Era of Big Data: Applications in Building

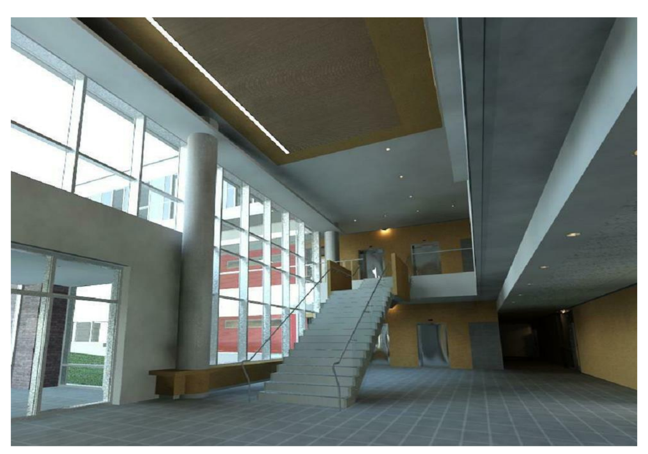
Burak Gunay, Sara Gilani, Aly Abdelalim, Zixiao Shi| Professor: Liam O'Brien | Human-Building Interaction Lab, Carleton University

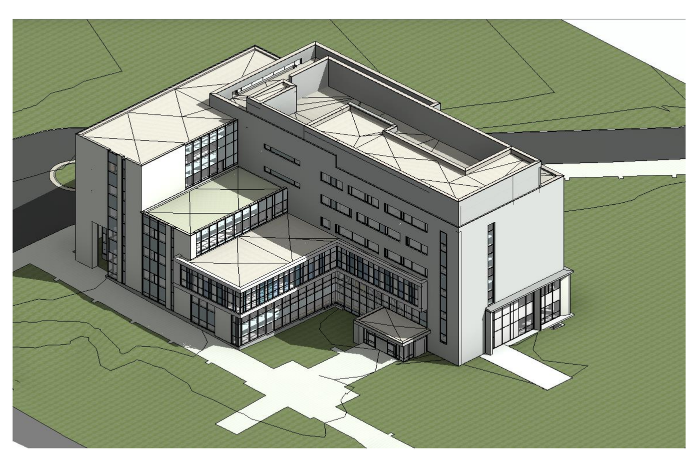
Research Partners:

Building Information Modeling (BIM)

Building drawings used during the design and construction periods contain every detail about the building but are hardly used during operation and maintenance. With Building Information Modeling (BIM) technology, every piece of information about every single building component gets recorded and updated during building design, construction and operation. All those digitized data enable us to develop self-learning/predictive building controls and perform building diagnostics and retrofit with much higher accuracy and efficiency.

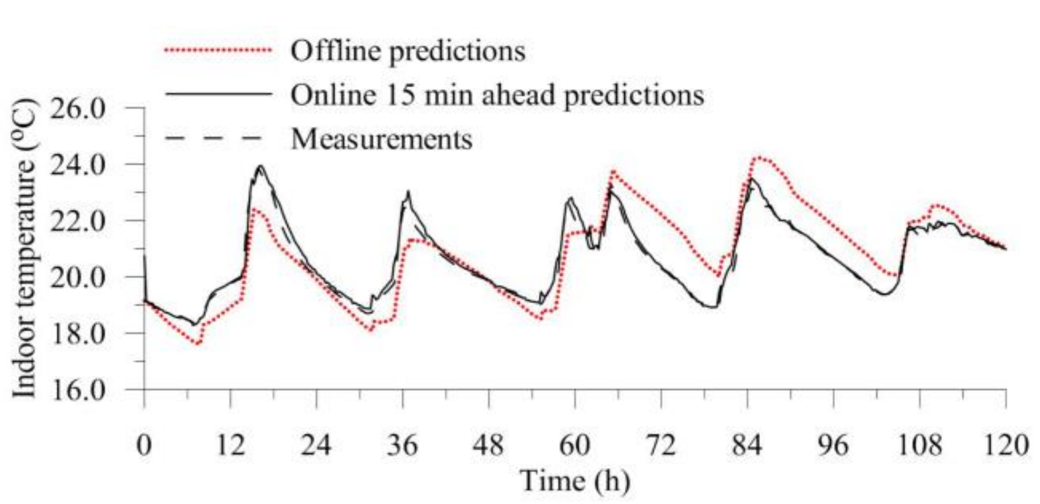
Digital Campus Innovation (DCI) is an ongoing collaboration between the Human-Building Interaction Lab and the Carleton Immersive Media Studio to develop BIM models for all major buildings in Carleton University. A screenshot of rendered interior view (left) and architectural BIM model of the Canal Building (right) are shown below.



