Willy Bernal

Curriculum Vitae

Education

University of Pennsylvania, Philadelphia, PA.

2010 – 2014 **Masters of Electrical Engineering**, *GPA: 3.81.*
Area of Study: Cyber-Physical Systems

2005 – 2010 **Masters of Mechanical Engineering**, *GPA: 3.94.*
Area of Study: Robotics

2005 – 2010 **Bachelor of Mechanical Engineering**, *GPA: 3.85.*
Area of Study: Embedded Systems

2005 – 2010 **Bachelor of Electrical Engineering**, *GPA: 3.80.*
Area of Study: Mechatronics and Robotics

Professional Experience

2014–Present **Mechatronics and Controls**, LITMOTORS, San Francisco, CA.
Build a framework for system identification and develop multiple iteratons of controls for driving an auto-balancing 2-wheel electric vehicle (*AEV*).
Detailed achievements:

- Design static balancing and driving controls for an the (*AEV*).
- Develop dynamic models using Lagrange and Kanes equations of motion.
- Perform structure identification using first-princicples and greybox modeling.
- Statistical filtering for state estimation (Kalman filtering).
- Perform Frequency Response (I/O) analysis to develop controls using frequency compensation.
- Design the test experiments for identification.
- Simulate and visualize 3-D dynamics of the vehicle.
- Program the real-time embedded platform using the Real-Time Explorer.

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Summer 2013 **Research Participant Program**, NREL, Golden, CO.

Develop an integrated framework for campus-wide building energy modeling and simulation in the Matlab/Simulink environment.

Detailed achievements:

- Expand the capabilities of *MLE+* to interconnect multiple buildings through a heating/cooling piping system.
- Automate the dispatch of multiple Computing Units from the Amazon Web Services to distribute computation of multiple building simulations.
- Create a database with wheather feed to pull information on demand for the simulations.
- Program Real-Time target machine (OPAL RT-Lab) to perform hardware-in-the-loop simulation.

Past Projects

MLE+: A Tool for Integrated Design and Deployment of Energy-Efficient Buildings

- *MLE+* is a Co-Simulation Toolbox for integrated design and deployment of energy-efficient building controls for buildings simulated in EnergyPlus. MLE+ leverages the high-fidelity building simulation capabilities of EnergyPlus and the scientific computation and controller design capabilities of Matlab.
- The software provides integrated building simulation and controller formulation with integrated support for system identification, control design, optimization, simulation analysis and communication between software applications and real building equipment. (*mlab.seas.upenn.edu/mlep*)

MLE+: Integrated Campus-Wide Simulation

- The *Integrated Campus-Wide project* simulates and captures the entire campus' energy dynamics and consumption to qualitatively measure the interaction between supply-side equipment, e.g. chiller plants, and demand-side loads, e.g. buildings. This analysis is paramount to achieving coordinated operation for energy efficiency and demand response strategies.
- MLE+ coordinates and synchronizes the exchange of data across multi-systems and multi-building models. Through MLE+, we analyze the interactions of multiple buildings connected through a water loop as in a university campus.

MLE+: Cloud-Based Optimization

- The cloud module in MLE+ leverages the computation power of Amazon Elastic Compute Cloud Units (EC2) provided by Amazon Web Services (AWS) for highly-intensive simulations.
- The module computes the optimal campus control strategy when faced with a DR event using MLE+.
- The system automatically balances and dispatches the computation of the EnergyPlus and Matlab/Simulink models into the Amazon Elastic Compute Cloud (EC2) service.

Low-Cost Portable Wireless Sensor System for Inverse Building Modeling

- The objective of this activity is to develop and deploy a wireless sensor system for training a building model that can support Model Predictive Control. This work will examine sensitivity of model training results to the location, density of sensors and richness of training data via simulation and through real deployment.
- To gather environment data (solar radiation, ambient temperature, etc) we are designing and building a fleet of low-cost wireless sensor nodes.
- This project is part of the Energy-Efficient Buildings Hub (*EEB Hub*) supported by the Department of Energy. This initiative focus on advancing promising areas of energy science and engineering from the earliest stages of research to the point of commercialization.

SolarSkin: Leveraging Fine-Grained Solar Radiation and Temperature Sensing in Advanced Building Controls

- SolarSkin aims at leveraging fine-grained monitoring of external conditions such as temperature and solar radiation to reduce HVAC energy consumption. This project focuses on the effect of external conditions and how they can lead to energy saving policies with low cost sensing. Solar flux, outdoor air temperature and the temperature of the building envelope (exterior wall) would allow us to refine our predictions of the building heat gains for short timescales (30-60 minutes) and locational granularity (differential between the East and West wings of a building).
- Our goal is to leverage this extra information in scheduling internal HVAC equipment to minimize energy consumption while meeting comfort standards. Simulation are performed using MLE+ for buildings modeled in EnergyPlus. Data was acquired for two office buildings in urban settings using a WSN.

