

# IPSN/SPOTS 2006 Research Demo

## High Fidelity and Multi-Modal Light Sensing Module for Wireless Sensor Networks

Heemin Park, Jonathan Friedman<sup>\*</sup>, Pablo Gutierrez<sup>\*</sup>, Vidyut Samanta<sup>\*</sup>, Jeff Burke, Mani B. Srivastava

Networked and Embedded Systems Laboratory  
Electrical Engineering Department  
University of California, Los Angeles  
{hmpark, jf, mbs}@ee.ucla.edu

<sup>\*</sup>Center for Research in Engineering, Media and Performance  
University of California, Los Angeles  
{pablo, vids, jburke}@hypermedia.ucla.edu

### Demo Abstract:

We will show our new light sensing module, the Illumimote, for wireless sensor networks. Our Illumimote is an intelligent, high fidelity and multi-modal wireless light sensing board compatible with the Mica platforms. In the demo, performance of the Illumimote comparable to a commercial light meter and color meter (as used by professional cinematographers) will be demonstrated by measuring incident various light intensities and color temperature settings and comparing with reference measurements with a commercial light meter and color meter. The Illumimote also has situational sensing capabilities (estimation of incident light angle and board attitude) and they will be shown in the demo. To demonstrate the performance and capabilities of our Illumimote, a couple of lights will be set up in the demo with MicaZ wireless sensor nodes and a laptop base station. Using the light sources, various light and color intensities are generated. The status of the Illumimote is displayed on the GUI visualization interface in real time.

### Background:

Wireless sensor networks (WSN) are pervasively employed in many areas like target tracking and habitat monitoring, but they also have exciting applications in the arts, multimedia, and entertainment. Poor sensor quality, fidelity, and diversity have limited such expansion into these new areas like film, video production, and lighting control applications. The Illumimote was conceived in a joint effort by filmmakers and engineers to apply the evolving technologies of WSN to new purposes in entertainment and applications that exploit light information. We have focused on lighting instrumentation as the first component of our Advanced Technology for Cinematography (ATC) project because of its vital role in the creative process of filmmaking. ATC is a joint project of UCLA's Henry Samueli School of Engineering and Applied Science and the School of Theater, Film and Television. The Illumimote is part of its larger vision to increase flexibility and creative control in media production using sensor networks and other emerging technologies. Deploying networks of tiny sensors adds a data acquisition layer to the film production environment that supports on-set decision making, such as the lighting adjustment described above, as well as post-production and asset management. Another component of the ATC project is UCLA's Augmented Recording System (ARS). In ARS, wireless sensors are deployed on a set to collect data in synchrony with the film or video frame rate. ARS provides a framework for

establishing a correlation between the media footage and sensor data. Initial work with ARS has prompted the development of the Illumimote to address limitations in sensors currently available for Mica mote platform. For example, the light sensors on the standard Mica sensor board (MTS310) are inadequate for high-fidelity applications, lacking the necessary dynamic range. To our knowledge, the Illumimote is now the fastest, lowest-power, most accurate, and most complete light sensor available in the field of WSN. Developing a high fidelity and multi-modal light sensing package involves the following research challenges: Above all, it must achieve performance comparable to commercial light meters while conforming to the beneficial size and energy constraints of sensor networks. At the same time, it should be able to acquire data through various sensing modalities as called for by the application.

### **Design of the Illumimote:**

The Illumimote's data acquisition capabilities cover the three principle attributes of illumination: Signal strength (intensity), frequency (color), and transmission vector (incident light angle and sensor attitude). There are eight light sensor channels allocated based on the number of detector circuits required to capture the illumination attribute: one for an incident light intensity sensor, three for RGB color intensity sensors for color temperature, four for incident light angle sensors. Signals from the eight light acquisition units and four situational units are multiplexed via the channel selection unit and presented to the ADC for conversion into a 10-bit digital signal. This resultant data is conveyed to the sensor nodes (Mica motes) via either the I2C data bus or a direct 16550A compatible UART link that uses line-level (rail-to-rail) output. The operation of the Illumimote's units may be controlled directly from the mote via the I2C bus or locally by an onboard Atmel Atmega48 microprocessor. The assembled Illumimote has a lumisphere that protects the sensors and integrates incident lights from all directions.

### **Verified Performance:**

<b>Specification</b>	<b>Range</b>	<b>Accuracy</b>
Incident Light Intensity	4.7 to 13,000 Lux	5% Average
Color Temperature	2900°K to 6560°K	5% Average
Incident Light Angle	360° X, Y above board	3° Average
Temperature	- 40°C to +85°C (+/-2°C)	
Board Attitude	+/- 90°(pitch), +/- 90°(roll)	
Power consumption	90mW	When all sensors are turned on
Measurement speed	340 measurements per second	

### **Conclusions:**

Our new light sensing module, the Illumimote, achieves performance comparable to a commercial light meter and color meter (as used by professional cinematographers) over the ranges indicated in our findings. It consists of incident light intensity, RGB intensity (for color temperature calculation capability), and incident light angle sensors as well as thermal and attitudinal sensors. In this demo, we show its performance and capabilities.

### **Links:**

Further information can be found at the project website, <http://nesl.ee.ucla.edu/research/illumimote>.