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Deep Learning to aid CFD simulations in Built Environment

Wei Liu
Giovanni Calzolari
KTH, BYV
CFD in the built environment

- CFD simulate airflow with great details, but there are uncertainties (turbulence models) and it is not fast enough.

- Literature review shows that in the built environment, deep learning is only used as surrogate modeling for faster prediction [1]

- Deep learning can aid fluid simulations instead of just replacing them.
Coupled Framework

• We develop a **coupled CFD – deep learning framework** where we substitute only the turbulence model of CFD with a MLP.

  - Run CFD simulation and gather data
  - Train MLP in Tensorflow
  - Implement the MLP on OpenFOAM and create the coupled framework
Flow Fields from literature

A. **Room** simulation mixed convection indoor airflow [2]. Data used to **train** the MLP.

B. **Office** simulation with displacement ventilation [3].

C. **Building array** simulation outdoor airflow [4].


Compared to standard CFD simulation using RNG k-ε model the new coupled framework is:

A. 14.5 % faster*

B. 16.7 % faster*

C. 17.2 % faster*

*based on run-time comparison using the same machine with the same simulation setup
Conclusion and future work

- The current framework proves the feasibility of the approach to aid and enhance CFD simulations with data driven models.

- **Future work** will focus on:
  - Development similar but more advanced types of interaction between deep learning and CFD.
  - New ways of aiding CFD such as leveraging **super-resolution** techniques with CNNs.
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