# Urban Pixels

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**Abstract.** "Urban Pixels" are wireless, solar-powered lighting units for cities that blur the boundary between digital display technology and traditional urban lighting. By combining a renewable energy source with RF communication it is possible to achieve a self-sustaining, distributed display network that can be attached to any building surface and reconfigured with ease. Depending on their configuration and placement, Urban Pixels can be used to convey place-specific information, respond to environmental conditions or support creative expression in urban public spaces. We describe early design iterations and preliminary findings that demonstrate the potential for such a system.

## 1 Introduction

Shaping urban environments through lighting effects and façade technologies has become an increasingly important domain for urban designers [1]. Digital technologies have enabled a host of responsive installations that create new opportunities for dynamic information display and user interaction in urban public spaces. In parallel, there is a burgeoning interest in urban sensor networks for monitoring environmental conditions or traffic [2]. Urban Pixels blurs the boundary between digital displays, distributed networks and urban lighting systems.

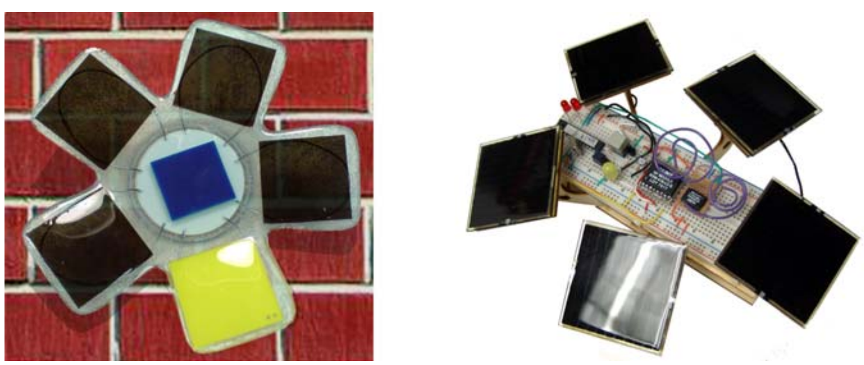

**Fig. 1.** Left: Design model with space for 4 solar cells (grey), PCB board with LED lighting (yellow), and battery (blue). Right: Prototype of pixel unit with circuitry and solar panels.

By harvesting solar energy, Urban Pixels form a self-powered distributed network. RF communication links support easy reconfiguration. Pixels can be applied to existing buildings, urban infrastructure and temporary structures in the vertical and horizontal planes. Depending on their configuration and placement, they can convey place-specific information, respond to environmental conditions or support creative expression in urban public spaces.

## 2 Background

This project draws from several disparate domains which span new display systems, urban street lighting, and distributed sensor networks. Among the vast field of urban display systems there are many distinct trends that relate to Urban Pixels. Designers are increasingly harnessing the potential of digital, responsive façades for urban contexts. Iconic projects such as Villareal's Supercluster presage the opportunities LED-based displays create for architecture [3]. Projects such as Yoon's White Noise White Light [4] create interactive, public installations by using lighting in playful ways. And ambient information systems at various scales have emerged as a way of conveying information implicitly and subtly without interrupting other human activities [5].

Urban Pixels will also leverage the technology developed in the large area of self-localizing sensor networks. Both outdoor systems such as the ENSBox [6] and indoor systems such as the Pushpin Computing project [7] have been developed for ad-hoc network configuration. These systems are sophisticated platforms for gathering, distributing, and displaying data on individual nodes that adapt to new physical arrangements.

Finally, urban lighting design is increasingly adopting solar power for effect lighting and signaling and more slowly for primary street lighting. Most of these lighting systems connect to the power grid and do not have a battery on board. However, in the developing country context there are many examples of solar-powered systems such as the Glowstar Lantern [8] which charge batteries to run autonomous devices.

## 3 Technical Design

Each pixel contains the following key components: four copper indium diselenide (CIS) solar cells; PCB board with 418MHz RF units, five super bright LEDs and additional control electronics; rechargeable NiMH battery pack; adjustable structure of wire and plastic; waterproof casing; and connector. The system is operated by an ATMEGA644 microcontroller running on a 8MHz crystal oscillator. Each unit is approximately 22cm in diameter.

**Communication.** Each board includes both a 418MHz Linx LR receiver and transmitter unit. These radios were selected for ease of use, low power consumption and their simple protocol. The latter further reduces power needs, which presents a benefit over more sophisticated RF units. These radios support long distance transmission in an urban setting with many physical obstacles. The system has been tested for displaying simple patterns in a three by three grid of nine nodes shown in Fig. 2. The units operate in master or slave mode to coordinate their display sequences.

