John M. House

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Research Engineer

Summary

Internationally recognized leader in the buildings community with over 25 years of experience conducting research in the public and private sectors to improve the control and operation of heating, ventilating, and air-conditioning (HVAC) systems. Contributions to the field of fault detection and diagnostics (FDD) are now incorporated in an industry guideline on high performance sequences of operation for HVAC systems, have been implemented in commercial products, and are commonly used as a benchmark for other FDD methods.

Expertise

- Fault Detection and Diagnostics
- Control
- Optimization
- HVAC Equipment and Systems
- Modeling and Simulation
- Energy Efficiency

Experience

Johnson Controls *Montreal, QC* **Jan. 2008 - Jan. 2020**

Lead Principal Research Engineer **Oct. 2011 - Jan. 2018**

- Initiated and conducted research on control algorithms and fault detection and diagnostic techniques to improve the energy efficiency of heating, ventilating and air-conditioning (HVAC) systems in buildings.
- Responsible for development of Modelica-based dynamic HVAC system models and use of models for development of control algorithms and diagnostic tools.
- Initiated and guided university research collaborations supporting internal technology priorities.
- Provided industry outreach and technical guidance for research projects funded by ASHRAE and U.S. Department of Energy.

Principal Research Engineer **Jan. 2008 - Oct. 2011**

- Collaborated with research colleagues to develop and test algorithms for integrated control and fault detection, model-based economizer control and optimal start.
- Developed simulation platforms using Matlab, Simulink, Energy Plus, and Modelica-based tools and libraries to aid development and testing of control and fault detection algorithms.

Natural Resources Canada *Varennes, QC* **Jan. 2005 - Jan. 2008**

Secondment Assignment from the Iowa Energy Center

- Developed research plans and established collaborative research projects for Intelligent Buildings Group.
- Conducted research on controls and diagnostics for HVAC and supermarket refrigeration systems.

Iowa Energy Center *Ankeny, IA* **Nov. 2000 - Jan. 2008**

Research Engineer

- Lead technical researcher of the National Building Controls Information Program.
- Conducted sponsored research and demonstration projects related to building controls, fault detection and diagnostics, and commissioning for private industry and federal government.
- Represented the Iowa Energy Center on national initiatives, collaborations and committees related to building energy efficiency.
- Provided technical support and guidance for IEC-funded research projects.

National Institute of Standards and Technology *Gaithersburg, MD* **Oct. 1994 - Nov. 2000**

Principal Investigator / Project Leader

- Conducted research related to the development and testing of fault detection and diagnostic (FDD) methods for HVAC systems. Led the development of APAR (Air-handling unit Performance Assessment Rules).
- Collaborated with staff at Johnson Controls, Inc. to perform simulation and laboratory testing of advanced control strategies and FDD methods.
- Participated in international collaborations to perform FDD research with the Korea Institute of Energy Research, the Scientific and Technical Building Centre in Paris, France, and members of the International Energy Agency (IEA) Annex 34 working group.
- Monitored sponsored research on FDD methods for rooftop units conducted at Purdue University.
- Served as the IEA Annex 34 country representative for the United States.

Education

The University of Iowa: Iowa City, Iowa

Doctor of Philosophy in Mechanical Engineering **1994**

- Ph.D. Dissertation: Optimal Control for HVAC and Building Systems

Master of Science in Mechanical Engineering **1988**

- MS Thesis: Development of Two Optimal Control Methodologies for Thermal Systems

Bachelor of Science in Mechanical Engineering, with distinction **1987**

Skills

Programming Modelica, Python, R, LaTeX
Applications Dymola, Matlab, Simulink, EnergyPlus, Jupyter Notebook

Certifications

6.00.1x: Introduction to Computer Science and Programming Using Python *MITx* **Mar. 26, 2020**
edX
Credential ID: 48f759f8883c44b9a6a0bad569f95df4

6.00.2x: Introduction to Computational Thinking and Data Science *MITx* **June 11, 2020**
edX
Credential ID: c9946c5df1464e06891f53737e9aaa54

DSBE001x: Data Science for Construction, Architecture and Engineering *NUS* **June 5, 2020**
edX
Credential ID: 013beaa4ba034eba9cb168e2da9af7d2

Patents

Granted

Control system with dimension reduction for multivariable optimization
Timothy I Salsbury, Carlos Felipe Alcala Perez, John M House
US Patent 10,558,177, 2020

