AI For Behavioral Discovery

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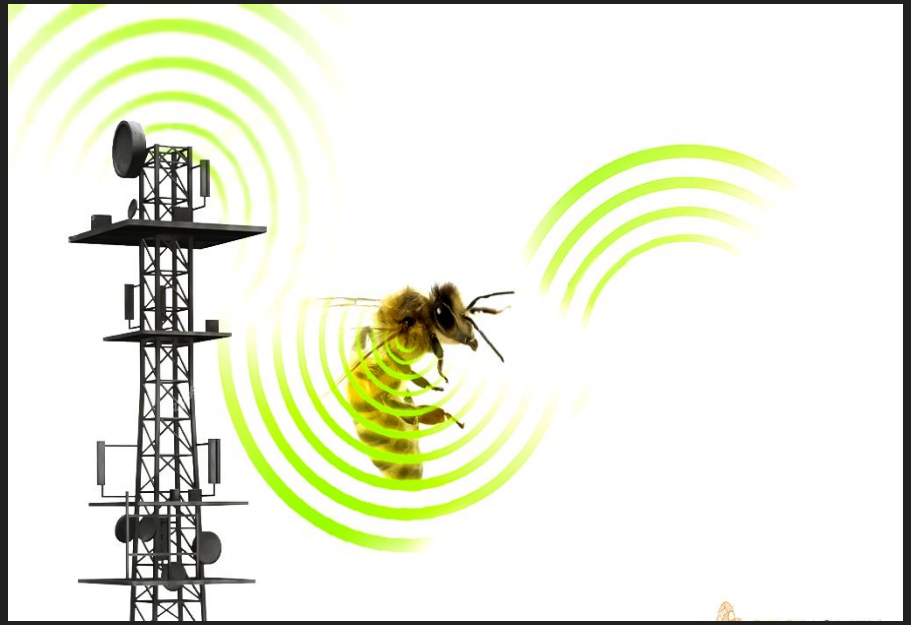
Motivation

Can machine learning learn the behavioral effects of EMF radiation on biological systems?



Machine Learning

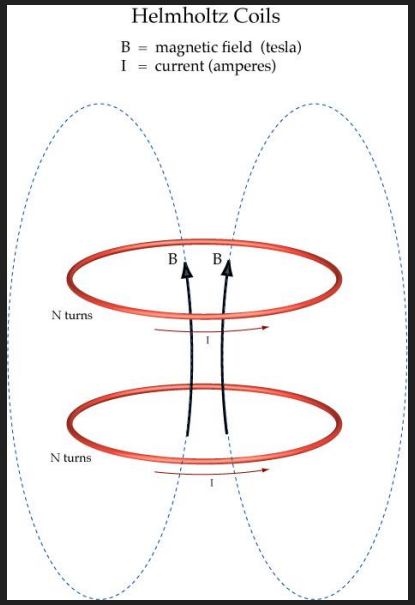
- Models are trained to identify complex patterns that humans can not easily recognize
- Highly scalable
- Shortcut Learning
  - Models learn the easiest feature (covariates)
- Noise Reduction
  - Uncontrollable features (typically unrelated)

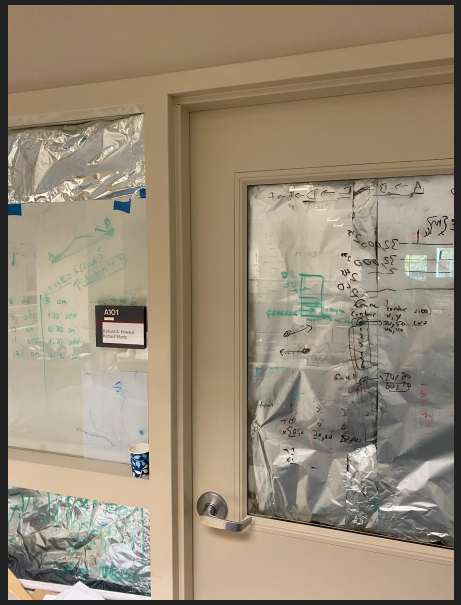
Our Approach

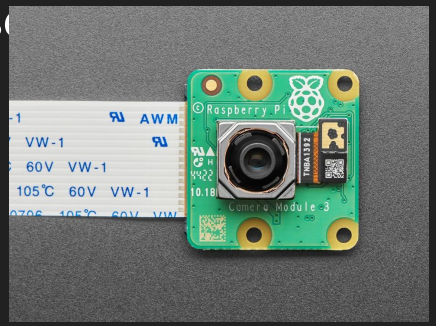
- Use simulation data to diagnose behaviors
- Camera recording data
- Using real video data starting with bees and ants
- Deep Neural Network to determine field presence
- Understand role of electromagnetic stimuli on multiple species

