Design Assignment

Senior Design 491: Soybean Parasitic Cyst Detector

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Problem Statement

- Develop a deep learning algorithm designed for small object detection to determine how many parasitic cysts are on the roots of soybean plants.
- Will also create a device to integrate image capturing with the machine learning algorithm.
- Increases productivity in farms.
- Reduces the amount of unnecessary pesticides.
- Helps farmers accurately fertilize their crops.

Design Context

- Project designed for famers
- Why are soybeans important?
  - Human and animal food source
  - Household products
  - Fuel
  - Reduces Carbon Emissions
- Our project increases production of soybeans and productivity on the farm

Prior Work/Solutions

- Sifting cysts off the roots and manually counting
- Small object detection algorithms

Faster R-CNN	You Only Look Once (YOLO)	Single Shot Detector (SSD)
Uses Region Proposal Network to generate regions containing objects for classification.	Uses Anchor Boxes to generate regions containing objects for classification.	Uses Anchor Box Pyramids to generate regions containing objects for classification.
Uses Convolutional Neural Network to classify objects.	Uses Convolutional Neural Network to classify objects.	Uses Convolutional Neural Network to classify objects.
Algorithm Training takes a considerable amount of time.	Algorithm Training takes a moderate amount of time.	Algorithm Training takes a moderate amount of time.
73% mean Average Precision (mAP)	50-65% mean Average Precision (mAP)	75% mean Average Precision (mAP)
Capable of handling high resolution images.	Capable of handling high resolution images.	Capable of handling high resolution images.

Technical Complexity

- Project requires a knowledge or ability to learn:
  - Knowledge of machine learning and neural network principles
  - Learning about small object detection algorithms
  - Ability to implement a small object detection algorithm
  - Integrate algorithm on a hardware device
  - Creation of image capturing device that uses a raspberry pi, cameras, motors, grabber tool, and colorized platform for image capturing
  - Labeling data sets

Design Exploration

- Conducted exhaustive group research on each algorithm.
- Process was iterative exploration of algorithms achieving more depth with each iteration.
- Using factual information, held group discussion discussing pros and cons of each algorithm.
- This discussion led to unanimous agreement on using Faster R-CNN algorithm.

Design Exploration

Method	mAP	FPS	batch size	# Boxes	Input resolution
Faster R-CNN (VGG16)	73.2	7	1	~ 6000	$\sim 1000 \times 600$
Fast YOLO	52.7	155	1	98	448×448
YOLO (VGG16)	66.4	21	1	98	448×448
SSD300	74.3	46	1	8732	300×300
SSD512	76.8	19	1	24564	512×512
SSD300	74.3	59	8	8732	300×300
SSD512	76.8	22	8	24564	512×512

Figure depicting accuracy (mAP) and speed (FPS) of the algorithms considered.

Considered 3 high performing object detection algorithms:

- Faster R-CNN
- You Only Look Once (YOLO)
- Single Shot Detector (SDD)

Points of interest for the algorithms:

- Classification accuracy
- Algorithm Speed
- Training time
- Region of interest generation
- Small object detection optimization

Proposed Design

Software: Task 1
(Develop a Machine Learning Model)

- Researched different algorithms and machine learning principles
- Found implemented Faster R-CNN algorithms on Github
- In the process of finding one implementation that works on our computers

Hardware: Task 2
(Develop a Prototype of a Soybean Scanner)

- Created conceptual sketches of scanner

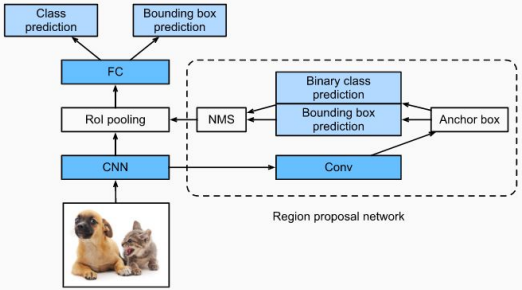


Fig. 14.8.4 The faster R-CNN model.

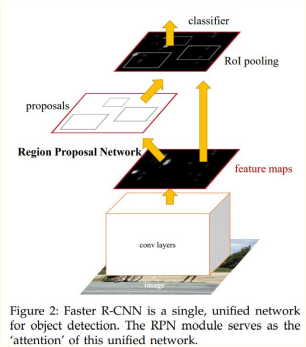
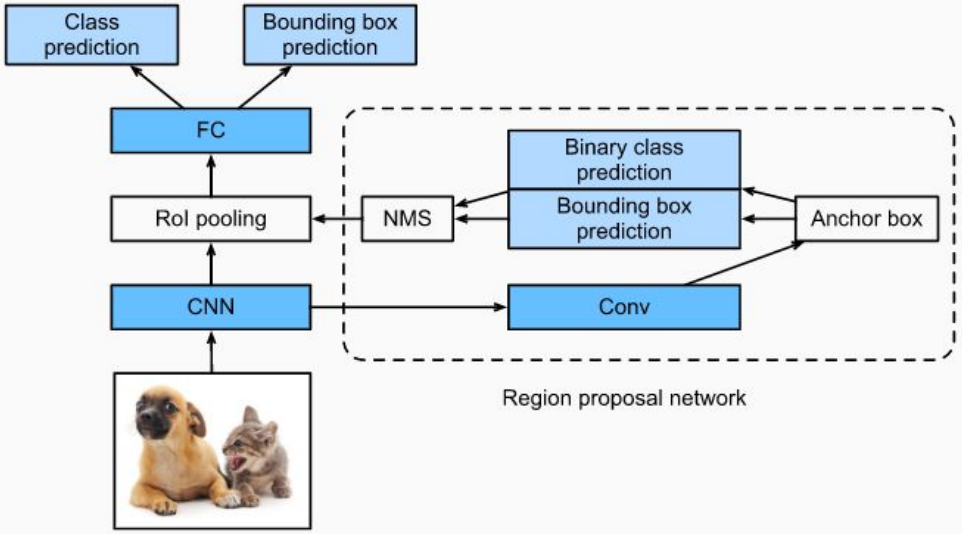


Figure 2: Faster R-CNN is a single, unified network for object detection. The RPN module serves as the 'attention' of this unified network.

