Multicriteria evaluation of electric motors

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Presentation overview

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Dataset generation

Result collection

Dataset structure

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Challenges in electric motor design

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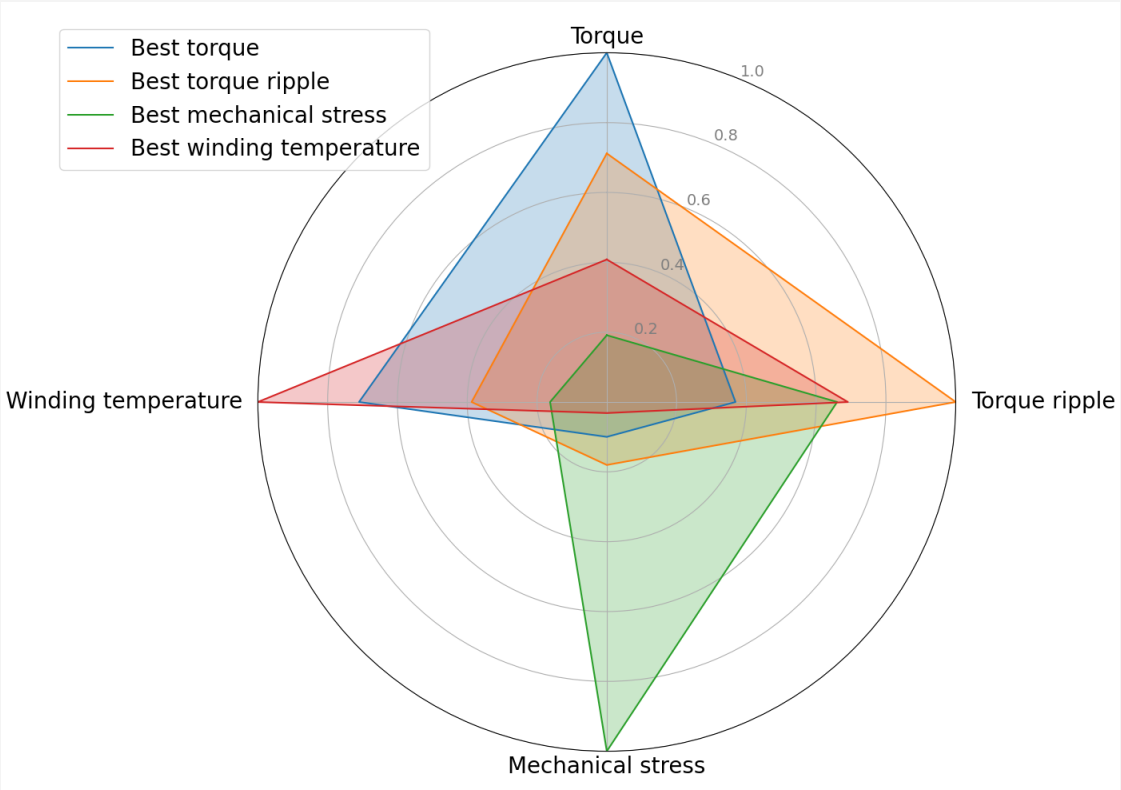
- As their performance are **stretched** to the limit, traction motors are a complex **design challenge**
- New interactions across problem domains appear (electromagnetic, thermal, structural, etc.) and require a **multi-physical** approach
- Different criteria must be considered as well in the design process, and most often, these are **contrasting** each other



Need for data driven surrogate models

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- **Pre-design** and **optimization** tools become crucial due to more demanding constraints
- as **new requests** are made to designers, at the same time, new methodologies based on **learning from data** are appearing
- their **pattern finding** capabilities help a new approach to design and pre-design tools
- whichever they are, all these procedures need a **training set of data** to be elaborated
- we propose a **reliable and open dataset of results** as a sandbox where to develop and test data-driven methodologies

Dataset generation

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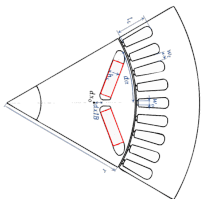
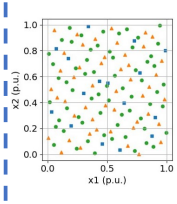
- The general procedure for the **dataset generation** is here described:

