Automated Biological Image Analysis using Computer Vision and Machine Learning

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What is our project about?

This project aims to develop a robust system for automatically analyzing images in order to detect, classify and catalog the biological specimens visible in the image.
In order to study how the environment affects the lifespan of *C. elegans*, people have to detect and count the number of adult worms, larvae and eggs.

**Why does our project matter?**

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Why does our project matter?

How about this one?
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Why does our project matter? and this one?
In one word, the above examples show that manual observation is very tedious and time-consuming.

This is our motivation to develop some automation.
C. elegans detection and counting

- modify low-cost hardware for automatically scanning and acquiring images;
- develop an annotating interface to collect data;
- build a machine learning architecture to learn the worm detector;
- design a C. elegans detection and counting system.

What do we contribute?
Why is it important to study *C. elegans*?

- *C. elegans* has emerged as a key model system for studying the biological processes that affect aging and animal lifespan.

- High-throughput tracking of worm health and lifespan in large populations is difficult, especially in natural conditions where worms continue to reproduce.
An Epson V700 Perfection Photo Scanner was modified in accordance to the procedures by Stroustrup et al.

- Low-cost solution
- High-throughput method
- Very modular and expandable
- 6400 dpi Maximum
- Maximum Scan Area: 8.5" x 11.7"

Hardware Modifications

- The position of the scanner lens was modified to optimize the quality of the images
• Adjusting the focus involved opening the scanner and manually moving the lens in the head unit the desired focus was achieved.
Hardware Modifications

- The scanner was modified to accommodate fans for temperature regulation.
Goal of Automation

- **What:** Each of the 9 plates
- **When:** Twice every hour
- **Where:** Web server
Environment

- Scientific Linux 7 Operating System
Software Environment

What

• Script: scanimage_custom.sh
Software Environment

When

- Scheduler: crontab.asc
Software Environment

Where

- Symbolic Link + Mount
Can we detect and segment the worms?
Our tool is deep learning --

Deep learning was ranked the first in ten breakthrough technologies 2013 by *MIT Technology Review*.

figure from "ImageNet Classification with Deep Convolutional Neural Networks", NIPS, 2012.
We develop a semi-automatic interface to collect worm data. After getting the training set, we can train our model.
With the trained model, we can segment the worms.
Let's zoom in to have a look at it...

Two interesting observations:

1. Even though many larvae are not annotated in the training images, the model can find them.

2. Even though the annotated worms consist of line segments, meaning there are sharp angles between two consecutive segments, the segmented worms are smooth.
• detect every single worm appearing in the image

• a deformable part based chain model to detect worms
Result

- count the number of larvae and adult worms
- obtain their aging stage distribution according to their body length
Thank you!