dependent studies.
- Consequently, a novel smart parallelizable algorithm is developed that overcomes these presented challenges.

Methodology

- Parent matlab file starts checks number of available processors on machine
- Creates a token file containing all parameters to simulate
- Starts children equal to the number of available processors
- Each child consists of a Matlab instance with a Comsol server livelink running on one processor
- Once all children are initiated and ready for parallel computation, the parent dies to free up memory

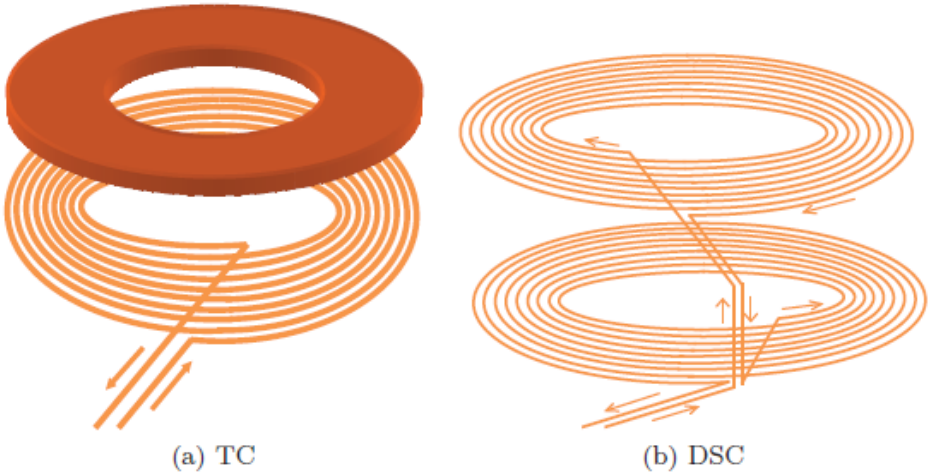


Methdology

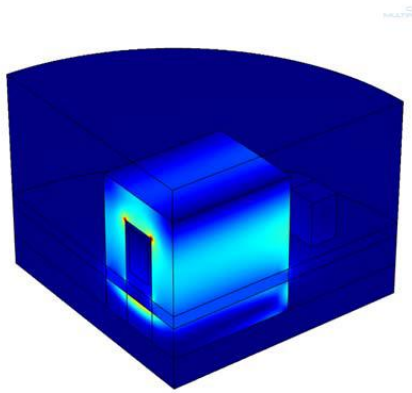
- The process is repeated by all children until the token list is exhausted
- The algorithm is smart since it identifies fails simulations cases and takes evasive action
- It is able to tighten the relative and absolute tolerances in stages until it solves
- If after 3 stages it fails, it abandons and marks this particular configuration and requests a new token

Use of COMSOL Multiphysics

- Used Comsol modules:
  - Magnetics
  - Solid mechanics
  - Moving mesh
  - Electric circuit
  - Global ODEs and DAEs
  - Heat transfer in solids
  - Weak form PDE



