Using the Raspberry Pi for ECL Reaction Excitation, Detection, and Analysis

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Introduction

During electrochemiluminescent (ECL) reactions, light is emitted from chemical reactants when excited by an electric current.

A system able to capture and analyze these reactions would have useful applications for educational and medical environments.

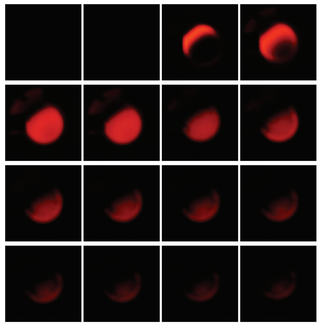

Figure 1: ECL reaction over time

ECL Reaction Analysis

Certain ECL reactant concentration can be determined by analyzing the emitted light intensity over time (figure 3).

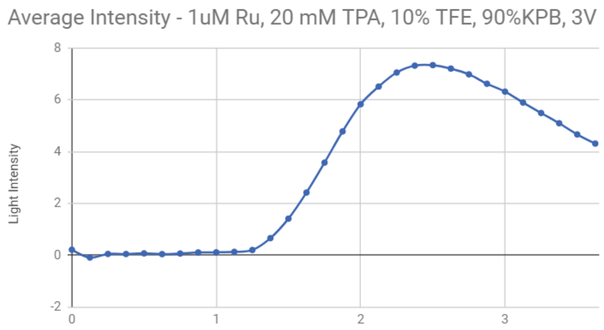

Figure 2: ECL intensity plotted over time under title conditions

Analysis Algorithm:

- Add pixel intensities
- Check if pixel is ambient light
- Subtract ambient light intensity from total light intensity
- Determine per-pixel color intensity averages

```
[xs, ys] = analysis_image.size
total_pixels = xs * ys
total_r = total_g = total_b = black_pixels \
    = black_r = black_g = black_b = 0

for x in range(0, xs):
    for y in range(0, ys):
        [r, g, b] = img[x, y][0:3]
        if (r + g + b) <= self.black_threshold:
            black_pixels += 1
            black_r += r
            black_g += g
            black_b += b
        total_r += r
        total_g += g
        total_b += b

avg_r = total_r / total_pixels
avg_g = total_g / total_pixels
avg_b = total_b / total_pixels
avg_black_r = (total_r - black_r)/(total_pixels - black_pixels)
avg_black_g = (total_g - black_g)/(total_pixels - black_pixels)
avg_black_b = (total_b - black_b)/(total_pixels - black_pixels)
```

Figure 3: Simple image analysis algorithm

The Raspberry Pi

The Raspberry Pi (figure 1) is a small, cost-efficient, easy-to-use, and readily available device. These qualities make it ideal for use in the taking and analysis of ECL images.

The following further make the Raspberry Pi ideal for use in a wide variety of physical environments:

- Detachable Touchscreen
- Energy Efficient
- Debian Environment Allows for Customizability
- Python Programs Allow for Automation of Tasks

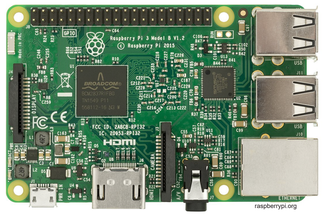

Figure 4: The Raspberry Pi

Applications of the Raspberry Pi ECL Device

Medical Applications:

- Potential to replace clunky and expensive mass spectrometry machines (figure 5)
- Diagnosis of disease and illness based on presence of biomarkers

Figure 5: Mass Spectrometry Machine

Educational Applications

- Provide students with a cost-efficient tool for use in laboratories
- Learn about ECL reactions and their applications
- Learn about image analysis techniques and applications

Future Developments

All-Inclusive Case

A case for the Raspberry Pi which contains an attached touchscreen, camera, and electrode housing is currently being developed (figure 6). This case, also capable of powering ECL reactions, will further increase the ease of use, convenience, and accessibility of the Raspberry Pi as an ECL analysis device.

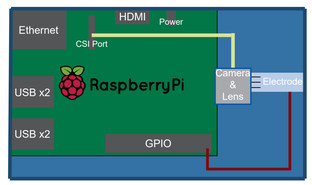

Figure 6: Potential internal layout of all-inclusive Raspberry Pi case

Machine Learning

Training a machine learning algorithm to determine ECL reactant concentrations based on color intensity information will allow for the concentration analysis of detectable substances without the need to perform numerous experiments for every such substance.

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