Inverse analysis of semi-discrete fluid mechanics in buildings

**Supervisor:** Dr John Craske, Dr Maarten van Reeuwijk and Professor Graham Hughes

Buildings are responsible for a majority of the world’s carbon emissions and therefore represent one of the biggest challenges and opportunities in the development of a sustainable future. Understanding and predicting the distribution of air flow and temperature within buildings will play a key role in the design of sustainable architecture, allowing designers to exploit naturally occurring phenomena to deliver comfortable and efficiently controlled spaces. A crucial ingredient in this regard is the up-scaling of models that describe the temperature structure and ventilation of individual spaces to networks of interconnected spaces. Thus, the aim of the proposed project is to incorporate models for buoyancy-driven mixing that can predict the continuous distribution of temperature and air flow within a single space into discrete models of entire buildings, as shown in figure 1. The focus will be on understanding how the physics associated with mixing in individual spaces influences the flow dynamics of the overall building and the implications this relationship has for design and building management strategies.

![Figure 1: Discrete model of building ventilation and temperature structure (left) and continuous model of buoyancy-driven mixing in a single space (right) in an optimisation problem.](image)

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J = (u, g) = (f, v) \\
A u = f \\
A^* v = g
\]
When modelling the behaviour of buildings, the boundary conditions and heat loads to which spaces are subjected are never known precisely. Quantifying the uncertainty associated with these unknowns therefore provides designers and building managers with valuable information. The proposed project will use inverse analysis to view the system from a dual perspective: how sensitively does the resulting temperature structure and flow topology depend on the inputs and characteristics of individual spaces? We would like to understand how uncertainty propagates through the system, to control the system and to obtain upper and lower bounds for various statistics that characterise the building’s ventilation and temperature structure. The successful candidate will investigate these issues by developing in-house software from first principles and ‘adjoint’ tools to analyse the system’s sensitivity.

The emphasis of this research is on obtaining insight into the fundamental physical processes that occur in the heating and ventilation of buildings to inform design practice and building management strategies. The results will be applicable to the design of both new buildings and the retrofitting of existing buildings.

Eligibility and Funding

Funding is available for applicants with settled UK status (see https://www.epsrc.ac.uk/skills/students/help/eligibility/ for eligibility). The studentship offers a stipend of approximately £16,000 per annum (tax free) and covers fees at the UK/EU student rate for a period of four years.

The successful candidate should hold at least a 2:1 degree in engineering, mathematics or physics and have a strong interest and ability in mathematical modelling, fluid mechanics, numerical analysis and computer programming. It is desirable that candidates have an interest in the built environment.

Contact

For informal enquires and to request more information, contact Dr John Craske (http://www3.imperial.ac.uk/people/john.craske07)

This PhD studentship is co-funded by the EPSRC CDT in Sustainable Civil Engineering at Imperial College London: (http://www3.imperial.ac.uk/sustainablecivilengineering)

Deadline

Review of application is now in progress and will continue until suitable candidate is identified. The starting date for this PhD Studentship is 1st of October, 2017.