GalFer Contest: DataSet Creation and EM Analysis

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Introduction

The objectives of this first part are:

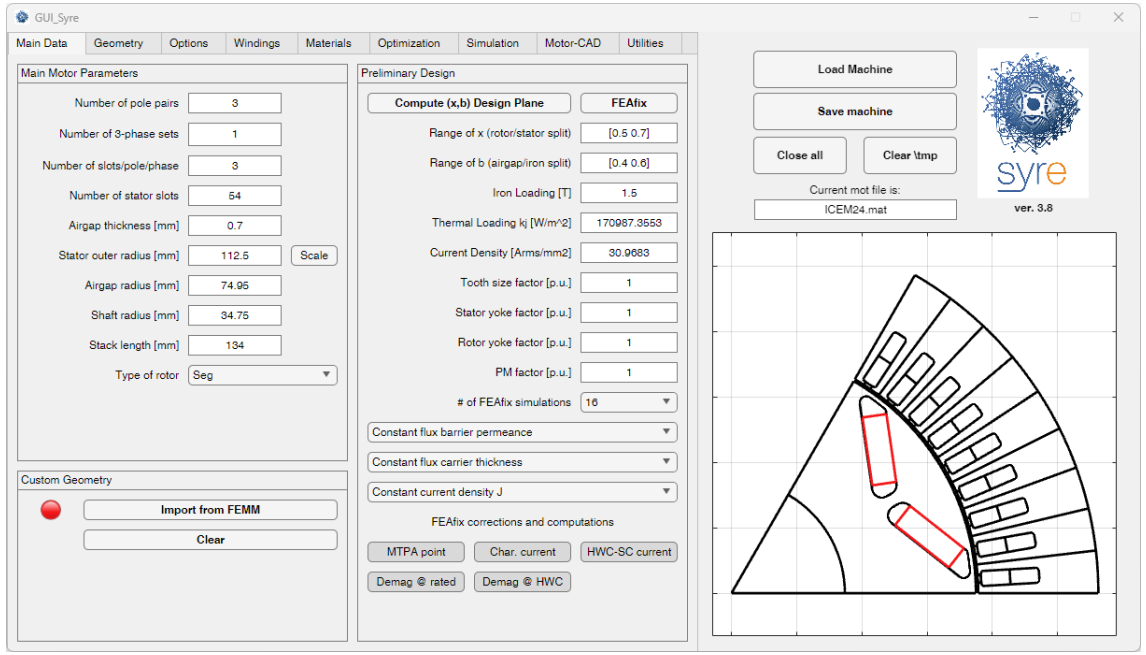
- Presents the geometric parametrization adopted
- Introduce the computation workflow and environment
- Show how the selected electromagnetic metrics are computed

The dataset is built and computed using SyR-e, available on GitHub and integrated with specific functions

Computation Environment: SyR-e

SyR-e is an open-source environment, developed for design and analysis of different kind of synchronous machines