Step 1
definition of parametric geometry by *p* real valued arrays

$\mathbf{x} \in \mathcal{R}^p$



Step 2
hierarchical generation of *N* points



Step 3
creation of motor structure

$\mathbf{x}_k,$

$k = 1, \ldots, N$

syre

Step 4
creation of the 2D triangular mesh

FEMM

Lua

Step 5
Multi-physics analysis based on 2D and 3D models

electromagnetic

thermal

structural

Step 6
collection of *m* results for each configuration

$\mathbf{y} \in \mathcal{R}^m$

results dataset

Workflow

Motor configuration definition

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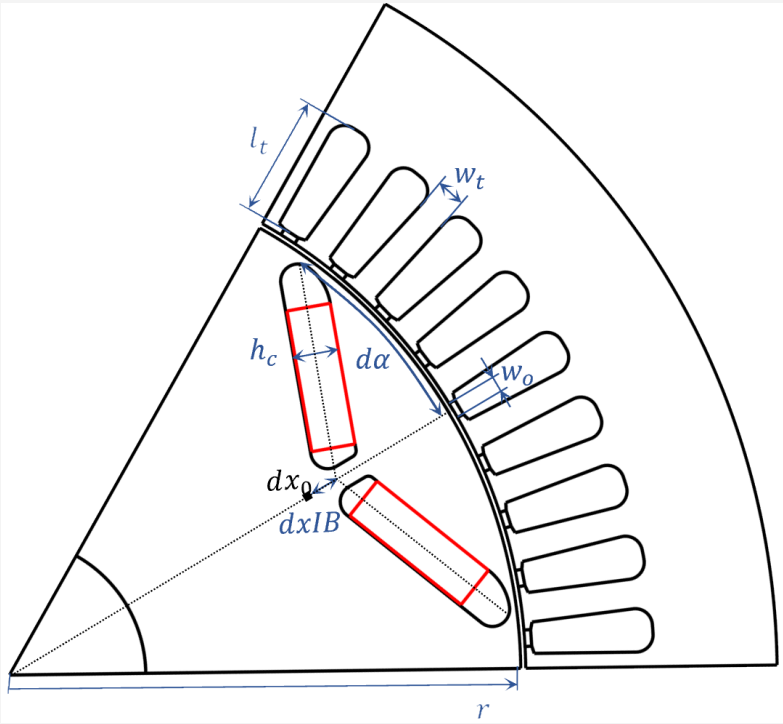
- A family of motors is generated by considering the **external dimensions** of the motor (stator outer radius and axial length) as fixed as well as the **power supply conditions** and **circuit data**
- The structure is modelled starting from its **2D cross section**
- **Seven geometrical design variables** uniquely define a geometrical configuration



- A further variable is the **current phase angle** γ, taken from the q axis

Sobol Sampling in Dataset Preparation

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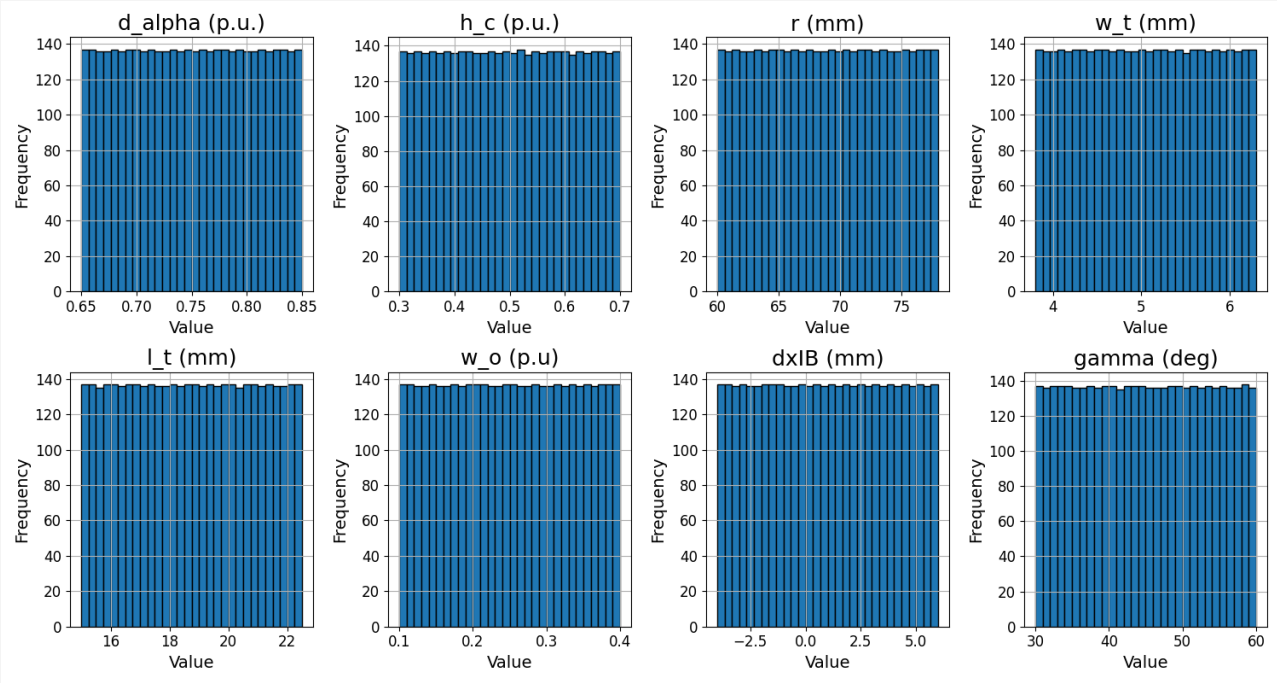
- Input variable configurations are generated through **Sobol sampling**, a quasi-random sequence generation method
- Advantages:
  - **Uniform coverage**: ensures complete exploration of input space
  - **Efficient sampling**: requires fewer points for high-dimensional spaces
  - **Reproducibility**: deterministic sequence enables consistent results