Extremum-seeking control system for a chilled water plant
Timothy I. Salsbury, John M. House
US Patent 10,352,576, 2019

Building climate control system with decoupler for independent control of interacting feedback loops
Timothy I. Salsbury, Carlos F. Alcala Perez, John M. House, Christopher R. Amundson
US Patent 10,253,997, 2019

Self-configuring extremum-seeking control system
Timothy I. Salsbury, John M. House
US Patent 10,209,684, 2019

Control system with maximum time constant estimation
Timothy I. Salsbury, John M. House
US Patent 10,364,997, 2019

HVAC system with multivariable optimization using a plurality of single-variable extremum-seeking controllers
Timothy I. Salsbury, John M. House
US Patent 10,365,001, 2019

Control system with combined extremum-seeking control and feedforward control
John M. House, Timothy I. Salsbury
US Patent 10,401,843, 2019

Systems and methods for estimating a return time
John E. Seem, John M. House
US Patent 9,739,496, 2017

Extremum-seeking control for airside economizers
Timothy I. Salsbury, John M. House
US Patent 9,835,349, 2017

Systems and methods for detecting a control loop interaction
Timothy I. Salsbury, John M. House, John E. Seem
US Patent 9,348,325, 2016

Systems and methods for fault detection of air handling units
John M. House, John E. Seem
US Patent 8,239,168, 2012

Pending

Hvac system with self-optimizing control from normal operating data
Carlos F. Alcala Perez, Timothy I. Salsbury, John M. House
US Patent App. 16/131,927, 2020

Variable refrigerant flow system with pressure optimization using extremum-seeking control
Robert D. Turney, Liming Yang, Yunrui Wang, Yasutaka Yoshida, Kazumoto Urata, Timothy I. Salsbury, John M. House
US Patent App. 16/029,246, 2020

Thermostat with estimation of run-time savings
Timothy I. Salsbury, John M. House
US Patent App. 16/531,892, 2020

Extremum-seeking control system for a plant
Timothy I. Salsbury, John M. House
US Patent App. 16/438,854, 2019

Thermostat with steady state temperature estimation
Nathan M. Zimmerman, Michael J. Ajax, Nicholas S. Van Derven, John M. House, Timothy I. Salsbury
US Patent App. 16/139,882, 2019

Building control system with cooperative extremum-seeking control
Timothy I. Salsbury, John M. House
US Patent App. 16/052,120, 2019

Extremum-seeking control system with constraint handling

Timothy I. Salsbury, John M. House
US Patent App. 15/950,009, 2018

Publications

Journal Papers

Self-perturbing extremum-seeking controller with adaptive gain
Timothy I. Salsbury, John M. House, Carlos F. Alcala
Control Engineering Practice *101 (2020). Elsevier, 2020*

Local self-optimizing control based on extremum seeking control
Zhongfan Zhao, Yaoyu Li, Timothy I. Salsbury, John M. House, Carlos F. Alcala
Control Engineering Practice *99 (2020). Elsevier, 2020*

Modeling and fault diagnosis design for HVAC systems using recurrent neural networks
Hadi Shahnazari, Prashant Mhaskar, John M. House, Timothy I. Salsbury
Computers & Chemical Engineering *126 (2019) pp. 189–203. Elsevier, 2019*

Distributed fault diagnosis of heating, ventilation, and air conditioning systems
Hadi Shahnazari, Prashant Mhaskar, John M. House, Timothy I. Salsbury
AIChE Journal *65.2 (2019) pp. 640–651. Wiley Online Library, 2019*

Heating, ventilation and air conditioning systems: Fault detection and isolation and safe parking
Hadi Shahnazari, Prashant Mhaskar, John M. House, Timothy I. Salsbury
Computers & Chemical Engineering *108 (2018) pp. 139–151. Elsevier, 2018*

Multi-variable extremum seeking control for a multi-functional variable refrigerant flow system
Liujia Dong, Yaoyu Li, Timothy I. Salsbury, John M. House, Zhigang Wu
Science and Technology for the Built Environment *24.4 (2018) pp. 382–395. Taylor & Francis, 2018*

Mode switching control for a multi-functional variable refrigerant flow system
Liujia Dong, Yaoyu Li, John M. House, Timothy I. Salsbury
Science and Technology for the Built Environment *24.4 (2018) pp. 418–434. Taylor & Francis, 2018*

