Electronics in Nature: Digital tools to explore our urban natural ecosystem

Aude Vuilliomenet
The Bartlett, CASA
University College London
London, UK
aude.vuilliomenet.18 @ucl.ac.uk

***Abstract* – The "Electronics in Nature" (EIN) Box is a lightweight, portable box containing environmental sensors and actuators to allow children to explore the nature and environment of their outdoors environment. The EIN Box is a device that aims to bridge both the world of nature and technology in an interactive and educational manner. The device creates new opportunities for children to explore and discover the hidden features of their parc and electronics components powering their video consoles and smartphones. Here, we present the first prototype of the EIN Box and show how it was used in forest school activities. We advance new ideas for a second that would allow two Boxes to communicate with one another.**

I. Introduction / Background

As our cities grow in sizes, the wilderness has become more distant. The challenges urban population faced in viewed of a rapidly changing climate, however, ask urban citizens to reconnect, give space, and embrace nature repopulating our cities. Our connection to and understanding of nature is a key factor for us to develop and practice sustainable action. In a world of concrete, pocket parks and green spaces become suddenly important spaces of learning and discovery, offering refuges to cultivate environmental awareness.

But the reality is that these outdoors spaces are so different from our daily life, that they can be seen as "uninteresting" and even "frightening". The quietness of a park is in opposite to the speed of technology that is embedded in every layers of our life. From the moment we wake up to screens, to the constant notifications of our devices, technology becomes at the centre of our daily lives. Yet, while technology can be seen as a barrier to nature, it can also be used as a tool to facilitate our interaction with it.

By building on the same electronics components powering our familiar devices, we can turn them into tools for exploration, creating new opportunities to attract children to explore their outdoor worlds and hidden elements of their smart devices. This paper presents a prototype of an environmental sensing device called the "Electronics in Nature" Box. The device is composed of different sensors that need to be wired with on another before it can be used. Once assemble, the device can be carry around a park to sense and observe different environmental conditions.

II. Related Work

The use of sensing devices and technology to observe nature has been explored by many others. A few studies have explored the use of mobile applications to encourage children to play outdoors. Other studies have explored the deployment of devices to collect information about children environment while these are away. For example, the *My Naturewatch* project saw the development of a DIY camera to capture birds and other animals visiting human gardens [1]. Moreover, the *ABBOT* toy was developed to help children capture images of elements of the outdoor their find interesting and captivating [2].

III. Imaginged or Existing Prototype Sketches/Drawings/Photos

The first prototype of the "Electronics in Nature" box consists of three different subprograms, each of them introducing a new environmental sensors and new actuator [3]. After introducing each subprograms, building them and testing them out, the final box was assembled.

A. Electronics Components

The first circuit introduces the measurement of moisture content. The circuit uses two nails to measure the moisture content of various media and three LEDs to visualise the moisture of the soil (pink for "Dry", green for "Average Moist", and blue for "Very Wet"). A LCD Screen is also integrated at the front of the box to read the moisture value in percentage.

The second circuit introduces the measurement of temperature and humidity. The circuit uses a DHT22 temperature and humidity sensor and a small servo motor. The speed of rotation of the servo motor adjusts according to the values recorded. The higher the temperature, the fastest rotates the motor as more, and the lower the temperature, the lowest rotates the motor. This is to reflect that in hot environment, more intense airflow would help having a cooler sensation that without any airflow.

The third circuit explores light intensity and our relationship with light and sound. The circuit is built using a photo resistor and a small speaker. Depending on the reading of the sensor (in shade, in full sun), a different melody is being played.

This first prototype uses an Arduino Uno, a breadboard and jumper wires to connect the components. All components were purchased on various consumer electronics website including the PiHut, DigiKey, Arduino, and Amazon.

The enclosure of the box was fabricated using 6mm plywood and cut to size using laser cutter machines. The choice of using plywood allows children to customise their own box by drawing and painting on it. One of the constrain on the size of the box was the size of the solar panel on the top, but also the space to hold all the electronics components.

B. Wiring Diagram

The wiring diagram below illustrates the v1.0 of the EIN Box. This diagram was developed so children could easily identify how to connect wires to the breadboard and understand which wire provides power, which one is grounded, and which ones are used for sending signals.

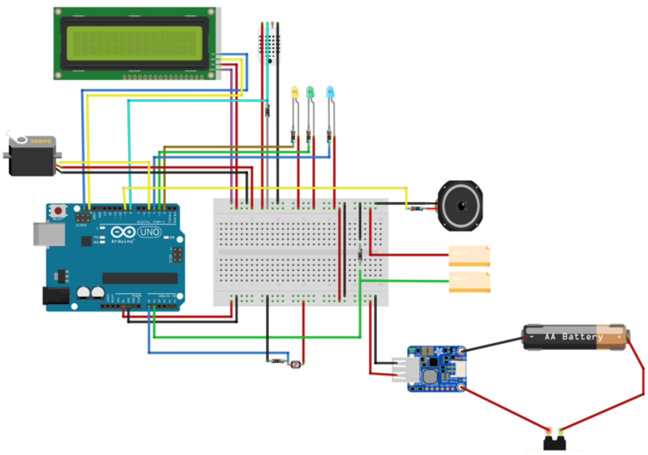

Fig 1: Circuit Diagram showing the wiring of the different sensors and actuators to the Arduino Uno Board.