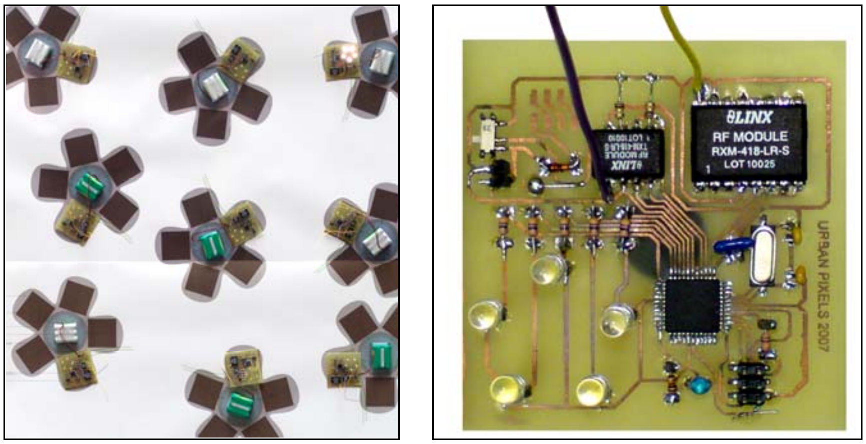


**Fig. 2.** Left: 9-pixel network for testing initial display patterns. Right: Circuit board (60mm x 60mm) with control electronics, RF modules, and LEDs.

**System Power.** A 3.6V NiMH battery pack provides 1,800mAh to each pixel. The CIS solar cells (60mm x 60mm, 2mm thick) are thin film solar cells that are more efficient under cloudy conditions and more durable than amorphous silicon-based cells. Under full sun conditions, the four cells output 50mAh each, ensuring a full charge during a 12 hour period. This arrangement would enable a display time of at least 10 hours with the current five LED (20mAh each) display. To maintain this display time during low light conditions, a maximum powerpoint tracking switching regulator has been developed, which obtains up to 90% efficiency at high currents (greater than 5mA), and only draws 20uA quiescent power, making it possible to harness energy from the cells which would otherwise be lost when the solar cell voltage drops below battery voltage.

**Self-Localization.** In an initial exploration of self-localization, we use ultrasound transducers (40kHz MSI omni-directional piezo film transmitter and receiver) to measure the distance between units. The maximum range achieved was 6.2m in an outdoor environment utilizing a peak transmit power of 250mW. Although the transmit power is high, the burst only needs to transmit for a short period of time during the initial localization phase. Tests of the system show a linear response over the range of 0.34m to 5.2m with less than 5% error. The transmitter is driven at 200V, and although the distance could be increased by boosting the drive voltage, better results have been shown with audible transducers [6], which are not as susceptible to absorption by vegetation. For this reason, the self-localization has not yet been integrated with the overall system as a lower power, lower cost, audible system is being developed.

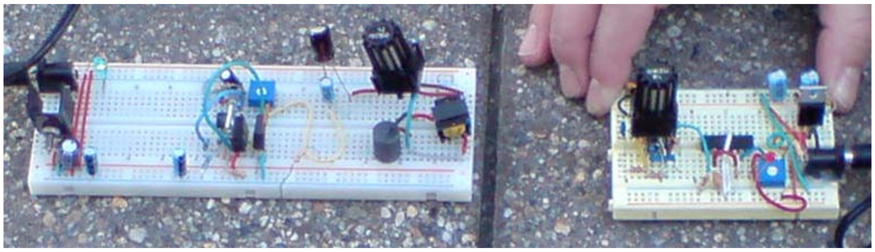

**Fig. 3.** Ultrasound distance sensing circuitry. Left: transmitter. Right: receiver.

## 4 Conclusion

Urban Pixels is a promising application for a distributed, self-sustaining display and lighting network. Further work is needed to produce and integrate a self-localization system; however, acoustic sensing is promising for the long-range needs of this application. Currently, the solar cells provide enough charge to power the system for a sufficient amount of evening display time, and non-localized light patterns that respond only to neighboring radio pulses could engender surprising emergent behaviours. Urban Pixels demonstrates the potential for an autonomous lighting and display network that links existing urban spaces and improves the quality of these environments through subtle informational and playful interventions.

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## References

1. Narboni, R.: Lighting the Landscape: Art Design Technologies. Birkhäuser, Basel, (2004)
2. Welsh, M. CitySense. (2007) http://www.citysense.net/
3. Villareal, L.: Super Cluster. New York (2003-2004) http://www.villareal.net/ps1.html
4. Yoon, M.: White Noise White Light. Athens, Greece (2004)
5. Ambient Intelligence: Exploring Our Living Environment. In Intelligence Vo. 12, Issue 4 (2005) Special Issue
6. Girod, L., Lukac, M., Trifa, V. & Estrin, D.: The Design and implementation of a self-calibrating acoustic sensing platform. In Proc. of the ACM Conference on Embedded Networked Sensor Systems. SenSys, Boulder, CO (2006)
7. Lifton, J., Broxton, M. and Paradiso, J.A.: Experiences and Directions in Pushpin Computing. In: Proc. of the Symposium on Information Processing in Sensor Networks. IPSN, Los Angeles (2005) 416-421
8. Glowstar Lantern. http://itcltd.com/glowstar/