(a) TC (b) DSC



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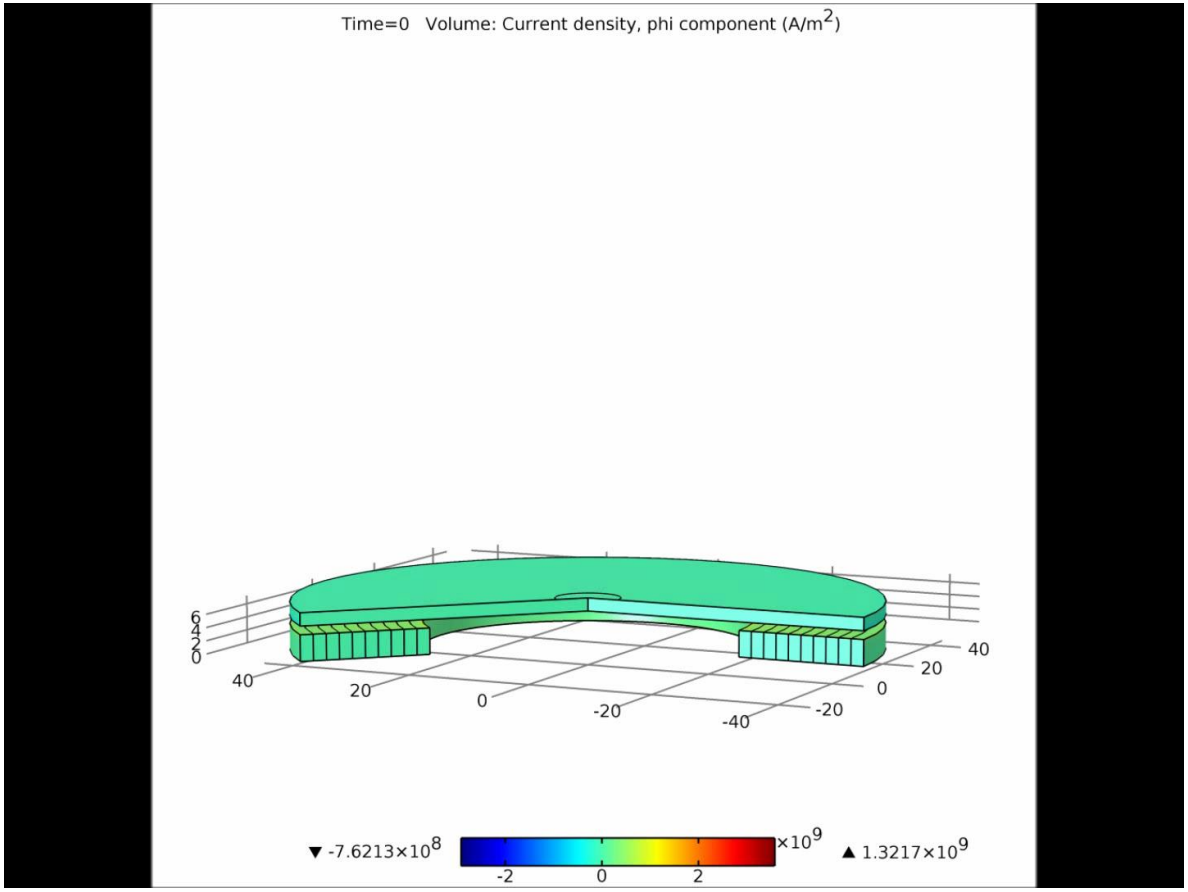
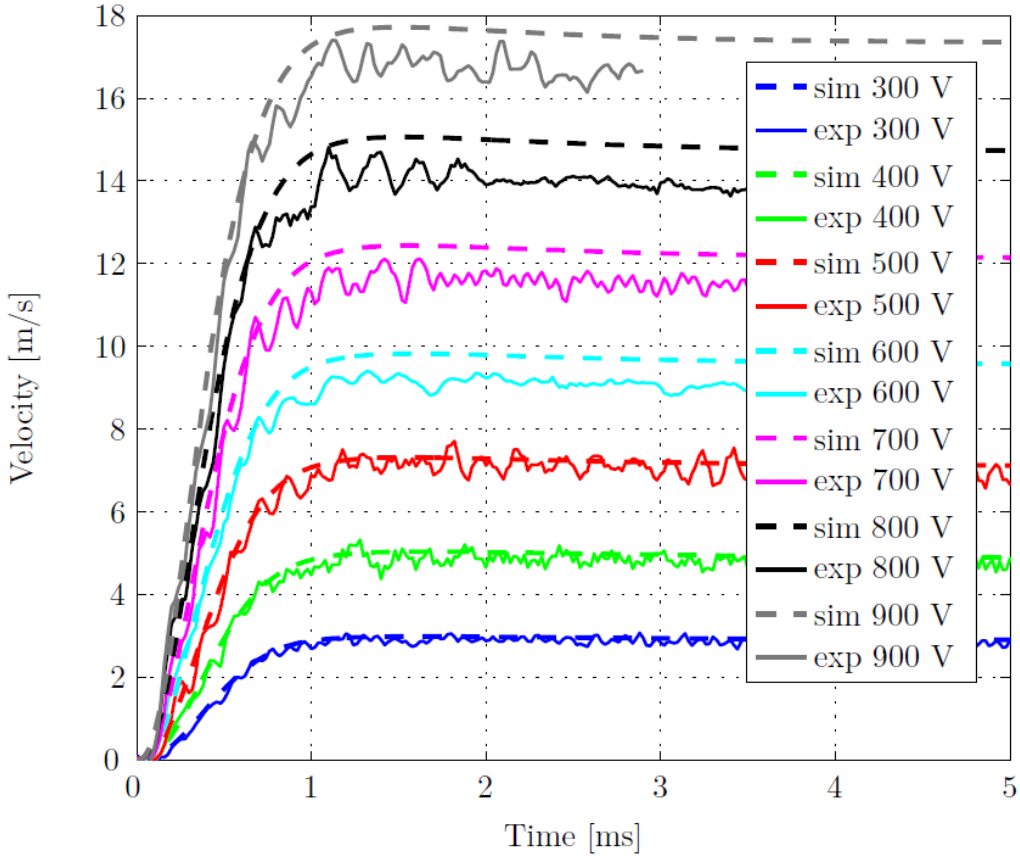


