AI Fighting Climate Change: Open Innovation Challenge

AI-Driven Engineering Simulations for Sustainability

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for
Schneider Electric European Hackathon 2023

24 November 2023

The Goal

- To introduce the potential of AI-driven engineering simulations in industries to reduce emissions by Implementing Energy Efficiency Measures.
- To present success cases to demonstrate the Energy Efficiency of AI driven simulations vs conventional approach.
- Discuss probable scalability and challenges to be faced while embracing the AI driven approach

Problem

- During engineering simulation workflow, many iterations are needed to adjust geometry and meshing to arrive at desirable solution.
- Pre-processing (meshing) is the most repetitive and error-prone task.
- According to [3], "*It is not unusual for the meshing process to take upwards of three-quarters of the entire simulation time*"

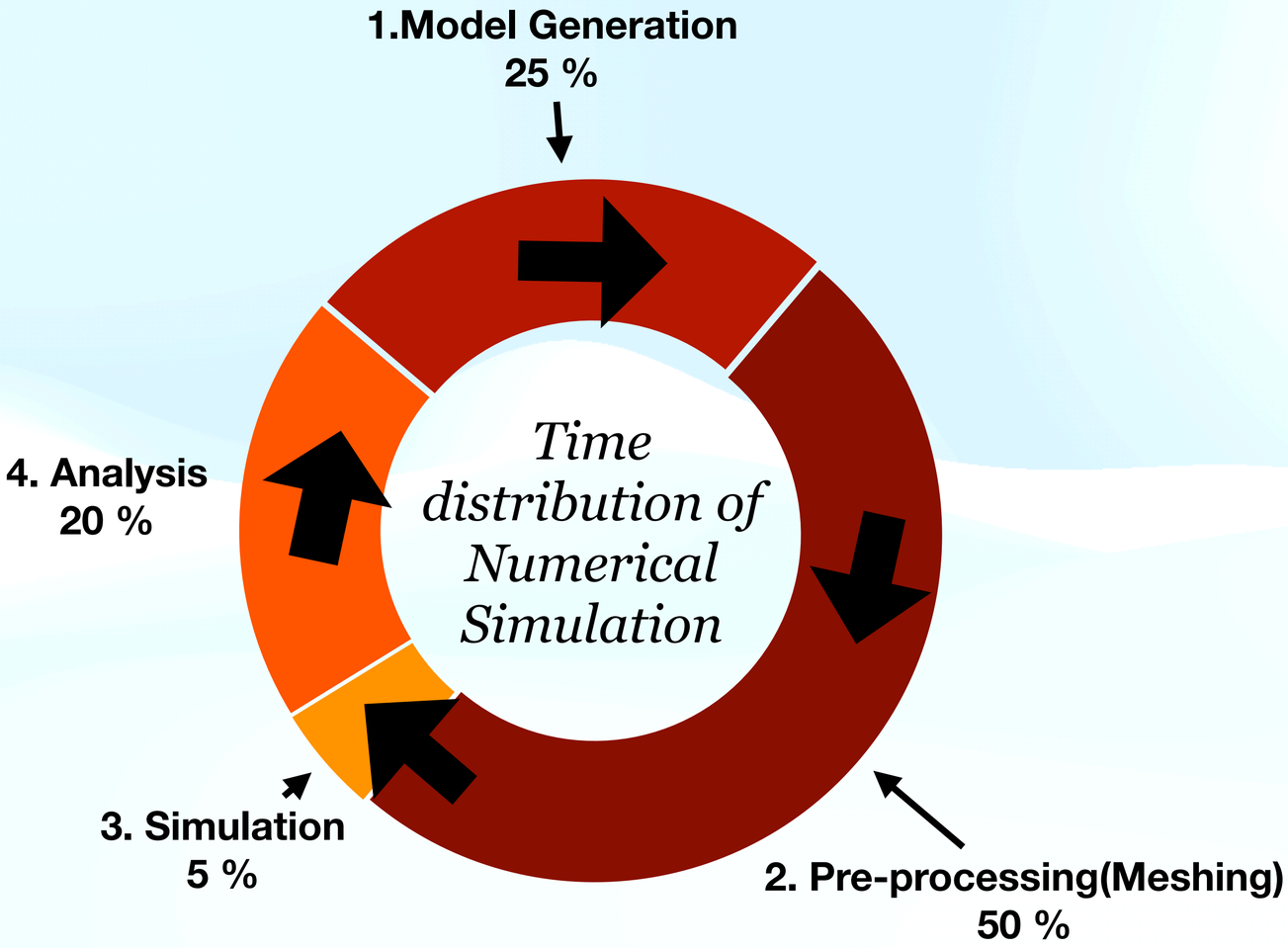

Fig. Process flow of Engineering Simulation showing time required for each step

Problem

- Hence, meshing is a primary bottleneck in the simulation, demanding a substantial share of the available resources i.e. time, cost and energy

- While many simulation softwares offer automated meshing capabilities, meshing complex geometries often necessitates human expertise and remains an iterative and error-prone process.