Proposed Design



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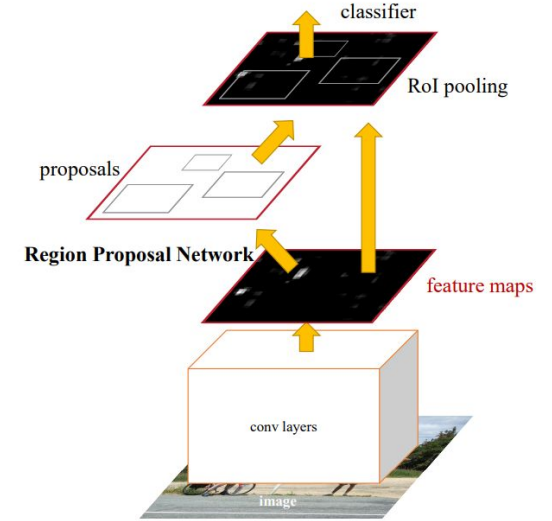

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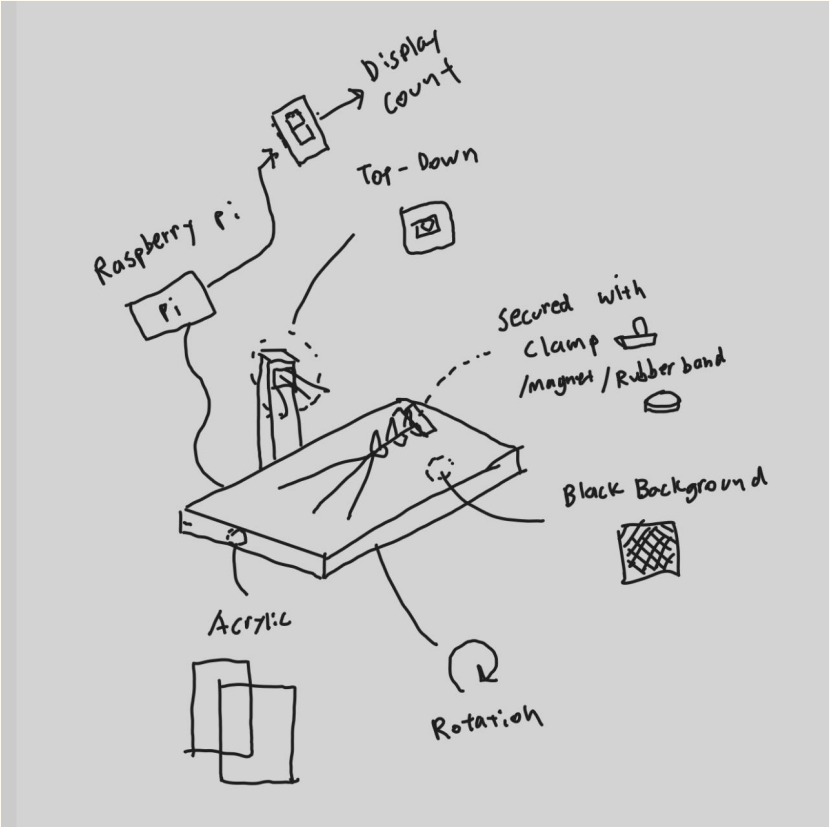


Camera is positioned for a top-down perspective of the soybean plant

The soybean is positioned on a **black background** so there is more contrast in the image.

The soybean is **secured** with a clamp/clip, magnets, or rubber bands in between two pieces of **acrylic** so there is **no harm** to the plant.

The **camera** takes pictures of the soybean roots and the user **flips** over the acrylic so the camera has a **front and back view** of the plant.

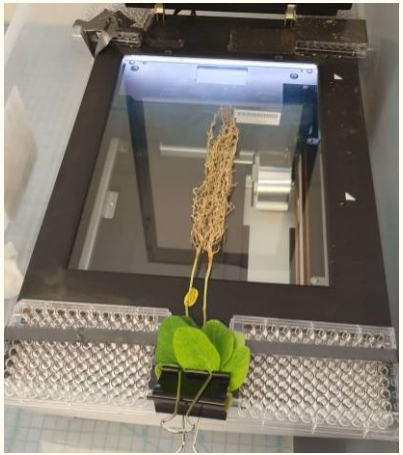
The images are processed on a **raspberry pi** which will have our machine learning model. The user is then given an estimate **count** of how many cysts are on the root of the soybean.

Design Analysis- Functionality

Get a general idea of the amount of pesticides are needed to treat the soybeans.

The soybeans would be planted and a few would be taken out of the ground between 2-5 weeks old. The user would be able to test how many soybean cyst nematodes are on the roots of the plant and then put the soybean back in the ground with no damage.

increases productivity in soybean production and reduces unnecessary pesticides



Design Analysis- Areas of Concern and Development

- Price: Keeping this device under the $500 limit
  - Resolution
- Time

> increase the upper limit of the device

> limiting the number of cameras we plan on using

> look on open software platforms to find an implemented machine learning model

> hardware design that prioritizes simplicity

Questions?