Lizardnet

Environmental Study of the Robert J. Bernard Biological Field Station Lizard Habitat

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1 Project Dates

The project will begin in April 2005 and continue through May 2006. These dates are chosen so that we can begin acquiring equipment before the end of the school year, and so that Presentations Days in 2006 is included. The project will take place in Claremont, at HMC and the Field Station.

2 Research

Our (Professors Adolph and Erlinger, and 4 unnamed students) goal is to investigate the temporal and spatial variations in microclimates in the Bernard Field Station. Microclimates are the immediate meteorological conditions experienced by organisms. We plan to do this in a non-intrusive way, basically by distributing remote sensors that would provide habitat monitoring via a wireless network grid. Sensor networks are an emerging technology that allow simple embedded computers with attached sensors to be placed in an environment for remote data gathering. A deployment in the Bernard Field Station can be used by biologists and ecologists to better understand how lizard habitats are affected by local phenomenon including temperature, light intensity, and noise. The

deployment can act as a testbed for sensor network research including the development of easier to deploy hardware and software elements, improved interfaces to the network, and network protocol development. Our activities parallel those of CENS. CENS (Center for Embedded Networked Sensing) [1] is an NSF sponsored project at UCLA which is one of the leaders in developing embedded network sensoring systems. Our proposed study has significant advantages of locality over similar habitat studies being undertaken, i.e., we are across the street from our study environment. A unique combination of technological advances (constantly developing hardware and software elements) and interdisciplinary aspects (application areas for investigation) of sensor networks make sensor networks a valuable research area in an undergraduate curriculum.

3 Education

Starting with the computer science side of things, sensor networks are small in size and complexity. This means that a good undergradate can assimilate the sensor network operating system, sensors, and the network architecture in a short period. Experience with domain constraints will provide for valuable discussion. Students can investigate how sensor network constraints effect network protocols and the architecture of the network. This encourages students to both review material that they have learned and to modify that information. By their very nature sensor networks are interdisciplinary. For the biologists, there are the data sets gathered with minimal impact to the environment. Also, biologists will need to think critically about what information they want and how they can get it. Being able to clearly specify this type of information will require interaction with the computer science students. Hopefully the result is better sensors and better microclimate data. Finally, sensor networks are real, which grounds students and their work in the real world.

4 Environment

Many environments are not easily accessible to those studying them. This can be the result of inaccessibility or the disturbance that many forms of observation would have on the environment. Sensor networks can solve this problem by providing low profile sensing (once installed, such networks can operate for upwards of a year without human intervention). Data sets collected by sensor networks can contain rich spatial and temporal data. There are tools for visualization of dense spatial or temporal data. Remote sensoring is an iterative process as there is the challenge

of tying the data back into a system; either by combining the data with field observations, or consulting with the folks making the hardware so that more (e.g., more focused) information can be gathered.

Microclimate temperatures are arguably the most important environmental factors affecting the ecology and behavior of small ectothermic animals in temperate regions. Previous work on lizards has shown that the spatial distribution of temperatures is an important determinant of how lizards use the habitat, for example, how much time they spend in trees, on logs, and on the ground; [5], [2]. Temporal and geographic variation in environmental temperatures strongly influences a variety of important traits in lizards, including growth rate [6], annual survival and reproductive rates [4], and age and size at reproductive maturity [3].

5 Feasibility

5.1 Hardware

Lizardnet will require various hardware and software elements. Most of the software is public domain, while the hardware is readily available.

- Motes - motes are the individual network nodes that make up the network. Through their connected sensors, motes sense and locally forward data. A realistic network would include 10 or 12 motes to do the sensing.
- Base Station - The base station is the box that listens to motes and forwards all the collected data. The base station uses normal wireless technology (802.11) to communicate with the outside world and is powered either by usual sources or solar cells.
- Home Base - A PC that listens to the Base Station and has all the supporting software. It is from the Home Base that the sensor network is monitored and data gathered.
- Sensors - We will purchase temperature and humidity sensors that interface to the motes.
- Lizards - copper lizards with internal sensors will be built by the team.

5.2 Software

There are various pieces of software, SOS, EmStar, and Linux. All are open source products available to us. SOS and EmStar make up the operating system and sensor controls for the motes and the base station, while Linux will be the PC operating system.

5.3 People

There are two groups of people needed for Lizardnet: computer scientists and biologist. The two faculty submitting this proposal will be deeply involved with the project, but the core of the day to day operation will be undertaken by students. Professor Erlinger has long experience in networks and systems, while Professor Adolph has been studying lizards and their environment for many years. The experiences of both faculty members bode well for the success of this project.

From the computer science aspect students would be responsible for creating the Lizardnet sensor network infrastructure. They would install hardware and software, and ensure that the sensor network is operational. This would include working in the Bernard Field station caring for the motes. These activities are all doable by HMC students who have taken the basic computer science curriculum. From the biologcal aspect students would be responsible for placing the sensor network and for the day to day data gathering and processing. Again HMC students have the background to handle these tasks.

6 Budget

We have also submitted a proposal to HHMI seeking support for this project. From the HMC Center for Environmental Studies we are seeking student and faculty support.

Budget	
CS/Bio Faculty Stipend	1,000
Bio or CS Student Stipend	3,900
Motes, Base Station, copper lizards	1,000
TOTAL	5,900

References

[1] *Center for Embedded Network Sensing*.

[2] S. C. Adolph. Influence of behavioral thermoregulation on microhabitat use by two sceloporus lizards. *Ecology*, (71: 315-327).

[3] S. C. Adolph and W. P. Porter. Growth, seasonality, and lizard life histories: age and size at maturity. *Oikos*, (77: 267-278).

[4] S. C. Adolph and W. P. Porter. Temperature, activity, and lizard life histories. *American Naturalist*, (142: 273-295).

[5] B. W. Grant and A. E. Dunham. Thermally imposed time constraints on the activity of the desert lizard sceloporus merriami. *Ecology*, (69: 167-176).

[6] B. Sinervo and S. C. Adolph. Growth plasticity and thermal opportunity in sceloporus lizards. *Ecology*, (75: 776-790).