Modular Robotics: Robotic Centipede

- Contributed to the design, control and testing of a *novel scalable biologically-inspired legged style of locomotion*.
- Built a dynamic model capable of simulating the dynamics of the robotic centipede in two and three-dimensions utilizing the Spring Loaded Inverted Pendulum (SLIP) template for the dynamical model.
- Designed and implemented a responsive feedback loop for the Hi-tech digital Servo to increase the robot dynamic response.
- Responsible of design, software development and manufacturing of custom mechanical and electrical research platforms: *CKbot*.
- Gait Generation and hardware design for the *Self-Assembly after Explosion (SAE)*. TechFest presentations in Chicago (2008) and Bombay (2009).

Teaching Experience

Fall 2013 **Teaching Assistant.** Real-Time Embedded Systems.
The course focus on understanding and obtaining hands-on experience with the state of the art wireless sensor networks.

2007 – 2009 **Teaching Assistant Real-Time Embedded Systems.** Explaining topics or concepts that were covered in class, helping develop sound study skills and time management skills, giving extra practice, and teaching the student how to study for tests.
Courses:
Math 241 (Fourier and Complex Analysis)
Math 240 (Vector Calculus)
Math 114 (Differential Equations)
Math 104 (Differentiation and Integration)

Awards

2012 Best Demo Award.
4th ACM Workshop on Embedded Sensing Systems For Energy-Efficiency in Buildings for **MLE+: A Tool for Integrated Design and Deployment of Energy-Efficient Building Controls.**

2005 – 2006
2007 – 2008 Dean's List.

Publications

Bernal, W.; Behl, M.; Nghiem, T.; and Mangharam, R. **Campus-wide integrated building energy simulation** *In ASHRAE/IBPSA-USA Building Simulation Conference, Atlanta, 2014.*

Willy Bernal, Madhur Behl, Truong X. Nghiem, and Rahul Mangharam **MLE+: A Tool for Integrated Design and Deployment of Energy Efficient Building Controls**, *4th ACM Workshop On Embedded Sensing Systems For Energy-Efficiency In Buildings*. (BuildSys '12), Toronto, Canada. 2012.

Sastra, J., **Bernal Heredia, W.**, Yim, M. and Clark J. **A Biologically-Inspired Dynamic Legged Locomotion with a Modular Reconfigurable Robot**, *Dynamic System Control Conference*. 2008.

Technical skills

Embedded Systems: Entensive Hardware and software experience in embedded systems, Real Time operating systems, wireless cards (Chipcon CC2420), and analog and digital electronics. Firefly, CKbot. ARM microprocessors (mbed), Motorola MCU's, Texas Instruments MCU's, Atmel ATmega MCU's, Microchip PIC MCU's, and others).
Real-Time Operating Systems: Nano-RK

Simulation Software: EnergyPlus, Design Builder, Rhinoceros, Daysim, Radiance, Open Studio, COMSOL, Fluent, Ecotect, SolidWorks.

Engineering Expertise: Control: Linear Systems Theory, Feedback, Non-Linear Control and Optimal Control Theory.
Optimization: Linear Optimization, Convex Optimization.
Robotics: Machine Perception, Motion Planning.
Statistics: Support Vector Machines, Regression Analysis, Estimation.

Programming	C/C++, Java, Matlab, HTML, Python, CSS.
Information technology	Networking (UDP,TCP, SLIPstream), Service (Apache).
Matlab	Experience with the following packages: Linear Algebra, Fourier transforms, Non-linear Numerical Methods, Support Vector Machines, GUI utilities, Optimization, Communication tools, Visualization, Simulink, MPC toolbox.
Analog and Digital Electronics	Analog and Digital Electronics: Bipolar and FET implementations of continuous and switched amplifiers, modulators, and filters.
Computer-Aided Design	Cadence OrCAD, NI Multisim, SPICE, Eagle CADsoft, AutoCAD, SolidWorks, GoogleSkepup.

Languages

Spanish	**Mothertongue**
English	**Full Professional Proficiency**

Interests

- Soccer
- Dancing
- Motorcycles

References

Academic Advisor: **Dr. Rahul Mangharam**. rahulm@seas.upenn.edu

Supervisor: **Dr. Brian Ball**. Brian.Ball@nrel.gov