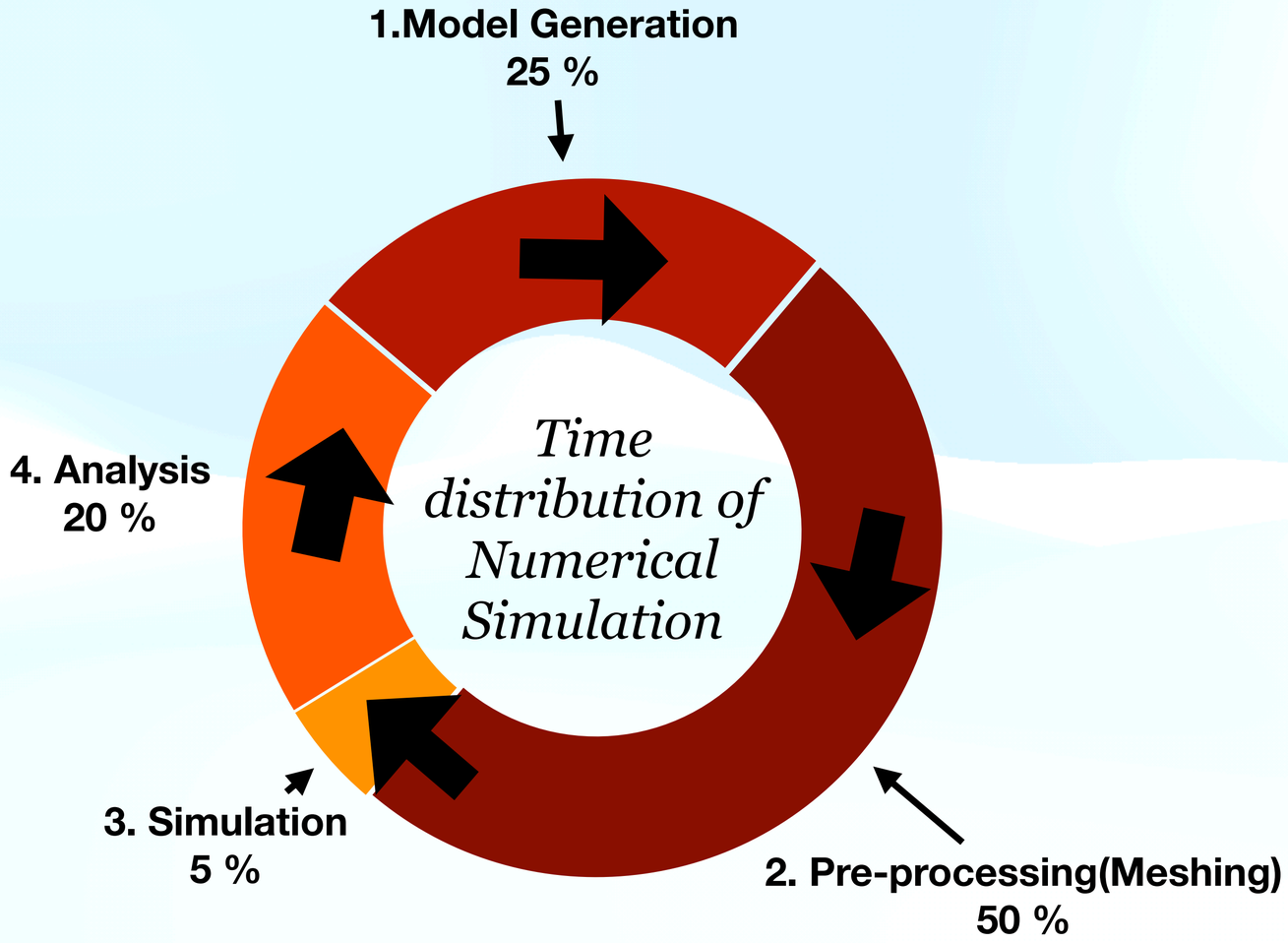

Fig. Process flow of Engineering Simulation showing time required for each step

Potential Solution: AI driven meshing

- The sustainability goal of many industries can be accelerated by substantially optimising the simulation processes in turn saving a lot of energy.
- The AI driven solutions for automation of meshing process holds immense potential to develop more accurate and energy efficient solutions for today and tomorrow driving efficiency and sustainability across industries
- According to [4], using machine learning for mesh generation can reduce the iterations considerably, furthermore the mesh produced will be of high quality, optimally adapted to the given geometry.

Why to chose AI driven meshing?

- For Industry:
  - Substantial energy saving
  - Accelerated Workflow
  - Optimised product
  - Reinforcing sustainability goals
- For Employees:
  - Minimal repetitive tasks
  - More productive time
  - Opportunity to learn and grow
- For End User:
  - Better, optimised product
  - Shorted delivery timeframes

And many more…

What does it mean for environment?

Implementation of AI in the simulation workflow could revolutionise the engineering deliverables. Apart from the direct benefit on energy, cost and time, the more optimal product bring uncountable intangible benefits to environment and user safety.

- For Environment:
  - Substantial energy saving at source, reduced emission
  - Optimised products: for example, cars with more efficient emission control, reduced noise and vibrations, energy efficient design
- For User:
  - More durable and quality products
  - Improved safely

Success Cases

- Reference[1] demonstrate the existing automated CAE workflow that batch-meshing(automated mesh generation) can substantially reduce meshing time up to 90%. (This is to be noted that generated mesh still needs quality inspection and subject further iterations)
- According to [4] If an AI model can successfully learn from the available data, the unstructured mesh generation process is extremely fast producing a high quality mesh at the first attempt (at similar cost to generating a uniform mesh with same number of elements).

Success Cases

- In reference[5], the authors demonstrates a very strong case where, the total carbon footprint and energy consumption is lowered more than 35 times when using the NN model(even considering the carbon footprint of training NN model) in compare to common practices.