C. Photos of Prototype

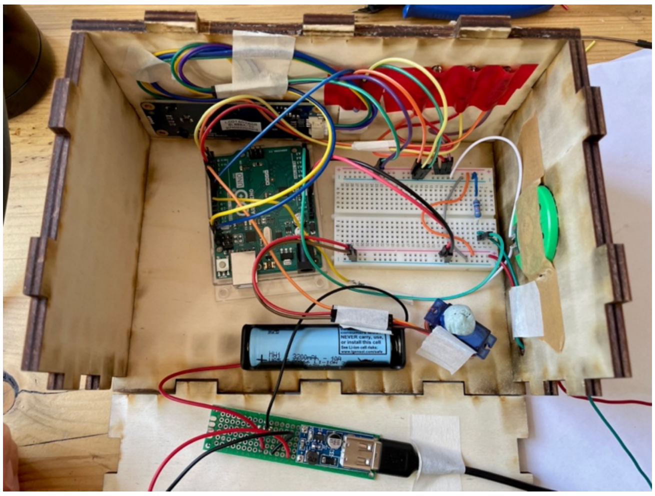

Fig 2: Picture of the wiring inside the EiN Box.

Fig 3: Picture of the EiN Box deployed in a planter.

D. Next Iteration

The aim is to go to a new iteration of the EIN Box to widen access to this tool for forest school teachers and allow more children to participate in building and using this EIN Box.

The v2.0 of the EIN Box aims to ease the wiring of the different elements. In the v2.0, the aim is to build and develop small printed circuit board so the box can be assembled in a much easier and less fiddly way.

The second change to the EIN Box is to add connectivity to the box so that information can be exchanged between them. This would see the addition of a second push-button that can be used to send messages between boxes. The LoRaWAN network would be used to send messages and therefore the Arduino Uno MCU would be replaced by an Arduino MKR1310. As MKR1310 are relatively costly, the aim would be to build a small PCB that can act as MKR1310.

The addition of connectivity to the EIN Box is to provide opportunities for children to exchange information with another while being in different location of a park. It would also give the to explore the concept of networks. On one hand acting as a metaphor for the mycorrhizal network hidden in the soil, but playing a crucial role in connecting our trees. On the other, opening the door to discuss how messages and information are transmitted in wireless networks.

IV. Responsible Innovation

If the Electronics in Nature Box can help urban citizens reconnect to the outdoors and start wondering about the role that nature play in regulating and managing our urban climate in an interactive, explorative and playful manner, we might start to see our relationship with nature, but also technology in new lights.

Electronics have a carbon, and climate impact and we cannot ignore this when building more devices and deploying them outdoors. To mitigate this device taking the dust and not being used, the aim is to designed it in a way that components can be repurposed. The connection between different elements should therefore be standardised.

Responsible innovation also means following best practices so that others can replicate it. We aim to following open-source hardware guidelines and practices to document, share and develop a new prototype.

V. Author Bio(s) / experiences

I am a PhD Candidate affiliated with the CASA's Connected Environment Lab and CBER's People and Nature. My research, called "Gardens of Things" combines elements from electronics engineering, ecology and interaction design. I have a keen interest in the application of technology for making our cities greener and connecting human to nature. I aspire to become more familiar with electronic PCB design and manufacture to develop hardware sensing devices that can facilitate the work of ecologists. More importantly, I am keen to introduce some of these sensing technology to school children, opening their curiosity for the electronics components powering their smart devices.

Through my past experiences in the vertical farming industry, I have been exposed to the design and manufacture of hardware systems at scale. I have been involved in components selection and sourcing, schematic review, and working with local and overseas manufacturing partners. I have developed some good practices on low-voltage electronics assembly (i.e., wiring, soldering, debugging).

As a teaching assistant for two of the modules of the MSc. in Connected Environments (CASA0016: Make, Design, Build and CASA0018: Deep Learning for Sensor Networks), I have assisted students with tools such as oscilloscope, multimeter and soldering irons, and helped them with C++ programming.

I have a broad background and an ability to adapt to new fields. If I had to pick a tool to describe my skills, I would probably say that I am like a “Swiss Knife”, useful in many cases, but not really adapted to many others. My aim, if I am accepted in this workshop, would be to sharpen my toolkit and learn and exchange with other participants.

For my PhD research, I have been working on both software and hardware. One example is my work in developing a python software to ease the deployment of AI bioacoustics classifiers on Raspberry Pi devices. Another, is the build and assembly of an enclosure stuffed with a range of sensors (i.e., accelerometers, microphone, environmental sensors) to monitor the activity of a wasp nest.

VI. Acknowledgements

I am thankful to URKI EPSRC for financially supporting my PhD research via the grants: EP/R513143/1 and EP/T517793/1.

The Electronics in Nature Box was a collaboration with Paula Harvey, a trained and recognised Forest School teacher, Director of Urban Forest Tribe CIC (14181537). It couldn’t have happen without the financial support from the London National Park City (LNPC) Foundation (1173267).

VII. References

[1] Gaver, William, Andy Boucher, Michail Vanis, Andy Sheen, Dean Brown, Liliana Ovalle, Naho Matsuda, Amina Abbas-Nazari, and Robert Phillips. "My naturewatch camera: disseminating practice research with a cheap and easy DIY design." In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1-13. 2019.

[2] Delprino, Federica, Chiara Piva, Giovanni Tommasi, Mirko Gelsomini, Niccolò Izzo, and Maristella Matera. "ABBOT: a smart toy motivating children to become outdoor explorers." In Proceedings of the 2018 International conference on advanced visual interfaces, pp. 1-9. 2018.

[3] GitHub Repository: Electronics in Nature, Aude Vuilliomenet, Link: https://github.com/audevuilli/Electronics-in-Nature