

Syllabus

Program: MEC-BAC – Bachelors in Mechanical Engineering		
Department: CCT-DEM – DEPARTMENT OF MECHANICAL ENGINEERING – CCT		
Course: Ambient Control I (AI-Enhanced HVAC Systems & Smart Building Control)		
Code: ST2CAM1	Class hours: 54 hours	Academic year: 2026/2
Professor: MARCUS VINICIUS CANHOTO ALVES		e-mail: marcus.alves@udesc.br

Topics

Foundations and Data Acquisition (Machine Learning for Civil and Environmental Engineers)
 Intelligent Control Strategies (Advanced Decision Making for HVAC Engineers)
 Neural Networks for Load Forecasting (Advanced Decision Making for HVAC Engineers)
 Fault Detection and Diagnostics – FDD (Predictive Maintenance for HVAC Systems: Leveraging Machine Learning)
 System Integration and Sustainability (IoT/IA Control of VRF Distributed Building Air-Conditioners)

General Objective

The primary objective of this course is to present undergraduate students the possibility to bridge the gap between mechanical HVAC principles and data science to design autonomous, energy-efficient, and resilient building systems.

Specific Objectives

- 1 Integrated modeling – combining traditional physics based thermal models (thermodynamics, fluid mechanics and heat transfer) with modern Machine Learning;
- 2 Autonomous Energy Optimization – understand the use of AI-driven control strategies such as Model Predictive Control (MPC) to dynamically adjust parameters in real-time;
- 3 Predictive Diagnostics – develop and implement Automated Fault Detection and Diagnosis (FDD). Students will learn to use AI to interpret sensor data, identify anomalies (like refrigerant leaks or sensor drift) and transition from reactive to proactive maintenance.
- 4 Smart Grid and IoT integration – understand the role of IoT-enabled sensor networks and digital twins in aggregating data for building-to-grid communication, allowing HVAC systems;
- 5 Sustainability and compliance – evaluate how AI-based optimizations contribute to net-zero carbon goals and ensure alignment with international energy standards like ASHRAE Guideline 36;

Program

Module 1: weeks 1 and 2: Foundations and Data Acquisition (Machine Learning for Civil and Environmental Engineers)
 Physics-based vs. Data driven modeling;
 Sensor fusion and IoT telemetry in HVAC;
 Module 2: weeks 3 to 8: Intelligent Control Strategies (Advanced Decision Making for HVAC Engineers)
 Fuzzy Logic;
 Genetic Algorithms for setpoint optimization;
 Model Predictive Control
 Module 3: weeks 9 to 11: Neural Networks for Load Forecasting (Advanced Decision Making for HVAC Engineers)
 Time-series forecasting using RNNs and LSTMs;
 Predicting occupancy;
 Weather-dependent demand;
 Module 4: weeks 12 to 14: Fault Detection and Diagnostics – FDD (Predictive Maintenance for HVAC Systems: Leveraging Machine Learning)
 Anomaly detection in chillers and Air Handling Units (AHUs) using unsupervised learning.
 Module 5: week 15: System Integration and Sustainability (IoT/IA Control of VRF Distributed Building Air-Conditioners)
 Integrating VRF systems with smart Grids;
 Carbon footprint reduction via AI;
 Module 6: weeks 16 to 18: Final project:
 Project design using core challenges: Energy forecasting or Anomaly Detection

Syllabus

Methodology

The presential lectures focus on the delivery of fundamental material and provide an environment to discuss the salient concepts of fluid mechanics with the help of partially prepared slides and notes. Solution of limited exercises and in-depth examples during lectures. Homework problems every week, with a final project for the students to present.

Grading system

Homework – H;
Final project – FP;

Semester grade – SG;
 $SG = 0.4H + 0.6FP$

If the semester grade (SG) is greater or equal 7.0 the student is considered approved. If the semester grade (SG) less than 7.0, the student is considered to be under Final Examination (FE) and can take a final test that will be graded according to the following weighting (articles nº144 a nº148 of UDESC's general regiment and Resolution 044/2007 CONSUNI) and generate the Final Score (FS):

$FS = 0.6SG + 0.4FE$;

If the student's FS is greater or equal to 5.0, the student is considered approved; if not, the student reprovved in the discipline and will not be granted the scholar credits.

Frequency is mandatory to a minimum of 75% of the classes, otherwise the student will be automatically fail by frequency.

All tests and exams will be graded from 0.0 to 10.0 and will be evaluated in the following criteria:

- 1- Interpretation;
- 2- Organization;
- 3- Notation and unities;
- 4- Solution detailing and justification;
- 5- Final answers;

Basic bibliography

- 1- Lechner, Norbert. *Heating, cooling, lighting: Sustainable design methods for architects*. John wiley & sons, 2014.
- 2- Aherne, V., and M. Henderson. "Optimising your heating, ventilation and air conditioning systems." *Office of Environment and Heritage* (2015): 1-109.
- 3- American Technical Publishers, and National Joint Apprenticeship and Training Committee for the Electrical Industry. *Building Automation: Control Devices and Applications*. American Technical Publishers, 2008.

Supplementary bibliography

- 1- Li, H., Wang, Z., & Hong, T. (2020). AlphaBuilding - Synthetic Buildings Operation Dataset. [Data set]. Open Energy Data Initiative (OEDI). Lawrence Berkeley National Laboratory. <https://doi.org/10.25984/1784722>
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