Thermal Modelling of Homes and Buildings From Minimal Sensor Deployments

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Recent years have seen significant research into providing homes and buildings with real-time feedback on their energy consumption in an effort to reduce the carbon emissions from both the domestic and commercial sectors. Much of this work has focused on solutions that use a small number of easily deployed sensors in conjunction with intelligent algorithms to infer what cannot be measured directly. A mature example of this approach is non-intrusive appliance load monitoring that attempts to disaggregate total electricity consumption within a building using measurements from a small number of sensors [1]. However, both the heating and cooling of buildings are significant consumers of energy, and much less work has attempted to monitor and understand this consumption through minimal sensor deployments. To address this shortcoming, in our work, we have developed a range of models that attempt to capture the thermal dynamics of buildings in realistic deployments where we have very limited sensor data and also limited information about the construction and use of the building itself. Our approach extends existing grey-box thermal models [2], with approaches from the machine learning literature, using hidden Markov models to capture changing operational settings, and latent forces to capture *a priori* unknown thermal dynamics [3, 4]. We describe how these approaches have been used within a deployed system, named Joulo, which uses a single low-cost temperature logger and online intelligent algorithms to model the thermal characteristics and use of heating systems in homes (www.joulo.com). Joulo provided personalised home heating advice to over 750 households in its original deployment, and has gone on to commercial trials with a number of UK energy companies [5].

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