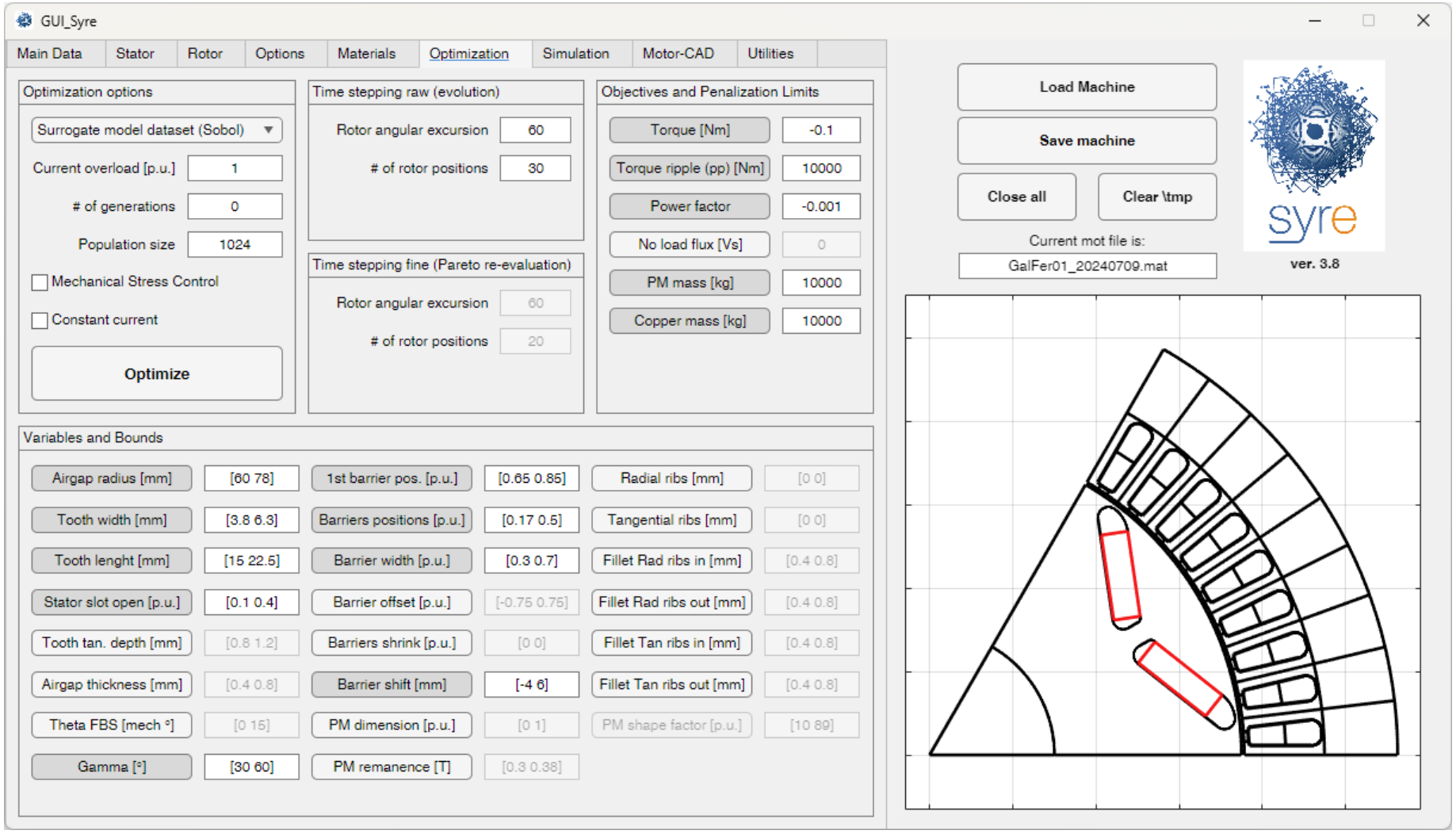
- Originally created for SyRM optimization
- In the years, it evolves, adding other machines (PM-SyRM, SPMSM, IPMSM, …) and preliminary design procedures
- It embeds specific procedures for flux maps manipulation and elaboration and the link with eDrive models (Simulink/SimScape, PLECS, …)
- It is based on FEMM for the EM FEA simulations
- Available on GitHub e Matlab File Exchange
- Used for the dataset creation for GalFer Contest, embedding specific functions from the contributors



