Willy G. Bernal

CONTACT INFORMATION

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RESEARCH INTERESTS

Energy-Efficient Buildings, Control theory, Embedded Systems, Robotics, Dynamical Systems, Cyber-Phyisical Systems

EDUCATION

The University of Pennsylvania, Philadelphia, Pennsylvania USA

P.h.D., Electrical and Systems Engineering (expected graduation date: May 2016)

- Advisor: Professor Rahul Mangharam
- Area of Study: Cyber-Physical System
- GPA: 3.55/4.0

M.S., Mechanical Engineering and Applied Mechanics, (May 2010)

- Advisor: Professor Vijay Kumar
- Area of Study: Robotics
- GPA: 3.94/4.0 (10 courses)

B.S., Electrical Engineering, (May 2010)

- Electrical specialization (emphasis on Embedded Systems)
- GPA: 3.85/4.0 (12 courses)

B.S., Mechanical Engineering and Applied Mechanics, (May 2010)

- Mechanical specialization (emphasis on Mechatronics and Robotics)
- Minor in Mathematics
- GPA: 3.80/4.0 (15 courses)

AWARDS

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.**

The University of Pennsylvania

- Dean's List,
  2005-2006, 2007-2008.

CURRENT 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)

- We are currently working on simulating multiple buildings and its interactions. To distribute the computational burden and decrease simulation time we are extending MLE+ to migrate the computation to the Cloud, specifically Amazon Web Services (AWS).

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.

Past Projects

Home Automation Network

- A real-time, low-power wireless sensor network system that can actuate any AC appliance, open and close window blinds, and monitor, in real-time, power consumption of each device on the network.
- The project implements the Firefly sensor nodes, Nano-RK(a realtime operating system), relays, and various other electronic components to build the hardware for actuation.
- The Firefly sensor nodes wirelessly (IEEE 802.15.4) communicate with a gateway node while an iPhone web application and Java web application facilitates two-way communication with the actuation network over Wi-Fi or 3G and provides an interface for the user for actuation and sensing.

Electrocardiogram Wireless Sensor, (iBOD)

- This project consists of a high-confidence and low profile medical device for long-term onbody monitoring.
- This project targets low cost disposable on-body hardware-base health-strip, an adaptive real-time operating system design for runtime programmable control and long-term context-based medical sensor data interpretation.

Academic Experience

The University of Pennsylvania, Philadelphia, Pennsylvania USA

Ph.D. Candidate in Electrical Engineering **mLAB** **Fall 2009 to Present**

- Development of Energy-Efficient Building Controls software. MLE+ Developer.
- Design of advanced controls for Energy-Efficient Buildings.
- Design and construction of Wireless Sensor Networks for data gathering.

Research Assistant **Modular Robotics** **January 2006 to 2009**

- 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).

Research Assistant **Radiology Department** **Summer 2009**

- Software implementation (using Matlab) for supervised learning methods used for classification such as Support Vector Machines (SVM) in order to differentiate benign and malignant breast masses on ultrasound scans.

Official Tutor **Satellite Tutoring Center** **August 2007 to December 2009**

- 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)

Publications

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

Building and Mechanical Simulation Software:

- EnergyPlus, Design Builder, Rhinoceros, Daysim, Radiance, Open Studio, COMSOL, Fluent, Ecotect, SolidWorks.

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

Programming Experience:
- C/C++, Java, Matlab, HTML, Python, CSS.

Information Technology
- Networking (UDP,TCP, SLIPstream), Service (Apache).

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.

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.

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.

Affiliations

The University of Pennsylvania
- Tau Beta Pi, Engineering Honor Society, Delta Chapter.
- Eta Kappa Nu, Electrical and Computer Engineering Honor Society. Lambda Chapter.
- SPHE, Society of Hispanic Professional Engineers

References

Rahul Mangharam
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