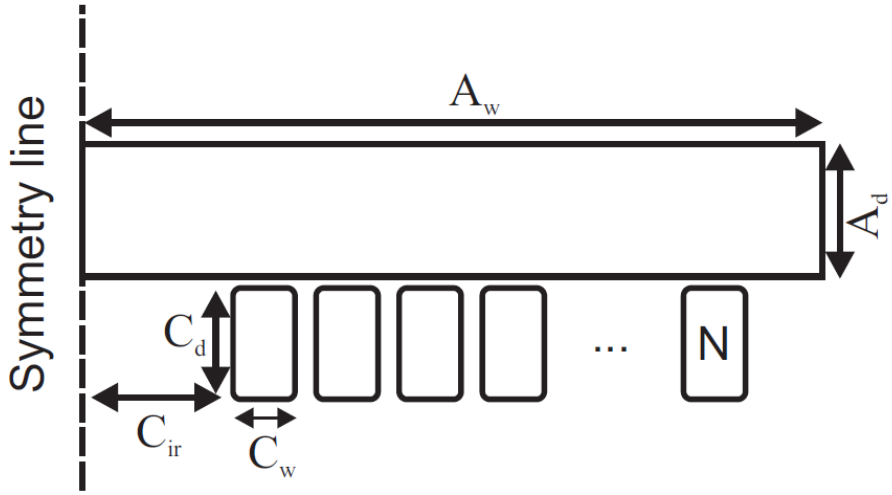
Experimental Verification

- High speed camera 10000 fps
- Motion tracking
- Good match between simulations and measurements!