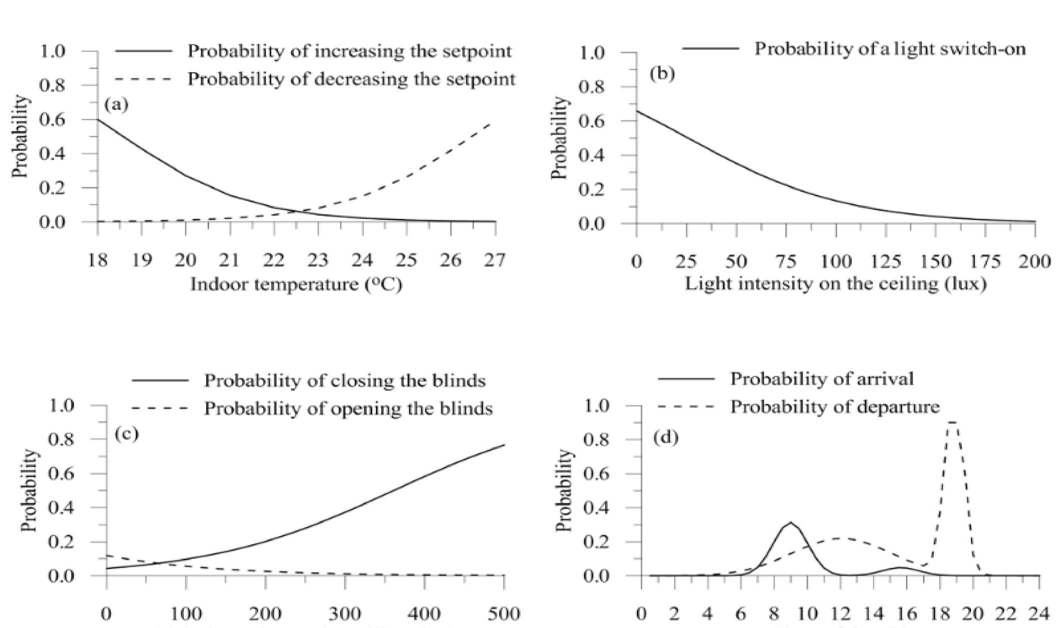


Self-learning/Predictive Controls

Traditional control systems in buildings are largely static and rarely maintained. Typically, a single operator is in charge of all control algorithms in the building, and it's very hard to provide personalized control for each occupant. By learning occupants' behaviour patterns and preferred environment conditions and predicting energy use, a self-learning/predictive control can optimize the indoor environment quality and minimize building energy usage by adjusting indoor air temperature, lighting, shading and other environment controls.



Online prediction that utilizes both real-time and historical building data significantly improves the accuracy of the prediction of changes in indoor environment conditions due to variations of outdoor environment, occupant behaviour and equipment inputs. This way we can optimize the control system to minimize energy use by reducing excessive heating/cooling and shift peak energy load.



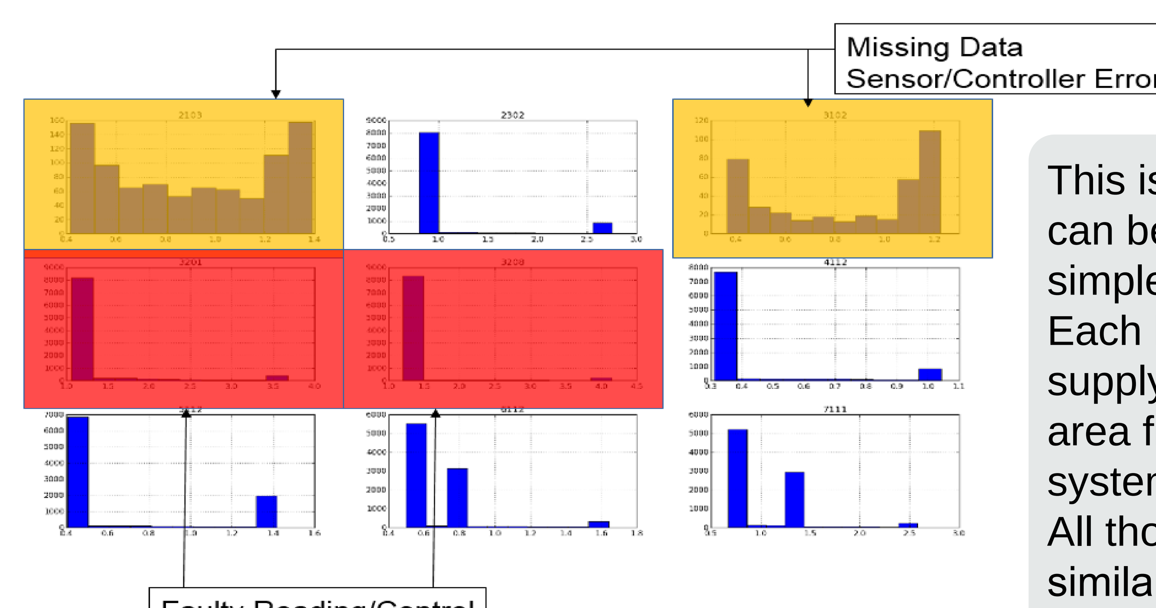
We can also learn from occupant's preferences to provide an optimal indoor environment and allow the occupant to focus on his/her tasks. Those graphs show sample probability distributions learned in our control system.