GitHub

File Exchange

Computation Environment: SyR-e



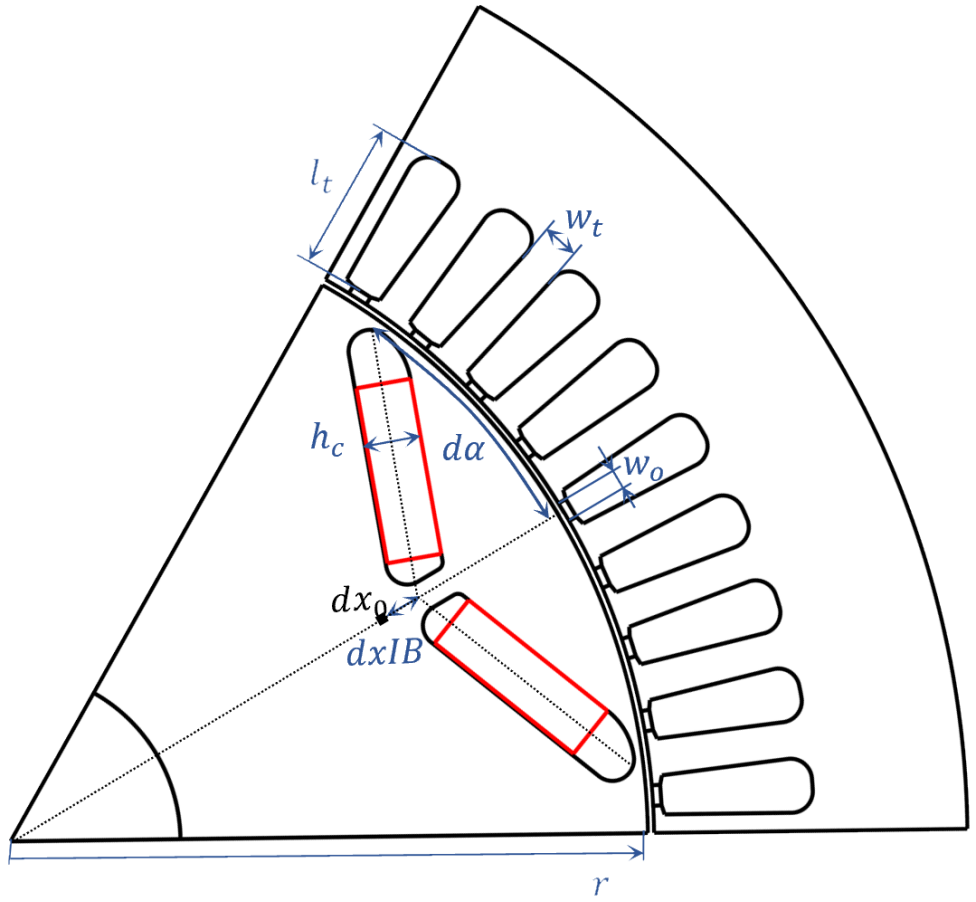
Parametrized Geometric Model

SyR-e exploit geometric parametrization, primarly for the optimization problem.

The parametrization is adopted also for the GalFer Contest dataset definition

The geometric variables, selected for the contest, are:

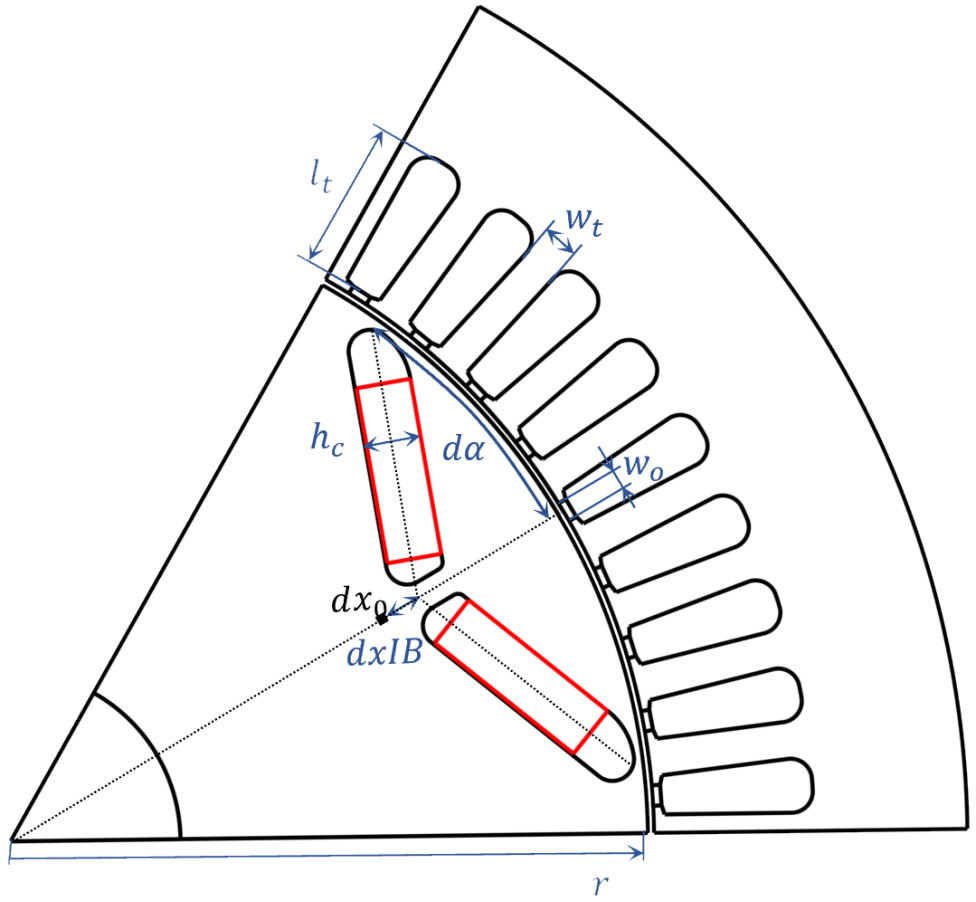
- Rotor radius r
- Pole span angle $d\alpha$
- PM thickness hc
- Barrier shift $dxIB$
- Stator tooth length l_t
- Stator tooth width w_t
- Stator slot opening w_o