Real-time optimization of a chilled water plant with parallel chillers based on extremum seeking control
Baojie Mu, Yaoyu Li, John M. House, Timothy I. Salsbury
Applied energy *208 (2017) pp. 766–781. Elsevier, 2017*

An extremum-seeking control method driven by input–output correlation
Timothy I. Salsbury, John M. House, Carlos F. Alcala, Yaoyu Li
Journal of Process Control *58 (2017) pp. 106–116. Elsevier, 2017*

Experimental evaluation of anti-windup extremum seeking control for airside economizers
Baojie Mu, Yaoyu Li, John M. House, Timothy I. Salsbury
Control Engineering Practice *50 (2016) pp. 37–47. Elsevier, 2016*

Offset-free model predictive control of a heat pump
Matt Wallace, Prashant Mhaskar, John M. House, Timothy I. Salsbury
Industrial & Engineering Chemistry Research *54.3 (2015) pp. 994–1005. ACS Publications, 2015*

Offset-free model predictive control of a vapor compression cycle
Matt Wallace, Buddhadeva Das, Prashant Mhaskar, John M. House, Timothy I. Salsbury
Journal of Process Control *22.7 (2012) pp. 1374–1386. Elsevier, 2012*

Energy efficient model predictive building temperature control

Matt Wallace, Ryan McBride, Siam Aumi, Prashant Mhaskar, John M. House, Timothy I. Salsbury
Chemical Engineering Science *69.1 (2012) pp. 45–58. Elsevier, 2012*

Development and evaluation of optimization-based air economizer strategies
John E. Seem, John M. House
Applied energy *87.3 (2010) pp. 910–924. Elsevier, 2010*

Integrated control and fault detection of air-handling units
John E. Seem, John M. House
HVAC&R Research *15.1 (2009) pp. 25–55. Taylor & Francis, 2009*

A rule-based fault detection method for air handling units
Jeffrey Schein, Steven T. Bushby, Natascha S. Castro, John M. House
Energy and buildings *38.12 (2006) pp. 1485–1492. Elsevier, 2006*

Subsystem level fault diagnosis of a building's air-handling unit using general regression neural networks
Won-Yong Lee, John M. House, Nam-Ho Kyong
Applied Energy *77.2 (2004) pp. 153–170. Elsevier, 2004*

Controls and diagnostics for air distribution systems
John M. House, Kwangduk Douglas Lee, Leslie K. Norford
J. Sol. Energy Eng. *125.3 (2003) pp. 310–317. 2003*

A damper control system for preventing reverse airflow through the exhaust air damper of variable-air-volume air-handling units
John E. Seem, John M. House, George E. Kelly, Curtis J. Klaassen
Hvac&R Research *6.2 (2000) pp. 135–148. Taylor & Francis, 2000*

A new sequencing control strategy for air-handling units
John E. Seem, Cheol Park, John M. House
Hvac&R Research *5.1 (1999) pp. 35–58. Taylor & Francis, 1999*

Optimal control of HVAC systems using DDP and NLP techniques
Narendra N. Kota, John M. House, Jasbir S. Arora, Theodore F. Smith
Optimal Control Applications and Methods *17.1 (1996) pp. 71–78. Wiley Online Library, 1996*

Comparison of methods for design sensitivity analysis for optimal control of thermal systems
John M. House, Jasbir S. Arora, Theodore F. Smith
Optimal Control Applications and Methods *14.1 (1993) pp. 17–37. Wiley Online Library, 1993*

Effect of a centered conducting body on natural convection heat transfer in an enclosure
John M. House, Christoph Beckermann, Theodore F. Smith
Numerical Heat Transfer *18.2 (1990) pp. 213–225. Taylor & Francis, 1990*

Conference Papers

Self-optimizing Control of an Air Source Heat Pump
Zhongfan Zhao, Yaoyu Li, Timothy I. Salsbury, Carlos F. Alcala, John M. House
2019 American Control Conference (ACC), 2019

Identification of a Self-Optimizing Control Structure from Normal Operating Data
Carlos F. Alcala, Timothy I. Salsbury, John M. House
2019 American Control Conference (ACC), 2019

Decoupling Method for PI Controllers via Setpoint Modification Applied to HVAC Systems
Timothy I. Salsbury, John M. House, Carlos F. Alcala
Proceedings of the Dynamic Systems and Control Conference, 2018

Decentralized Proportional-Integral Extremum Seeking Control for Heating, Ventilation and Air Conditioning (HVAC) Systems
Judith Ebegbulem, Martin Guay, John M. House, Timothy I. Salsbury
2018 IEEE Conference on Control Technology and Applications (CCTA), 2018

