A scalable method of diagnosing HVAC sensor faults in smart buildings

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Heating, ventilation and air-conditioning (HVAC) systems are the biggest consumers of energy in a building. For smart buildings, technologies have evolved to improve energy efficiency of HVAC systems, but faults often occur. Due to the complex nature of large-scale HVAC systems used in buildings, diagnosing these faults can be challenging.

A team of researchers led by Professor Marios Polycarpou, Director of the KIOS Research and Innovation Center of Excellence, Cyprus, has developed a distributed sensor fault diagnosis algorithm, a sequence of well-defined computer-implementable instructions for detecting and isolating multiple sensor faults in large-scale HVAC systems in smart buildings. The team published their findings in *IEEE/CAA Journal of Automatica Sinica*.

"The operation of Heating, Ventilation and Air-Conditioning (HVAC) systems in our homes, work spaces and public indoor spaces are based on the use of feedback measurements from sensing devices to make adjustments for maintaining a desired temperature. The presence of faulty measurements disorients the system and may create uncomfortable indoor conditions and/or significantly waste energy," said Professor Polycarpou.

This study presents an algorithmic approach that can be applied either on existing Building Management Systems or on plug-in Internet-of-Things (IoT)—a system of physical computer devices that are interconnected via a network for collecting and sharing data—to notify the building's users and operators about the presence of faulty measurements, as well as the location of any faulty sensors.

In this study, the authors model a large HVAC system consisting of 83 building zones as a network of smaller interconnected sub-systems, rather than using a global model that describes the HVAC system for the entire building. This simplified method not only makes the design of model-based fault diagnosis more feasible, but it is also scalable, allowing for other parts of the building to be incorporated into the network using a plug-and-play approach.

According to Polycarpou, the utilization of thermal models of the variation of temperature in HVAC equipment and building zones, in

combination with the design of diagnostic algorithms implemented in a multi-agent framework—a self-organized system consisting of several intelligent agents that interact with each other to solve complex problems that would be difficult for them to solve singularly—enables the development of advanced methods for detecting and isolating sensor faults, "In this framework, a wireless smart sensor can communicate with its neighboring sensors to enhance the fault diagnostic process in terms of reliability, robustness, sensitivity, and scalability," Polycarpou explains.

"Our ultimate goal is to develop lifelong diagnostic systems for smart buildings, which are able to continuously monitor their operation over the lifetime of the buildings, to detect, diagnose and self-heal any faulty behavior, and to be able to learn from their prior experiences, as well as from the experiences of diagnostic systems from other smart buildings," said Polycarpou.

More information: Scalable Distributed Sensor Fault Diagnosis for Smart Buildings, *IEEE/CAA Journal of Automatica Sinica* (2020) www.ieee-jas.org/article/doi/1 … 109/JAS.2020.1003123

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