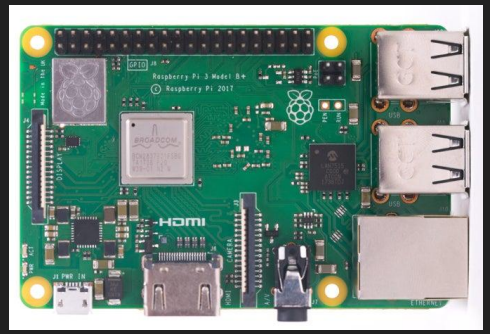
Experimental Setup

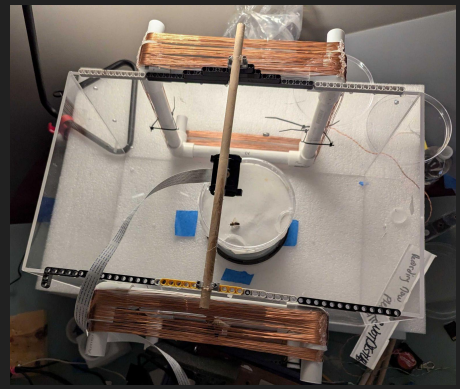
- Copper Helmholtz coils -> Uniform field
- Petri dish to hold insects
- Sealed off light cavities to reduce noise
- Raspberry Pi + Overhead camera