Result collection

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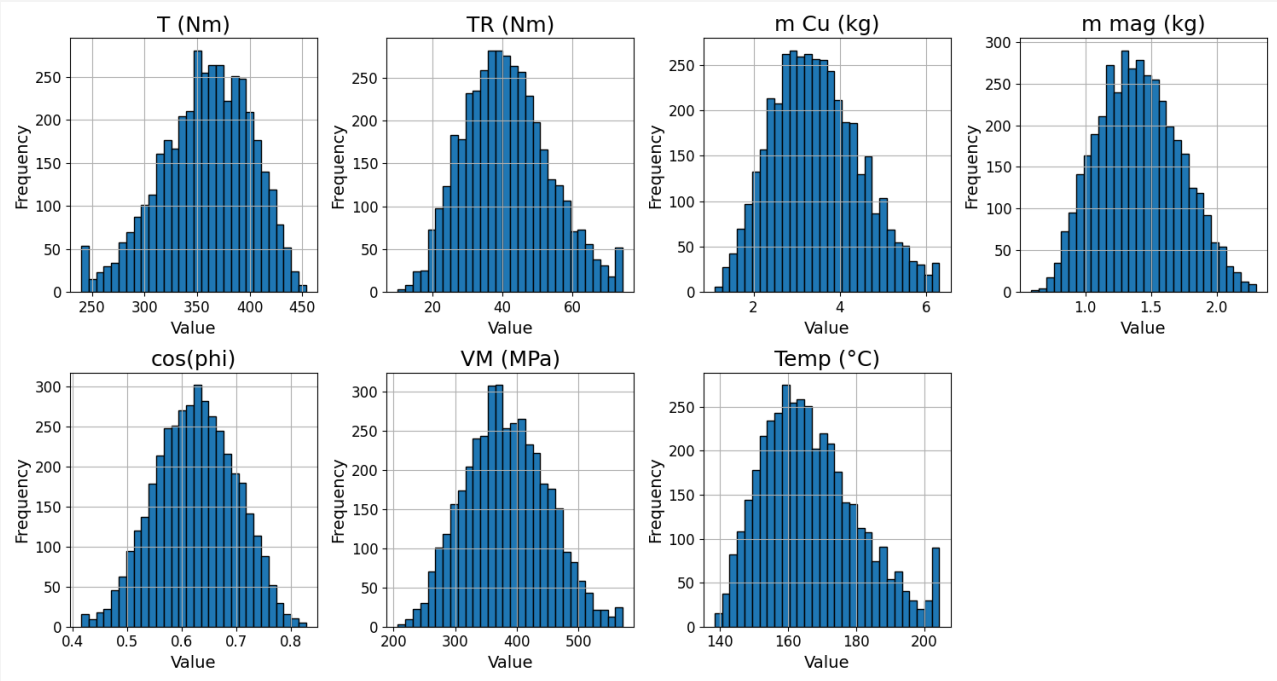
- For each motor configuration, 7 outputs are collected:
  - Electromagnetic: average torque, torque ripple, power factor
  - Structural: Von Mises equivalent stress
  - Thermal: maximum winding temperature
  - Geometrical: copper and magnet masses



