Open-source Lasercut Portable Incubator for Microbiology

Primary contact for the team

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Team

The team is comprised of the 5 members who are currently involved in WaterScope - a not-for-profit Cambridge startup which aims to detect bacteria in water in less than 2 hours using a low-cost, portable kit. The skillset of the team is suitable for the development of the project and the individual roles are described below:

Sammy Mahdi (sm2205) - Sensors, heater and control electronics

Richard Bowman (rwb27) - Parametric OpenSCAD design of incubator

Alex Patto (ap726) - Fabrication and characterisation of incubator

Tianheng Zhao (tz275) - Software and device interface

Nalin Pate (nlp28) - Component sourcing and usability testing

Summary

One of the most used instruments in a microbiology laboratory is the microbiological incubator, it is used for bacteria growth, incubation of cells and tempered storage. This project aims to create a incubator that can be fabricated in a typical makerspace environment at a low cost while achieving the same performance as commercial units. The incubator will also feature a parametric CAD design to allow the users to modify it depending on their volume requirements. Finally, the proposed incubator will have two power options: mains-powered mode and battery powered mode for portable instrumentation in remote environments.

The problem

One of the most common instruments in any microbiology laboratory is the incubator, it has numerous different applications (bacteria growth, incubation of cells, tempered storage and others) however the starting cost of a very basic incubator is approximately £700 which can be prohibitive for people who want to start experimenting with biology. In addition, currently there are no solutions for portable incubators which makes it challenging to perform experiments outside of a research environment.

Hardware design goals

Mechanical Design (2 weeks)

The incubator will be designed in a parametric open-source CAD software such as FreeCAD or OpenSCAD. The user will be able to select parameters related to the incubator dimensions. Optional features would include add ons such as microscope slide holder or petri dish holder. An image of a very basic prototype designed by WaterScope in shown in Figure 1. The incubator has to be designed in such way that it allows fabrication by a laser cutter and easy assembly. At the moment, acrylic is the prefered material however, if possible, other temperature resistant materials such as polycarbonate will be investigated.

Heater design (2 weeks)

Two different heater designs will be examined - a resistive heater based design and a Peltier based design. The advantage of the resistive heater based would be in design simplicity and cost whereas a Peltier based design would allow the incubator to operate both as incubator and refrigerator. One disadvantage of Peltier modules is their lifetime however this can be systematically investigated.

Electronics (4 weeks)

The electronics will be based on open source hardware, most likely an Arduino Nano and an additional drive board to allow for driving of high current loads (heaters, fans). One of the important electronic components is the temperature sensor that will be used to allow for the best accuracy of the system at a reasonable cost. A systematic evaluation on different type of temperature sensors will be performed and the electronics have to be designed in a way that allows the user choose between a low-cost or a high-performance sensor.

Another important aspect of the incubator will be the power supply, as mentioned previously there would be two different options: portable version powered by an external battery and a laboratory version powered by the mains. Finally, the incubator should be a standalone instrument and it would feature a basic indicator and control panel.

Software (2 weeks)

In terms of software, the most important aspect is the control of the temperature which would be achieved using a PID controller. This would allow for quick warm up time and reduced steady state error. If time permits, it is possible to make the incubator an IoT device by adding a WiFi module to it. This would allow the users to monitor and control the temperature remotely.

Characterisation (2 weeks)

The performance of the incubator will be characterised and compared to existing incubators. The expected operating range of the incubator will be 25 - 60 °C however if a Peltier unit is used, the lower boundary can be as low as 0 °C.

Project implementation

The project will be implemented over 12 weeks with 2 weeks of contingency and the time allocated to each part of the project is mentioned above. The responsibilities for each individual members are described in the teams section of this proposal.

Outcomes and benefits

The project aims to deliver an incubator which will have the following features:

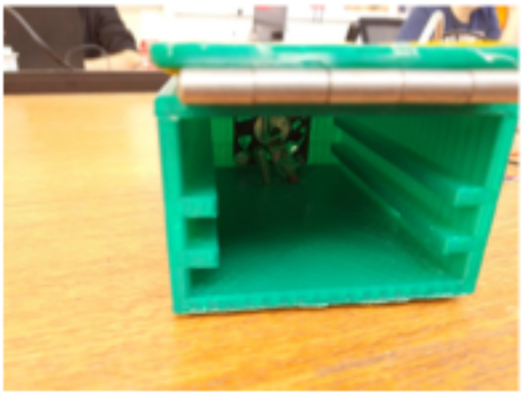
- Open-source and low cost
- Portable/mains operation
- Parametric design
- High accuracy
- Easy assembly

Components and budget

Table 1. Estimated cost of components

Item name	Estimated cost
Heating components	£100
3D printing materials	£50
Laser cutting materials	£50
Makespace membership	£40*3*3 = £360
Control electronics	£100

Figure 1. 3D printed alpha prototype



Control electronics	£100
Sensor components	£50
Total	£710