Parametrized Geometric Model

Some geometric quantities are constant in the database:

- Stator outer radius
- Stack length
- Number of poles
- Number of slots
- Type of rotor (V-type)
- Materials
- Winding pattern
- Slot filling factor
- (Number of turns)



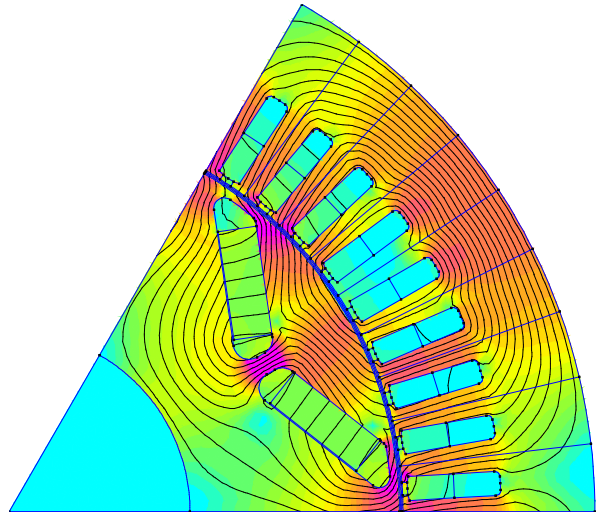
FEA Model and Simulations

FEMM is adopted for ElectroMagnetic FEA

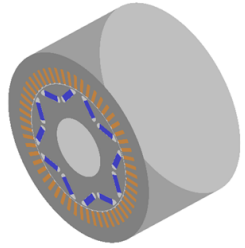
- 2D Static Time Step FEA Simulation
- Simulation of 60 elt degrees rotation, 30 rotor position

FEA settings:

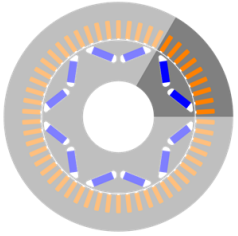
- Geometric model is created through SyR-e parametrization and workflow
- Current amplitude is defined starting from the **thermal loading** (i.e. loss in peak conditions)
- **Current angle** in dq reference is part of the variables



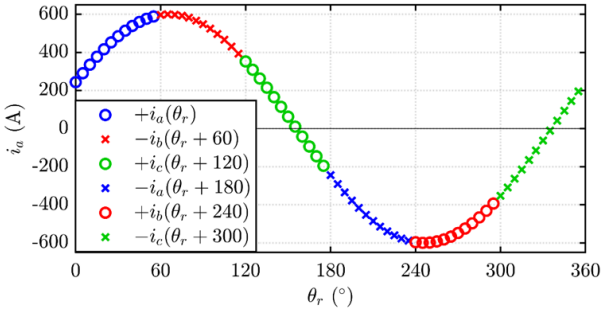
3D→2D



2p→1



360°→60°



FEA Model and Simulations

Results from FEMM:

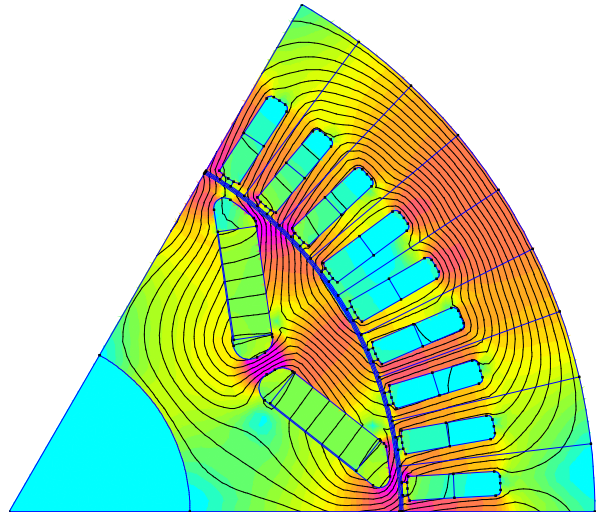
- Flux linkages (phase and dq waveform)
- Torque waveform

Then, electromagnetic output are computed and included in the dataset:

- Average torque
- Peak-to-peak torque ripple
- Power factor (from dq quantities, R_s neglected)

Furthermore, geometric output are computed, as cost metric:

- Copper mass (windings)
- PM mass



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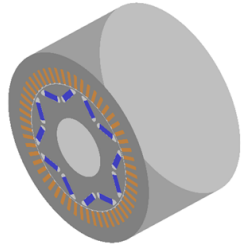

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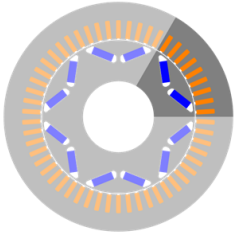

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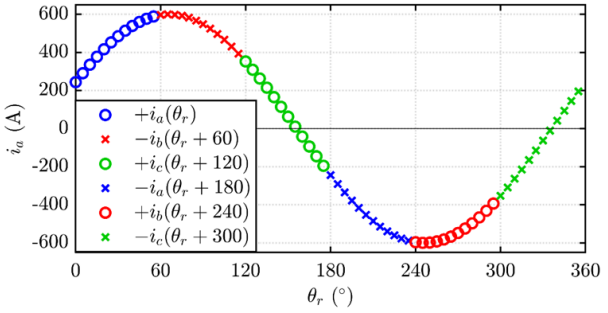


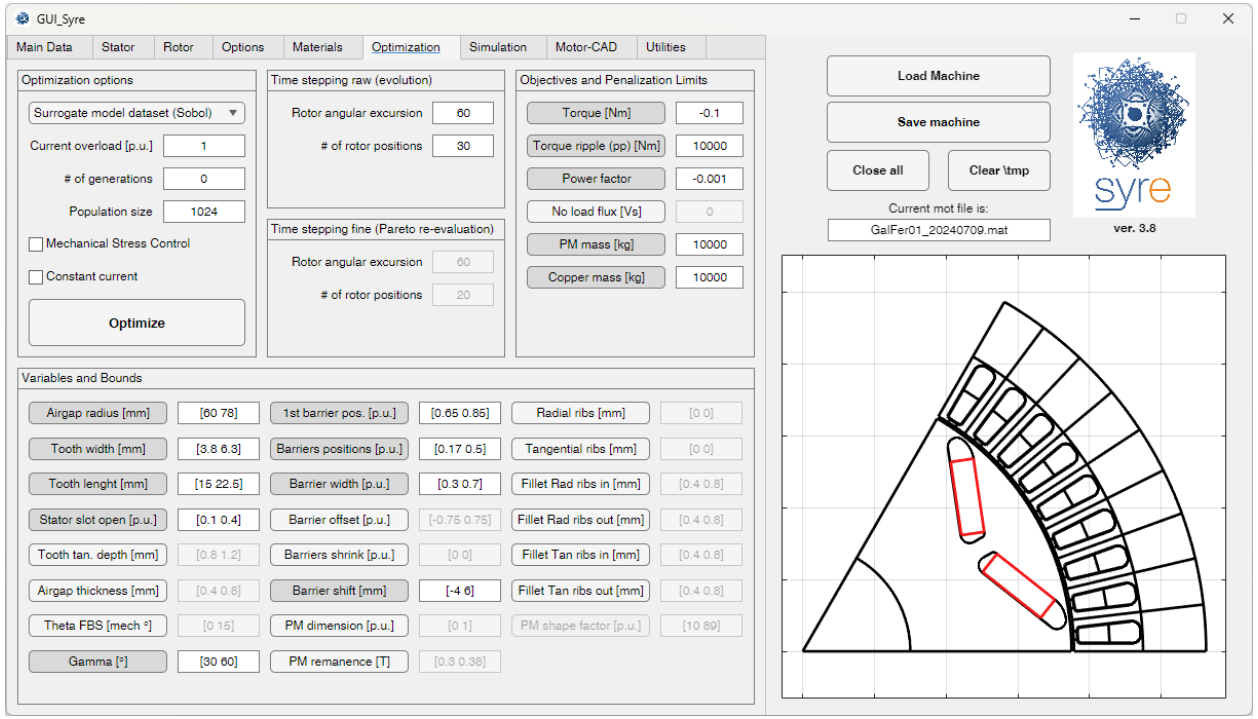
Computation Workflow in SyR-e

SyR-e optimization workflow is modified and expanded for the dataset creation:

- Latin hypercube or **Sobol** sampling
- Structural simulations are implemented in the dataset workflow simulation (was developed just as stand-alone simulation)
- Thermal simulations are implemented (UniPD code)

NB: FEMM mesh is adopted for all the physics

- EM: natively FEMM
- Structural: 2D, PDE toolbox, same mesh
- Thermal: 3D, extruded mesh, starting from FEMM



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