Introduction

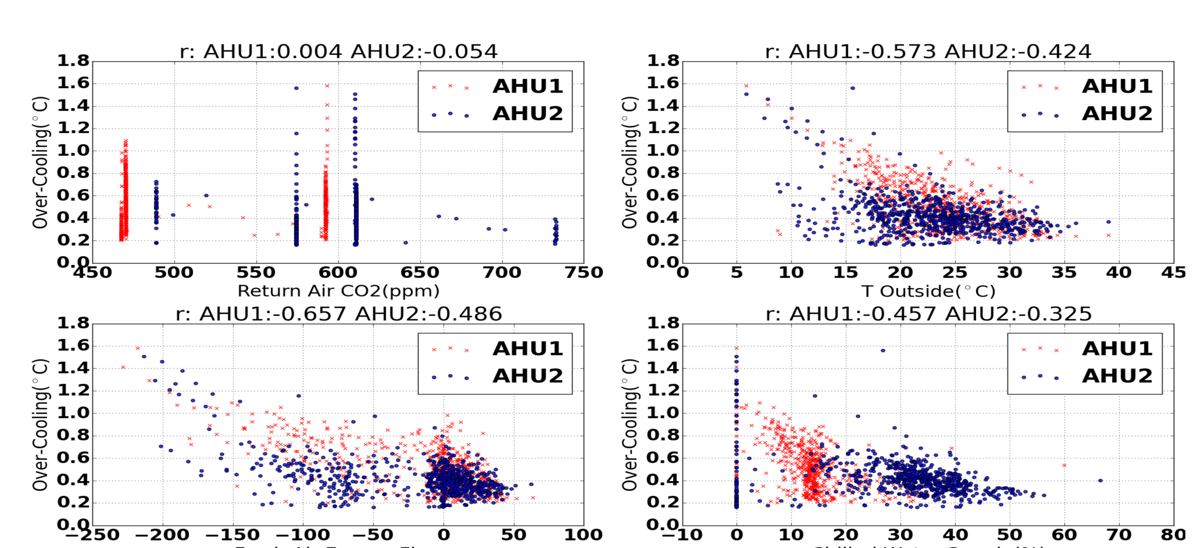
The shift to digitization, the development of complex sensor networks as well as robust data storage have made building data unprecedentedly available, accessible and accurate. This presents unique opportunity and challenges to improve building performance by sharing, analyzing and visualizing the data. This poster focuses on fives areas of the current research effort of Carleton University's Human-building Interaction (HBI) Lab to fully exploiting the building data using some of the leading technologies, in order to create next-generation intelligent and self-correcting buildings that provides healthy and comfortable environment to occupants, with reduced energy consumption and environmental impact as well as higher resilience to climate change.

Building Diagnostics

"Smart" buildings are not that smart: they don't perform self-diagnostics. Although we have much more sensors and data in buildings than before, complex building systems have also become harder to diagnose. With the help of modern data mining and machine learning techniques we can perform building diagnostics and fault detection in a totally different way.

