iLAB: next-generation coding for physiological monitoring

Team (*primary contact)

- **Joanna Brunker*** CRUK Cambridge Institute, University of Cambridge; jb2014@cam.ac.uk

  Jo is a postdoctoral research fellow with a PhD in designing devices to measure blood flow, so will contribute her knowledge of device design and biological monitoring.

- **Catherine Fitzpatrick** Department of Engineering, University of Cambridge; crmf2@cam.ac.uk

  Cat is a postdoctoral research associate currently working with Raspberry Pi programming for medical optics, and with previous experience in medical technology consulting. She will therefore contribute her skills in programming, device development, and assessment of medical market needs.

- **Marcel Gehrung** CRUK Cambridge Institute, University of Cambridge; mg858@cam.ac.uk

  Marcel is a German Masters student studying for six months in Cambridge. He has a background in programming, machine learning, and cell biology, so will help with programming and analysing the biological data.

- **James Joseph** Department of Physics, University of Cambridge; jj412@cam.ac.uk

  James built optical imaging systems during his PhD, and is characterising imaging system stability for his postdoctoral research. He will therefore contribute to the design and engineering of the monitoring systems and reliability testing.

- **Calum Williams** Department of Engineering, University of Cambridge; cw507@cam.ac.uk

  Calum's post-doc follows his PhD in optical engineering, in which he fabricated and characterised various optical devices. He will contribute to programming and optical sensing.

Summary

Our iLAB (interactive Learning Across Boundaries) project has three aims. The first is to give school students – the next generation of researchers – access to stimulating education about applications of programming to medical technology. This links to the second aim, which is to hold a competition in which five teams of students work over a series of tutorials delivered in school to build a low-cost Arduino based device to monitor a body function, such as heart rate. Each team will also design a website with full details of their device, thereby enabling other students to reproduce their ideas at the end of the project. Finally, the tutorials will facilitate exchange of knowledge and experience amongst our iLAB team of researchers, so that we each develop a deeper understanding of medical technologies, how to exploit these to probe different body functions, and also how to teach basic programming to 14-15-year-old students.

Proposal

Problem and biological system

Physiological parameters, such as heart rate, body temperature, and blood pressure, are important biomarkers that indicate conditions of health or disease. Such parameters are routinely monitored in clinical settings, but often using sophisticated systems that are unaffordable in low-income areas of the world. In these areas, conditions such as hypertension and malarial fever could be more readily diagnosed and treated if there were low-cost monitoring devices available.

Design goals

The project will involve designing and building a series of low-cost programmable devices for monitoring physiologically relevant body parameters. This will be achieved by five teams of 14-15-year-old students over a series of eight tutorials delivered in County Upper School, Bury St Edmunds by the Biomaker team of researchers. The four major goals are described below and in Table 1.

1. Building and programming prototype sensors

Devices to monitor heart rate, body temperature and blood pressure will be designed and programmed. This will be achieved using the £250 Starter Kit provided, together with additional components as required (Table 2).

2. Design of tutorials

(Table 2).

2. Design of tutorials

A series of tutorials will be planned to incorporate an introduction to physiological monitoring, medical robotics and artificial intelligence, drawing on the relevant background knowledge and expertise of the iLAB team. This theoretical background will be taught alongside the practical programming.

Project implementation

3. Delivery of tutorials in school

Five teams of approximately 4-5 students will work competitively over eight sessions to design and build a physiological monitoring device of their choice, and to publish it online. The practical aspects of the workshops will be interleaved with theoretical background discussions setting the project in the context of clinical care and medical robotics. Teachers at County Upper School in Bury St Edmunds have already expressed an interest in this series of medical technology workshops.

4. Testing and further development of the devices

The devices designed and built by the students will be presented online and in the final tutorial when they will be judged according to innovation and successful functioning. The best device(s) will be selected for further development. For example, a Wi-Fi module will be incorporated to enable physiological monitoring from anywhere in the world via the Internet.

Proposed outcome and benefits

Our central mission is to give school students access to stimulating University-style education, focusing on programming Arduinos, through a series of free tutorials delivered in school. Unlike most initiatives of this type, our iLAB is a long-term approach where we work with students on a weekly basis rather than a one off talk or a few classes. It is our belief that this approach will raise attainment for students and enable achievement and opportunity for all.

Additionally, our iLAB project will generate new ideas for low-cost monitoring systems for body functions. We propose to select the most promising device produced by the students and develop it further for use in clinical settings in low-income areas of the world.

The iLAB project will also enable a diverse group of researchers, forming the Biomaker team, to exchange and develop skills, knowledge and ideas. Teaching 14-15-year-olds will reinforce our own knowledge and confidence in programming and biological applications of medical technology. Thereby we will expand our current capacity for innovative research crossing the biological, technological and engineering disciplines, whilst also training the next generation of scientific researchers.

Figures and Tables

iLAB

Interactive Learning Across Boundaries

Figure 1: Logo design for the iLAB project. Further information about our existing team can be found here: https://www.hughes.cam.ac.uk/academic-life/connection/ilab/

Figure 2: Students at Jack Hunt school (Peterborough) working with electronic circuits in a pilot tutorial run by the iLAB team.

Table 1: Estimated timescale for the project milestones

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Milestones	**Months:**	**1**	**2**	**3**	**4**
1. Building and programming prototype sensors					
2. Design of tutorials					
3. Delivery of tutorials in school					
4. Evaluation, testing and further device development					

Table 2: Estimated costs of additional kits and components, and also travel expenses.

Item	**Quantity**	**Unit cost**	**Total cost**
• Return car trip to Bury St Edmunds school	8	£ 15.00	£ 120.00
• SparkFun Single Lead Heart Rate Monitor - AD8232	5	£ 15.37	£ 76.85
Additional kits identical to those provided by the Biomaker starter pack:			
• ARDX Starter kit for Arduino	5	£ 53.87	£ 269.35
• 4D systems touch screen	1	£ 55.20	£ 76.00
TOTAL			**£ 422.20**