Constraint handling in ESC control strategies with application to HVAC systems
Liujia Dong, Yaoyu Li, Timothy I. Salsbury, John M. House
2018 Annual American Control Conference (ACC), 2018

Fault diagnosis design for heating, ventilation and air conditioning systems
Hadi Shahnazari, Prashant Mhaskar, John M. House, Timothy I. Salsbury
2018 Annual American Control Conference (ACC), 2018

Experimental evaluation for an extremum seeking control strategy based on input-output correlation with a mini-split air conditioning system
Zhongfan Zhao, Timothy I. Salsbury, John M. House, Yaoyu Li
Proceedings of the International Refrigeration and Air Conditioning Conference, 2018

Model-free control and automatic staging of variable refrigerant flow system with multiple outdoor units
Liujia Dong, Yaoyu Li, Timothy I. Salsbury, John M. House
Proceedings of the International Refrigeration and Air Conditioning Conference, 2018

Input selection for multivariable extremum seeking control with application to real-time optimization of a chilled-water plant
Zhongfan Zhao, Yaoyu Li, Timothy I. Salsbury, John M. House
2017 American Control Conference (ACC), 2017

Model Selection for Predicting the Return Time from Night Setback
John E. Seem, John M. House, Carlos F. Alcala
Proceedings of the International High Performance Buildings Conference, 2016

Optimization and sequencing of chilled-water plant based on extremum seeking control
Baojie Mu, Yaoyu Li, Timothy I. Salsbury, John M. House
2016 American Control Conference (ACC), 2016

Self-optimizing control and mode switching for multi-functional variable refrigerant flow air conditioning systems via extremum seeking
Liujia Dong, Yaoyu Li, Timothy I. Salsbury, John M. House
2016 American Control Conference (ACC), 2016

Evaluation of an extremum seeking control based optimization and sequencing strategy for a chilled-water plant
Zhongfan Zhao, Yaoyu Li, Baojie Mu, Timothy I. Salsbury, John M. House
Proceedings of the International High Performance Buildings Conference, 2016

Automatic mode switching for a multi-functional variable refrigerant flow system
Liujia Dong, Yaoyu Li, Timothy I. Salsbury, John M. House
Proceedings of the International Refrigeration and Air Conditioning Conference, 2016

Distributed Extremum Seeking Control for a Variable Refrigerant Flow System
Yang Zhu, Yaoyu Li, Liujia Dong, Timothy I. Salsbury, John M. House
Proceedings of the International Refrigeration and Air Conditioning Conference, 2016

Extremum seeking based control strategy for a chilled-water plant with parallel chillers
Baojie Mu, Yaoyu Li, Timothy I Salsbury, John M House
ASME 2015 Dynamic Systems and Control Conference, 2015

Offset-free model predictive control of a heat pump

Matt Wallace, Prashant Mhaskar, John M. House, Timothy I. Salsbury
2014 American Control Conference (ACC), 2014

An Experimental Investigation of Response Times for Duct-Mounted Relative Humidity Transmitters.
Shailesh N. Joshi, Michael B. Pate, Ron M. Nelson, John M. House, Curtis J. Klaassen
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2007

Integrated control and fault detection of air-handling units
John E. Seem, John M. House
IFAC Proceedings Volumes, 2006

Information resources for better building controls
Floyd E. Barwig, John M. House, Curtis J. Klaassen
Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, 2006

An Experimental Evaluation of Duct-Mounted Relative Humidity Sensors: Part 1-Test and Evaluation Procedures
Shailesh N. Joshi, Michael B. Pate, Ron M. Nelson, John M. House, Curtis J. Klaassen
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2005

An experimental evaluation of duct-mounted relative humidity sensors: Part 2-Accuracy results
Shailesh N. Joshi, John M. House, Michael B. Pate, Curtis J. Klaassen, Ron M. Nelson
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2005

An experimental evaluation of duct-mounted relative humidity sensors: Part 3-Repeatability, hysteresis, and linearity results
Shailesh N. Joshi, John M. House, Michael B. Pate, Curtis J. Klaassen, Ron M. Nelson
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2005

Building energy use and control problems: an assessment of case studies
Morteza M. Ardehali, Theodore F. Smith, John M. House, Curtis J. Klaassen
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2003

Application of control charts for detecting faults in variable-air-volume boxes
Jeffrey Schein, John M. House
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2003

