CDT Training Activity Proposal: Solar (and Meteorological) Data Collection – Workshop and Field Test

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Outline

CDT-PV students during their training in Bath would spend one day in a workshop assembling and/or programming an Arduino (or similar microcontroller) data logger, which would measure solar (and other meteorological) data at a nominated test site, such as Bath Abbey. This project would build on programming skills and exposure to the Xtralien (which operates similarly) gained at Sheffield. During the visit to the site, students would be able to obtain their data and/or retrieve the mini-weather station. Students would be able to take note of local topological and architectural detail which may impact device performance. Data obtained could be used to generate an annual projection of solar performance and compared to results of PVSyst modelling performed at Loughborough.

Objectives

The activity would collect real-world data at a CDT-PV trip site by students during their training, this could be made available to the Abbey informing their footprint project (or for similar purposes at other designated sites).

The device should be fabricated quickly and at low cost. Data must be extracted easily and stored on device during deployment. The device must operate independently to ensure flexibility of deployment.

Students should obtain an appreciation of the relative simplicity of the device and the activity should foreshadow future training events without overlapping. The students should be able to obtain the data, analyse the results and produce an estimate of the total power output per year and estimate the power output if the full available area at the test site was utilised.

Students would gain an understanding of basic electronics (where appropriate) and the opportunities created by low-cost microcontrollers through case-studies of other deployments. Students would also gain experience in programming an Arduino to read sensory data.

Students would also be able to observe the prototype device and access data from a longer deployment. If permission is granted, the prototype would be placed on a roof of a building at the University of Bath. This will serve as a backup option for gathering data in case of device failure or hazardous weather conditions.

Limitations

The workshop will only run for less than a day, so design, development and some of the construction may need to be performed beforehand. This limits the practical skills that the students will be exposed to, however it does help keep the workshop focused on solar.

The device will need to be powered for an extended period of time and operate without assistance for the duration. The likely power source would be the silicon solar module created by students on the Loughborough training, although a new and emerging material may allow for field degradation measurements in a long-term study.

Using small scale solar means the voltage and current inputs will be limited. Most microcontrollers can be operated from RC racing-car Li-Po size batteries for short periods of time, having a voltage input between 3.3V and 12V DC and a current requirement of roughly 30 – 50 mA per output pin.

It has been decided that power would not need to be supplied at night to the prototype. This means an energy storage solution will not be included.

Materials

Access to a lab with soldering facilities and solder will be essential during preparation and during the workshop.

Basic electronic parts. A set of resistors for creating voltage dividers so the voltage output of the module can be measured, further resistors for determining the current. A thermistor which can be calibrated for temperature measurements.

(Design for the anemometer has not been completed, however either a copper coil or a physical contact which counts as the gauge turns seem plausible. Materials to house this will be dependent on design.)

Microcontroller candidates are the Arduino (of which Oscilla's Xtralien is based) or the Raspberry Pi. Low operating power variants should be selected where possible. These will need to ship with a (micro)SD card reader and a GPS receiver (to track the time following a power outage) – although in some cases addons are available. This portion will be the bulk of the cost. SD card will need to be purchased. For the devices built during the workshop, LCD screens may be a cheaper option than SD cards.

Casing to protect the electronics against weather conditions.

Preparation

The device components would either be constructed in Bath using local facilities or could be a collaboration between more-senior CDT students. Most of the collaboration would be in either the design phase, producing the meteorological modules, or calibration of each section – with transport costs increasing considerably for the latter options unless incorporated into other CDT events. The CDT students would assemble their own devices during the workshop using the same (or similar) design to the prototype.

Timeline

Wk 0 to Wk 1:	A feasibility study would need to be undertaken to determine if the power input is likely to be sufficient to operate the device (if the silicon module is chosen this should be quicker).
Wk 1 to Wk 4:	Design of the device and sensors, choice of components would be undertaken in this period. Design should then be finalised and approved and lab time obtained. Funds would need to have been allocated and parts would need to be ordered to the manufacturing institution.
Wk 4 to Wk 7:	The device would need to be powered by the solar module and it should be established that basic device operation can continue for prolonged periods with just the solar module, microcontroller and measurement of power input. Work would then need to begin to make the microcontroller ready to write data to the SD card.
Wk 7 to Wk 8:	Work can commence on the meteorological components. The thermometer should take very little time and are sold as finished products. (The anemometer would need to be tested and any required changes made before the final version is fabricated.)
Wk 8 to Wk12:	Calibrations should then be performed. The microcontroller would need to be coded to assess the value at each I/O pin and calibration curves produced for the thermometer and solar power measurement.
Wk 12 to Wk 14:	Field tests should be undertaken to ensure device can operate, measure and store data over long periods and to ensure device does not experience unexpected failure. This test would also serve as back-up data if problems are experienced during the actual deployment.

This timeline assumes no more than 2 hours of work per week and completion of a prototype in advance of the Bath module.

Workshop

The workshop would be run in three parts: background and introduction to electronics; introduction to Arduino and coding on an Ardunio (or similar microcontroller if appropriate); preparing the device to read inputs and write outputs.

In the background section students would be exposed to current field-use of Arudinos and similar devices in research and surveying. They would then quickly be walked through some basic electronics (in particular the circuits used in the device to be deployed).

In the introduction to Arduino students would be taught about an Arudino and introduced to coding on an Arduino. (Reference books provided by Arudino no longer seem to be free but references will be provided). The coding will start with something basic such as lighting an LED and reading an analogue input (the Arduino's own 5V output passing through a potentiometer).

In the final session students will assemble into groups and be asked to create the circuitry for the solar measurement and then code up the Arudino to read the input. The students could then take their Arduino and calibrate it. Students will then be walked through the code for the prototype. Students would be able to get the Arduino to write an output through serial to a computer or to an LCD.

Calibration data and schematics could be provided to students for an assignment.

Students would then be taken to the trip site and an instantaneous measurement of the solar power generated would be taken. They would also get a chance to see the prototype on top of the university.

Budget - *For a single weather station*

Microcontroller x 1	£20 - £50	
GPS & SD Socket Add-on	£30	
SD Card		£5
Electronic parts (incl. veroboards)	£10 - 15 (dependent on lab availability)	
Thermistor x2 (Air and panel)		£20
LCD display (optional)		£15 - £20
Total (per device)		**£100 - £140**

Recommendations

If costs are to be kept low, then Bath should be the manufacturing institution as travel costs could be kept to a minimum. The proposer will consent to spending time on the project and has experience creating similar devices in a similar environment.

An Arudino should be the choice of microcontroller due to familiarity and the wide range of 'shields' which can be purchased that fit straight onto Arduino models such as the 'Uno.' It is also a low cost option which students may want to use in future field studies or as a hobbyist activity.

Bath Abbey should be the designated survey site, due to the trip's positioning in the year and to maintain ties with The Abbey. There is also previous modelling data available which could be incorporated into the workshop if there are large changes to the CDT curriculum.

Multiple Arduino's would need to be purchased, in an ambitious case it may be beneficial to perform a feasibility study to see if the devices could be performed with organic solar cells (this would also tie in with other training sessions during the module). However, this would raise the costs. OPV may also be a safer option for deployment on top of the university.

Notes

Permission would need to be obtained with the designated site and the site inspected so that a method of securing the solar module can be chosen.

Casing and water-proofing has not been incorporated into the budget and options are yet to be considered.

Batteries have not been incorporated into the budget. Including batteries would increase the cost and potentially alter the design. Research into an energy storage option would extend the preparation timeline.

Temperature measurements are optional but easy to incorporate and temperature would have an effect on solar module performance.