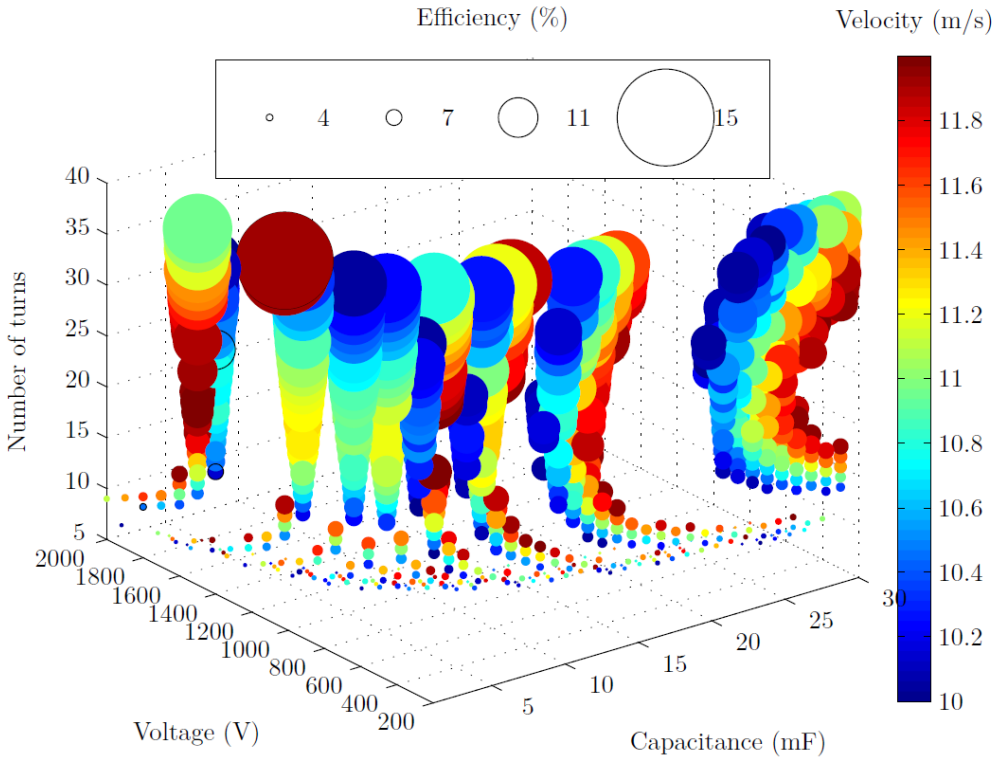
Test case

- The axi-symmetric model of the TC shown to the right
- Chosen variables are:
  - Capacitance
  - Charging voltage
  - Number of turns
- 20,520 simulations
- Parallelized on 4 CPUS
- Solving time: 7 weeks.
- If computed serially, this would take more than half a year.