The national building controls information program
Floyd E. Barwig, John M. House, Curtis J. Klaassen, Morteza M. Ardehali, Theodore F. Smith
Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, 2002

Demonstration of load shifting and peak load reduction with control of building thermal mass
James E. Braun, T. M. Lawrence, Curtis J. Klaassen, John M. House
Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings, 2002

An expert rule set for fault detection in air-handling units
John M. House, Hossein Vaezi-Nejad, J. Michael Whitcomb
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2001

Classification techniques for fault detection and diagnosis of an air-handling unit
John M. House, Won Yong Lee, Dong Ryul Shin
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1999

Fault diagnosis and temperature sensor recovery for an air-handling unit
Won Yong Lee, Dong Ryul Shin, John M. House
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1997

On-line monitoring and fault detection of control system performance

John E. Seem, John M. House, Richard H. Monroe
Proceedings of CLIMA 2000 Conference, 1997

A control system that prevents air from entering an air-handling unit through the exhaust air damper
John E. Seem, John M. House
Proceedings of the 17th Annual AIVC Conference on Optimum Ventilation and Air Flow Control in Buildings, 1996

Fault diagnosis of an air-handling unit using artificial neural networks
Won-Yong Lee, John M. House, Cheol Park, George E. Kelly
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1996

A system approach to optimal control for HVAC and building systems
John M. House, Theodore F. Smith
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1995

Optimal control of building and HVAC systems
John M. House, Theodore F. Smith
1995 American Control Conference (ACC), 1995

Optimal control of a thermal system
John M. House, Theodore F. Smith, Jasbir S. Arora
Transactions of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1991

Invited Presentations

Better Building Controls Through Simulation
Presented at the IBPSA-USA Winter Meeting, Jan. 21, 2012, Chicago, Illinois

The National Building Controls Information Program: A National Initiative on Better Building Controls
Presented to the ASHRAE Madison Chapter, Sept. 8, 2003, Madison, Wisconsin

Building and Equipment Controls
Presented at Energy 2003, Aug. 19, 2003, Orlando, Florida

Emerging Tools for Diagnostics and Commissioning
Presented at the ASHRAE Minnesota Chapter Education Seminar, Apr. 8, 2003, Minneapolis, Minnesota

The National Building Controls Information Program: A National Initiative on Better Building Controls
Presented at the ASHRAE Minnesota Chapter Education Seminar, Apr. 8, 2003, Minneapolis, Minnesota

Automated Fault Detection and Diagnostics
Presented to the ASHRAE Iowa Chapter, Nov. 18, 2002, Ankeny, Iowa

Application of Control Charts for Detecting Faults in HVAC Equipment and Controls
Presented at the University of Iowa Mechanical Engineering Graduate Seminar, Oct. 31, 2002, Iowa City, Iowa

Detecting and Diagnosing Faults in HVAC Equipment and Controls
Presented at the University of Iowa Mechanical Engineering Graduate Seminar, Mar. 22, 2001, Iowa City, Iowa

An Overview of Building Diagnostics
Presented at the 8th National Conference on Building Commissioning, May 4, 2000, Kansas City, Missouri

An Overview of Building Diagnostics
Presented at the workshop "Diagnostics for Commercial Buildings: from Research to Practice", June 16-17, 1999, San Francisco, California

Detection and Diagnosis of Faults in HVAC Systems: An Overview of NIST Research
Presented at the Korea Institute of Energy Research and Seoul National University, May 14, 1998, Seoul, South Korea

Professional Affiliations

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Research Administration Committee

- Research Planning Subcommittee Chair (2010-2012)
- Section 4 Research Liaison (2009-2010)

TC 7.5 Smart Building Systems

- Corresponding Member
- Past Chair (2003-2006)
- Past Vice-Chair and Research Chair (2001-2003)
- Chair of Project Monitoring Subcommittee for RP-1020 Demonstration of Fault Detection and Diagnostic Methods in a Real Building
- Chair of Project Monitoring Subcommittee for RP-1046 Building Operations and Dynamics Within an Aggregated Load
- Chair of Project Monitoring Subcommittee for RP-1390 Short-Term Curtailment of HVAC Loads in Buildings
- Chair of Project Monitoring Subcommittee for RP-1615 Fault Detection and Diagnostic (FDD) Methods for Supermarkets - Phase I

TC 1.4 Control Theory and Application

- Corresponding Member
- Past Research Chair