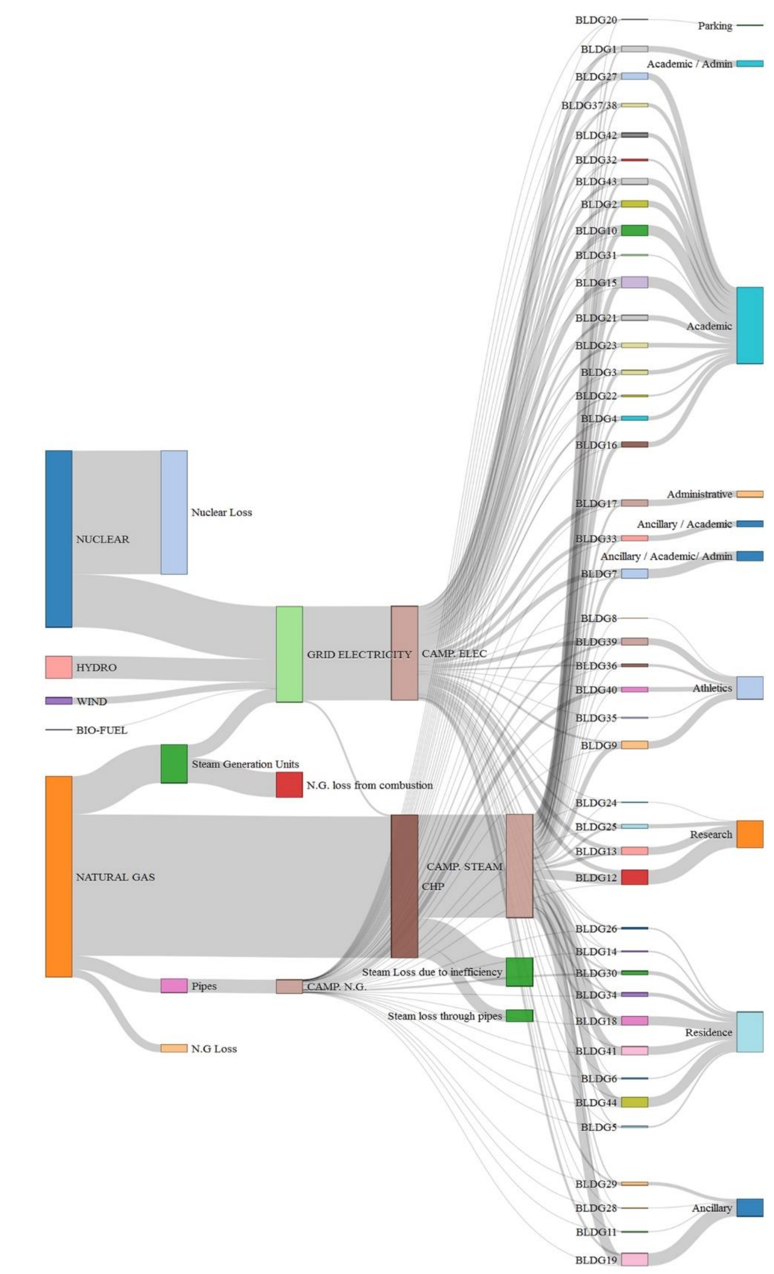


This is an example of what can be achieved using simple statistical inference. Each bar chart represents supply air flow per unit area from the HVAC system for a single room. All those rooms share similar properties. And it's very easy to identify problems in the existing HVAC and control system.



This is a chart showing the correlation between over-cooling and various HVAC related variables. We could visually identify the origin of the over-cooling problem: the HVAC system is taking in too much cold outside fresh air when not needed.

Building Energy Flow Visualization



Where does the energy come form? Where is it going? Visualization of energy flow within and between buildings provides us with an accurate answer with simplicity and clarity. It helps us better understand the interplay of different processes in different buildings and traces any change in energy consumption pattern easily. It can be a powerful tool for facility maintenance and operation and an effective education tool of building sustainability.

On the left is a Sankey Diagram of annual energy flow for each of the building on Carleton Campus. Energy quantity has been normalized to source energy. This helps us identify the exact energy flow for each building and visualize performance. We have also developed Sankey Diagrams for energy cost flow and energy usage index for each of the buildings on campus.

Climate Change Building Adaptation

Climate is changing, but can we predict its impact on building performance and limits its negative impact? By tracing historical climate data, correlating climate models and building models, now we are able to factor in future climate change impact at early design stage.

Based on the adaptive comfort model, we evaluate the potential of natural ventilation in office space as a low-energy design that adapts to climate in several cities located in different climate zones. The results (bellow) show a monthly decrease in the usability of natural ventilation in the months for which the adaptive comfort model is applicable, under climate change.