Figure. Diagram of proposed device.

A low-cost colorimeter for accurate detection of colour changes in medical diagnostic tests

Team

1) **Andrew Stretton** (primary contact), ajs309@cam.ac.uk, Sensor CDT & Chemical Engineering and Biotechnology (CEB)

Andrew's background is in sensors and is currently working on a air quality device to selectively detect volatile organic compounds. He will primarily provide expertise and knowledge on sensor design and development. Andrew has worked on several optical sensing projects and will contribute skills and experience in electronics and device prototyping.

2) **Cassi Henderson**, cjh212@cam.ac.uk, CEB and Institute for Manufacturing (IfM)

Cassi's background is in bioengineering and she is currently working on the development of the biological assay that the project will look to augment. She will contribute her expertise on the assay as well her knowledge of other colorimetric biosensors. She has also previously worked in medical device product development, so she brings skills in device requirement specification and project planning to support the project.

Summary

This project will aim to develop a low-cost colorimeter to detect colour changes in medical diagnostic assays, such as those for infectious diseases. The system will be intended for use in resource poor settings with the aim of improving diagnostic accuracy and sensitivity by removing user subjectivity from the interpretation of the test result. The system will be open-source and take a range of sample types to allow it to be easily adaptable to a large variety of colorimetric diagnostic assays.

Proposal

The Problem

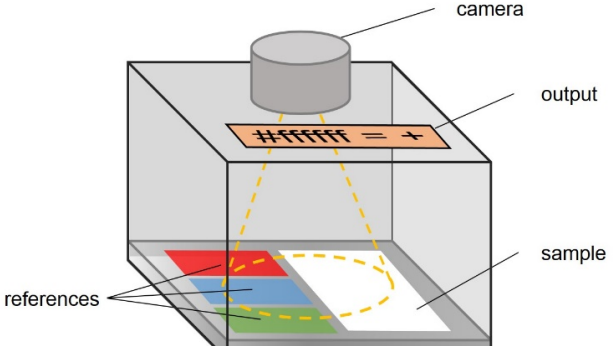
Many diagnostic tests rely on the colour change of a sample to determine if a patient has a specific condition or disease. Often these colour changes are subtle, such as red to pink, and perception of a change is conditional on the subjectivity of the tester. These subtle colour changes are also a limitation in the sensitivity of colorimetric assays. These challenges are especially relevant in the case of resource limited settings, where laboratory facilities and trained personnel are in short supply and colorimetric assays are preferred for their ease of use. If it were possible to reliably generate a code to represent colour, such as a hex, this element of doubt would be removed and diagnostic accuracy and sensitivity would increase.

Biological Systems

Colour changes are used across the spectrum of biological systems used in diagnostic assays. The project will initially work with an assay being developed in the Cambridge Analytical Biosensors (CAB) lab that uses a pH sensitive dye to detect the production of double-stranded DNA for the detection of pathogenic leptospirosis. (Leptospirosis is a bacterial disease that is prevalent in low and middle income countries). In the future, the system could be adapted to work with other colorimetric biological assays, such as immunoassays with dye-labelled antibodies or enzymes that convert substrates into colour-producing products. Other assays are currently in development in the CAB lab on which the system could be trialled, time permitting.

Design Goals

- The system should reliably produce a colour code for a range of biological samples that:
  - Allows for differentiation between samples, e.g. positive/negative
  - Remove subjectivity from interpretation
- To be applicable for use in a resource limited setting the system would need to be simple to print/produce, low-cost and run on battery power.



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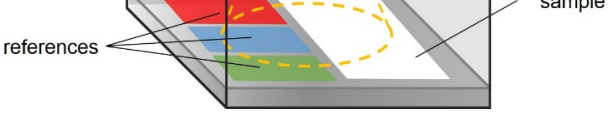

Plan to Implement the Project

		Jul Aug Sep Oct
1	Design basic hardware, i.e. housing, define focal length, define sample input (vial, slide etc.)	
2	Determine hardware optics - custom or smartphone	
3	Develop code/software by generating hex codes from established references	
4	Extend code/software to generate hex codes for unknown colours through reference comparison	
5	Test hex code generation on biological samples and correlate generated hex codes to positive/negative samples	

Proposed Outcomes and Benefits

Outcomes:

- Functional prototype
- Tested on leptospirosis biosensor system
- Validation of concept for reliable colour change spotting

Benefits:

- Improved diagnostic accuracy/ sensitivity
- Faster biosensor development – less resource required to develop a completely subjectivity independent sensor

Estimated Components

The majority of primary components are included in the Biomaker Starter Kit. Other initial components are:

- Raspberry Pi RS Stock No. 896-8660 £32.99
  - Power supply RS Stock No. 909-8126 £6.50
  - V2 Camera Module RS Stock No.913-2664 £20.99
- White light source (LEDs) RS Stock No.713-3955 £2.58
- Materials for housing: 3D printed (PLA) OR other plastic sheeting ~£50
- Biological consumables, e.g. nucleotides, enzymes, dyes (pH sensitive) ~£100
- Miscellaneous
  - Colour References RAL K7 colour fan deck, or similar £15
  - Sample loading elements Screws, metal sliders ~£30

EST. TOTAL: £258.06