Detailed Project Proposal

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Defining your Project

1.1 Project title

Help: *a brief statement about what you are actually going to do.*

Automated Microscopy Cell Counting using Neural Networks

1.2 Background

Help: *Provide the background to your project. This section should highlight the main topics in the area you are going to research. Essentially what is the project about, what has been done before and why is this project important? ~500 words*

Cyanobacteria are a contaminant in water which present a risk to health. They form trichomes—chains of filamentous cells whose count can be used as a measure of water quality. Presently the task of counting such cells on a micrograph can only reliably be done manually. Existing work has attempted to solve the problem of enumerating cells automatically [1], including those of cyanobacteria[2], but a novel approach has been investigated within the University which uses neural networks to transform micrographs into computer-interpretable, 'binary' images by semantic segmentation. In these images unnecessary details are removed and only individual cells are illustrated. These images are then subject to a subsequent process which counts the 'cells'. There is significant scope to build on this work and implement an artifact to contribute to a complete solution to the problem.

The project has broad and deep implications as described in 1.3.

[1] Xie, W et al. (2016). Microscopy cell counting and detection with fully convolutional regression networks. Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization. 1-10. 10.1080/21681163.2016.1149104.

[2] Baek, S et al. (2020). Identification and enumeration of cyanobacteria species using a deep neural network. Ecological Indicators. 115. 106395. 10.1016/j.ecolind.2020.106395.

1.3 Motivation

Help: *To whom is this project important? A project must address a question/problem that generates a small piece of new knowledge/solution. This new knowledge/solution must be important to a named group or to a specific client (such as a company, an academic audience, policy makers, people with disabilities) to make it worthwhile carrying out. This is the* ***motivation*** *for your project. In this section you should address who will benefit from your findings and how they will benefit. ~300 words*

Example 1: If you intend to demonstrate that a mobile application that automates class registers at RGU will be more efficient than paper-based registers - the group who would be interested in knowing/applying these findings would be both academic and administrative staff at RGU and they would benefit by time saved and a reduction in their administrative workload.

Example 2: You are demonstrating that a particular 3D model design increases realism in 3D environments. The group that would be interested would be games designers or developers of 3D virtual environment applications. The would benefit from producing more realistic environments that could increase sales of their products.

Example 3: You have designed a new network topology for IrishOil plc's new Aberdeen headquarters. The interested group would clearly be IrishOil. They would benefit from easier maintenance and improved security of their computer network.

An automated method of counting cyanobacteria in water samples would be of interest both to experts in the microbiology domain and the public at large. Such an automatic cell counter would replace a domain expert who would otherwise have to perform a time-consuming menial task, freeing their time for work more befitting of their expertise. It would also eliminate human error and, if it achieved a greater-than-human level of accuracy, could be a vehicle to improved water quality and a lower incidence of health effects from cyanobacteria. It could form the basis for a product deployable in areas with limited access to clean water, allowing water testing by non-expert users.

1.4 Aim & Objectives

Help: *Outline what are the main things your project is going to do and what steps or milestones will be used to achieve this aim. The Aim is unlikely to change throughout your project; however, the objectives are likely to adapt to your ongoing research and development. In particular it is highly likely that you may wish to split objectives into sub-objectives as work progresses. A good clear set of objectives give you something to evaluate your final project against.*

Example : For the timetable app outlined above
Aim: To create a functioning attendance application that efficiently automates the taking of class registers.
Objective 1: study existing register system in place at RGU and identify weaknesses
Objective 2: research existing automation technology's and identify and evaluate those that may be appropriate to taking in class registers
Objective 3: Implement chosen technologies to create prototype application
Objective 4: Conduct user trials to evaluate capabilities of prototype application
Objective 5: Create a refined application incorporating feedback from user trials

The project aim is to implement a machine learning model to form part of a complete cell-counting solution. This might take the form of one or more of the following:

- A model to transform micrographs featuring cyanobacteria into more interpretable, 'binary' images for use in a subsequent counting process.
- A model to count cyanobacteria cells, in such 'binary' images or otherwise.

The project can be broken down into several milestones:

- Evaluate the existing methodology
- Review and synthesise existing literature and identify an appropriate approach to the problem
- Develop a machine learning model to act as part of an automatic cell counter
- Evaluate the model and refine it iteratively

1.5 Key Techniques

Help: *Perform some initial research into the area and outline what techniques you my research in further detail here. The techniques you cover here should include references to the papers where you have sourced the information. The techniques mentioned here are very likely to become the section headers in your literature review.*

Techniques to research include:

- Object counting
    - Detection-based
    - Density map-based
- Computer vision & image processing (e.g. OpenCV)
    - CNNs
- Neural style transfer
    - GANs (e.g. pix2pix)
- Evaluation of machine learning models

1.6 Legal, Social, Ethical, Professional and Security issues

Help: *Here you should discuss any legal, social, profession and security issues that you believe may occur during the course of your project. It is not acceptable to write none in this box, all projects, regardless of focus will have to address issues in one, or more, of these categories. This is an extremely important part of your honours project to which there is no correct answer, this section must be fully discussed with your Honours Supervisor.*

Example 1 : In the class register example above – there would be a Legal and Security issue with the gathering and storage of student data. There may be a social constraint as you may be relying on a user to have access to a specific technology. There will need to be consideration of user accessibility.

Example 2 : A 3D model design may have ethical considerations in its evaluation. What if your model made users feel nauseous. Social constrains may again be access to technology or accessibility issues.

Example 3 : You network design need to adhere to specific company policies. You would need to consider the possibility that your design could be wrong, compromising the company's security.

The project will exclusively make use of a dataset originating from the University. The data is not sensitive and there are no data-protection concerns. In the event that user evaluation takes place, the resulting data will not be attributable to any individual. Any research participants must be able to give informed consent.

1.7 Project Plan

Help: *This is the project plan as to how you will go about achieving the objectives of the project.*

Example: In the class register example above the research plan may involve:
Collecting and analysing paper-based registers in a given class on five occasions.
Identifying the error rate average on these occasions
Researching existing automation techniques
Designing and implementing a mobile application that automatically records attendance in class.
Deploying the application in the class on five occasions.
Identifying the error rate average of the mobile application on these occasions.
Comparison of data and summary of findings.

The project output will comprise the following milestones:

1. Nov 2021: Research existing methodology in automated object counting and neural image processing
2. Dec 2021: Define the project's requirements
3. Jan 2022: Produce a proof-of-concept machine learning model to contribute towards an automatic cell counter
4. Feb 2022: Prepare a ten-minute demonstration and accompanying poster to illustrate the project
5. Mar 2022: Submit a final Project Report (15,000 words maximum) describing the project with all necessary appendices

1.8 Ethics Form

You must include in your signed ethics form in this submission or you will not be able to continue the project.