INTELLIGENT MATERIALS

Responsive architecture

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This research interest surrounds the ways that buildings and, in particular, façades could be dynamic and physically articulated to respond to changes in synoptic weather conditions across seasons. A practical demonstration of this approach was the Deployable External Insulation (DEI) developed at the Bartlett, and realised with a full-size pavilion in 2008, using the Bartlett's manufacturing workshop. This showed how a kinetic façade with movable shutters could be operated by passive thermo-hydraulic actuators. These actuators exploit the liquid-to-solid transitions of Phase-Change Materials (PCMs) such as paraffin waxes, when they absorb sufficient thermal energy above ambient they expand to generate a large hydrostatic force; a property that can be used to directly move building elements.

A novel mechanism was invented to demonstrate how an arrangement of this actuator could respond to different outdoor conditions by moving the façade's shutters into three different positions (see figure, right). When it is cold or during night-time, the shutters are closed to provide insulation and reduce heat-loss. During daytime, they are fully opened to admit daylight. And during hot weather, they are half-closed to provide shade and limit the risk of overheating.

Two linked actuators, each powered by a different paraffin wax, respond individually to the amount of ambient thermal energy that is available. The climate-controlled chambers at the Bartlett were used during the extensive development and testing of this mechanism with a series of full-size prototypes. This invention is the subject of a patent application to the UK intellectual property office, through UCL's business department.

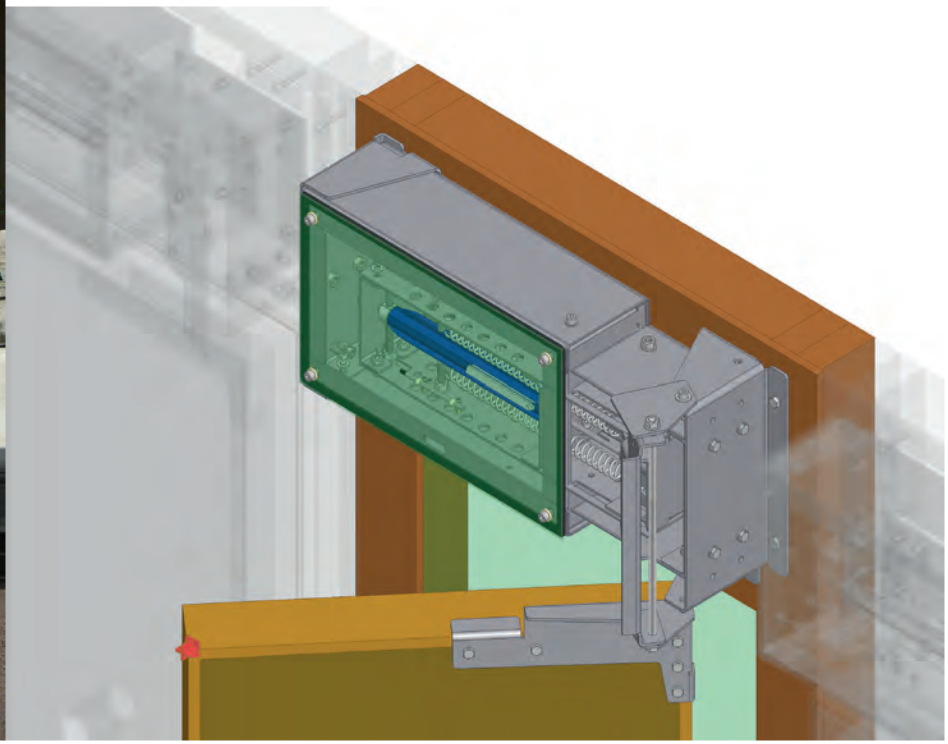
Visible and thermal-band time-lapse imaging was used to produce photogrammetric solutions. These allow the actual 'as-operated' observations to be compared with the 'as-simulated' by virtual models. The linking of practical, computer-based, thermal laboratory and field observations has given the insights necessary to account for the passive flow of thermal energy through these unique actuators. This informed the development of a thermal engineering analysis, using the finite element method.

The approach taken by this research, challenges the architect with the task of achieving a balance in the design of the building envelope. One in which the passive flow of energy into and out of this type of actuator system can be marshalled as the organising principle for the variety of its states, while matched to the prevailing seasonal variation in ambient conditions.

Personal statement

As a practising architect, I am motivated to conduct applied research that adapts and transfers technology from other fields. My doctoral studies on the EngD have explored the feasibility of a thermo-hydraulic actuator system that embodies both the actuation method, and the control logic entirely passively, as an integral part of the architectural design for the building's envelope. The EngD Centre sits amongst the engineering, prototyping, climate testing and manufacturing facilities that are needed to explore this research topic. I am currently completing a thesis as a candidate for the EngD and regularly give lectures on the topic of climate-responsive architecture and his findings on the subject.

An actuator responds to different outdoor conditions by moving a façade's shutters



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