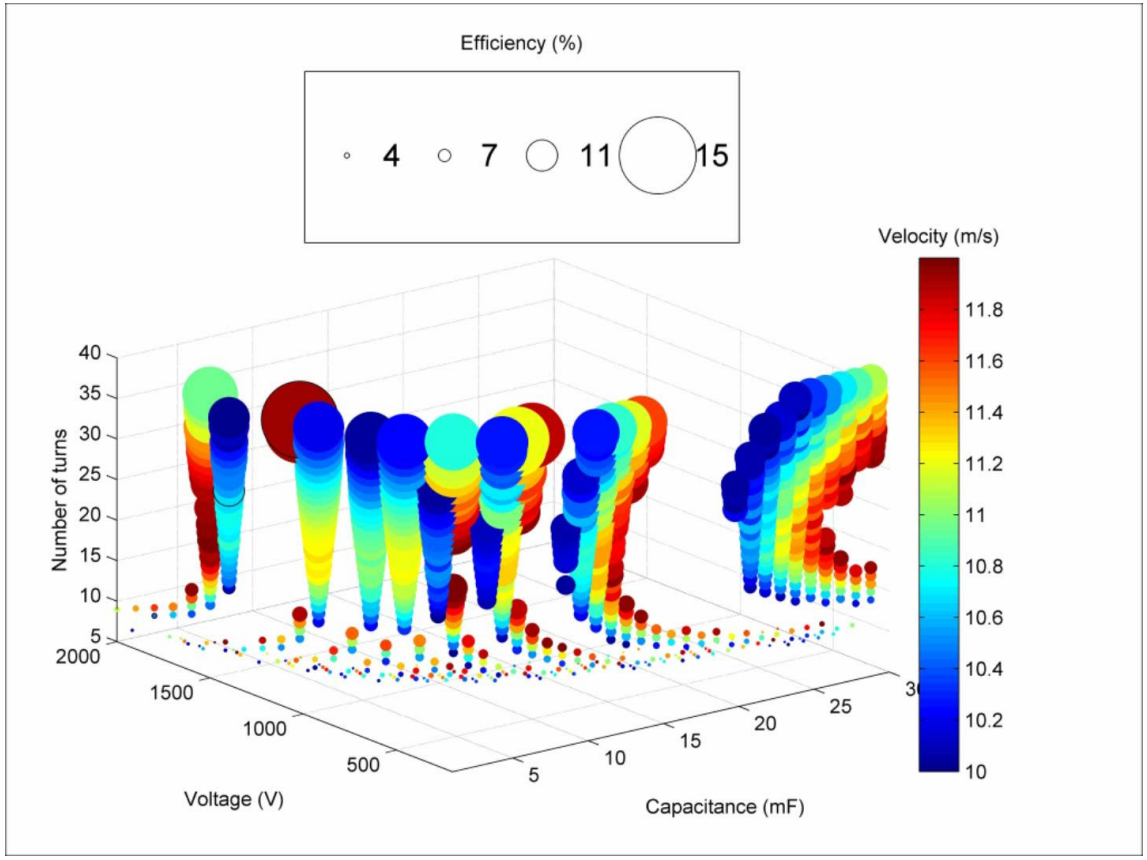


Results

- A 5D plot showing all combination sets resulting in a velocity between 10 and 12 m/s
- Dimension 1 on x-axis: Capacitance
- Dimension 2 on y-axis: Voltage
- Dimension 3 on z-axis: Turn number
- Dimension 4, color: Velocity
- Dimension 5, bubble size: Efficiency



Results



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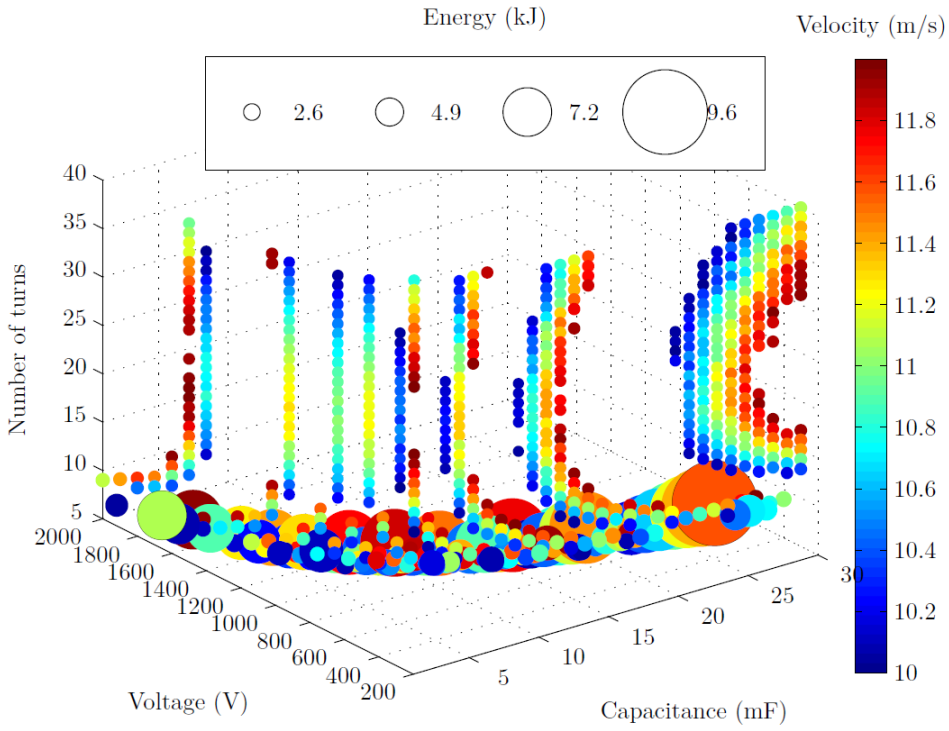

Conclusions & Future work

- Smart and parallelizable algorithm
- Increase in speed almost proportional to the number of parallel instances
- This algorithm is still at its infancy
- A dedicated multi-objective optimization algorithm will also be incorporated
- Coupling such a tool with COMSOL Multiphysics opens up a new frontier enabling fast and automated prototyping
- This significantly speeds up the chain from ideas to products

Questions?

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