- Author also mentions that the proposed method lies in the category of **green AI research**, demonstration that computational resources and time are substantially reduced with AI driven approach, when compared to current practice in industry.

	Near-optimized NN generated mesh	Mesh with traditional method
Total footprint Carbon (Kg CO2 equivalent)	14.81	527.17

Challenges

- AI generated meshing technology is still in the stage of early development. To arrive at a generalised technology which could be utilised by variety of models and compatible with existing infrastructure needs initial investment in research.
- A lot of organizations lack expertise to manage AI driven projects which leads to either invest in external consultants or training the employees
- Organizations may encounter difficulties in fostering awareness and encouraging the adoption of AI within their work culture.

Scalability

- Developing AI generated meshing technology which could adapt to numerous industrial applications.
- Parallelisation of AI driven mesh generation for large scale simulations.
- Reducing human interventions leading to optimal meshes for given type of geometry and nature of problem.

Reference Documents and Code

1. 2nd ANSA & μETA International Congress June 14-15, 2007 Olympic Convention Center, Porto Carras Grand Resort Hotel, Halkidiki Greece.
2. Lock, C., Hassan, O., Sevilla, R., & Jones, J. (2023). Meshing using neural networks for improving the efficiency of computer modelling. Engineering with Computers, 39(5), 2315-2327.
3. Owen, Steven & Clark, Brett & Melander, Darryl & Brewer, Michael & Shepherd, Jason & Merkley, Karl & Ernst, Corey & Morris, Randy. (2007). An Immersive Topology Environment for Meshing. Proceedings of the 16th International Meshing Roundtable, IMR 2007. 553-577. 10.1007/978-3-540-75103-8_31.
4. Zhang, Z., Wang, Y., Jimack, P.K., Wang, H. (2020). MeshingNet: A New Mesh Generation Method Based on Deep Learning. In: Krzhizhanovskaya, V.V., *et al*. Computational Science – ICCS 2020. ICCS 2020. Lecture Notes in Computer Science(), vol 12139. Springer, Cham. https://doi.org/10.1007/978-3-030-50420-5_14
5. Courtesy to the authors of MeshNet[4] who have made their work publicly available on **https://github.com/iMoonLab/MeshNet/tree/master**