Input - Output correlation

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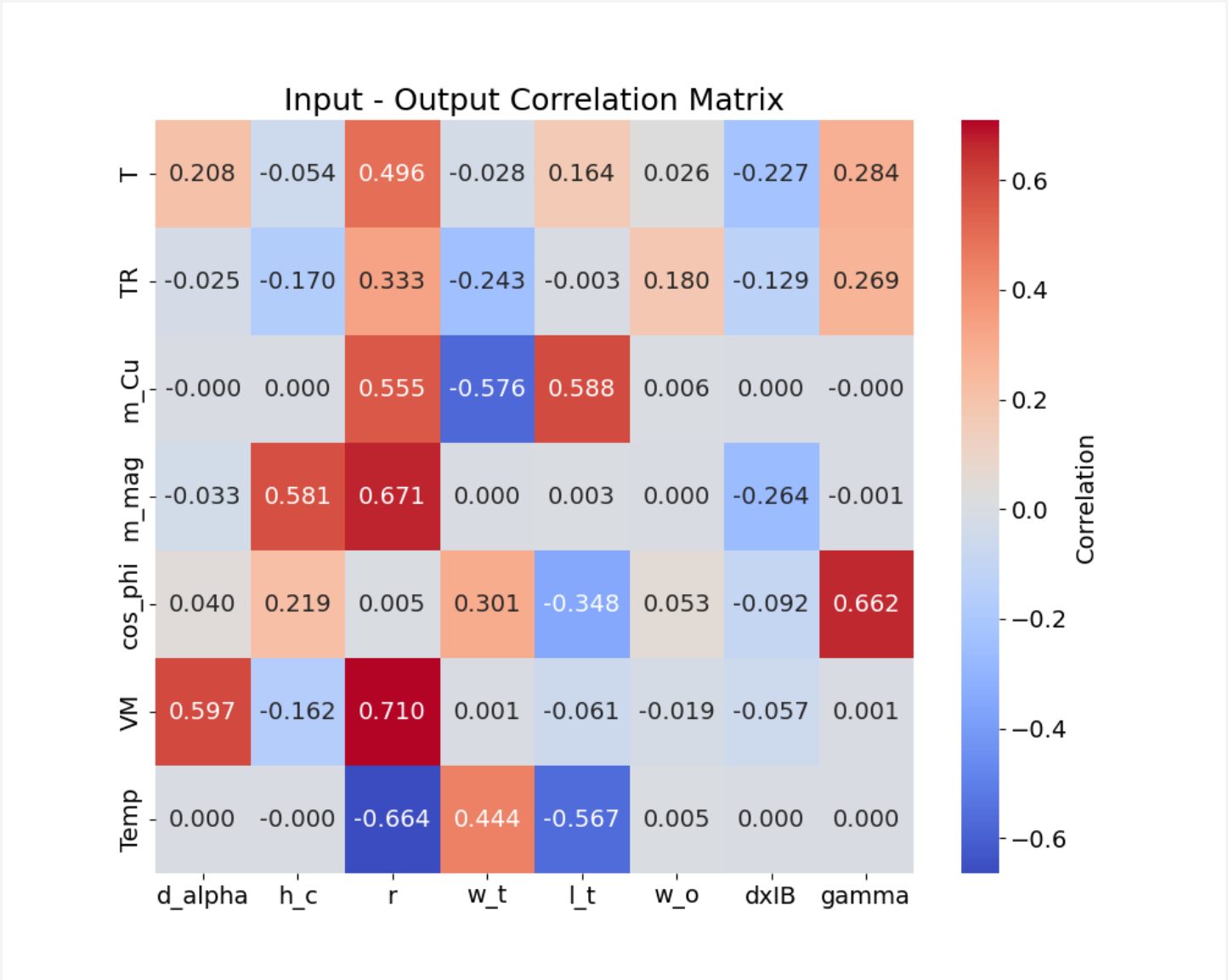

Dataset structure

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- Dataset structure:
  - 8 inputs (the ones your evalution function will receive)
  - 3 additional inputs (actual values of the "p.u. inputs"): the link between actual and p.u. values is geometry definition procedure of `Syr-e`
  - 7 outputs (the ones your model will predict)

Input

d_alpha (pu)	h_c (pu)	r (mm)	w_t (mm)	l_t (mm)	w_o (pu)	dxIB (mm)	gamma (deg)	d_alpha (deg)	h_c (mm)	w_o (mm)
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-

Output

T (Nm)	TR (Nm)	m_Cu (kg)	m_mag (kg)	cos(phi) (-)	VM (MPa)	Temp (°C)
-	-	-	-	-	-	-
-	-	-	-	-	-	-

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- Prepare an executable function (in Python or Matlab) as:

```
[T, TR, m_Cu, m_mag, cos_phi, VM, Temp] = your_fun(
d_alpha, h_c, r, w_t, l_t, w_o, dxIB, gamma)
```