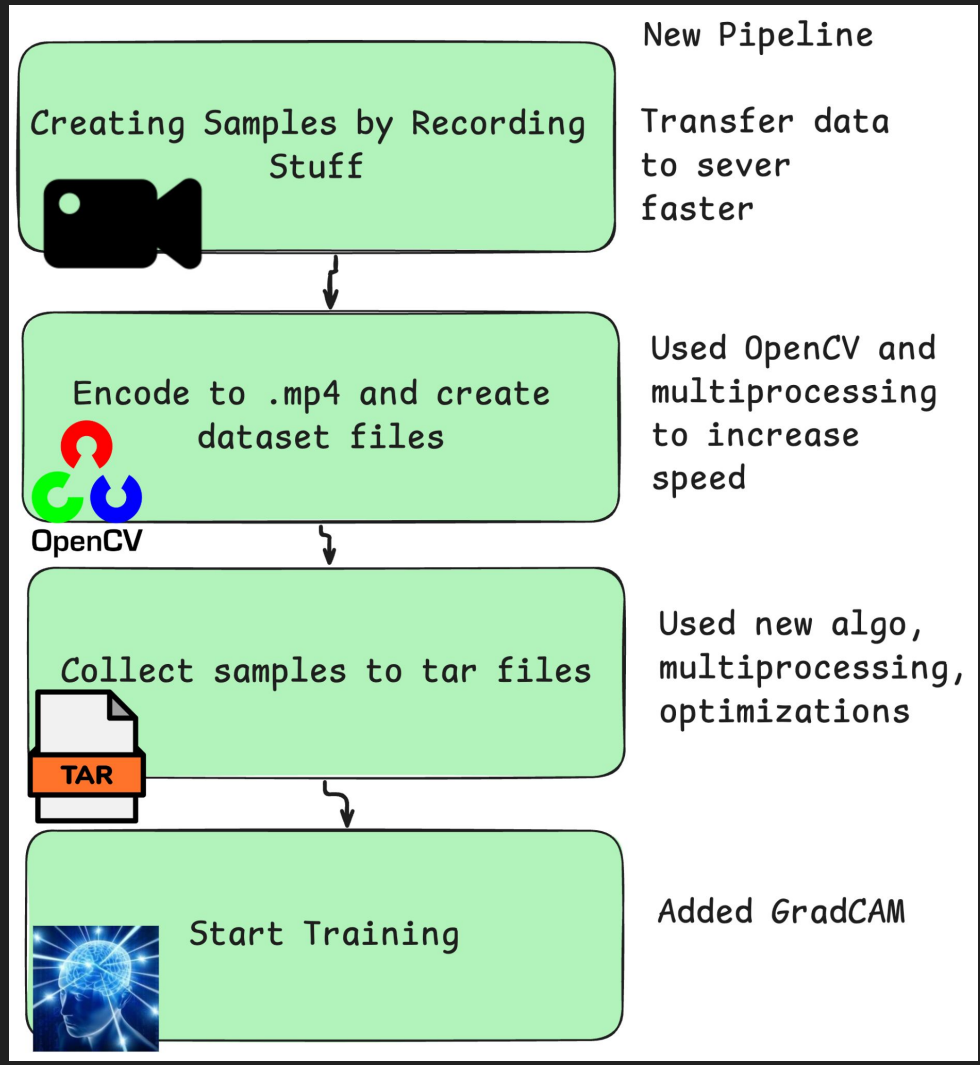






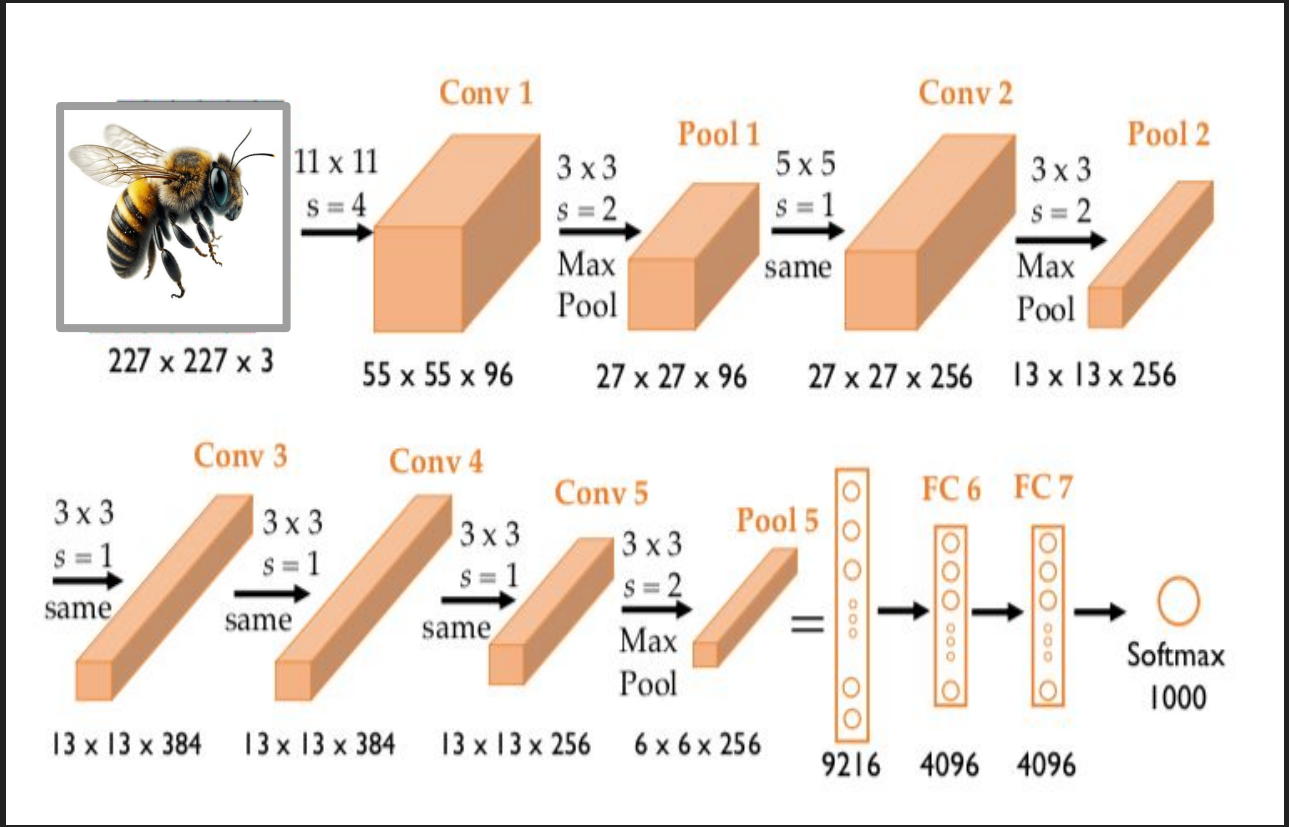
Software Pipeline

- Shell scripts
- Slurm to run scripts.
  - Access to GPUs
  - Unreliable
- K-Fold Cross Validation
  - Removes potential biases
- Finished new pipeline -> shorter execution times (multiprocessing)



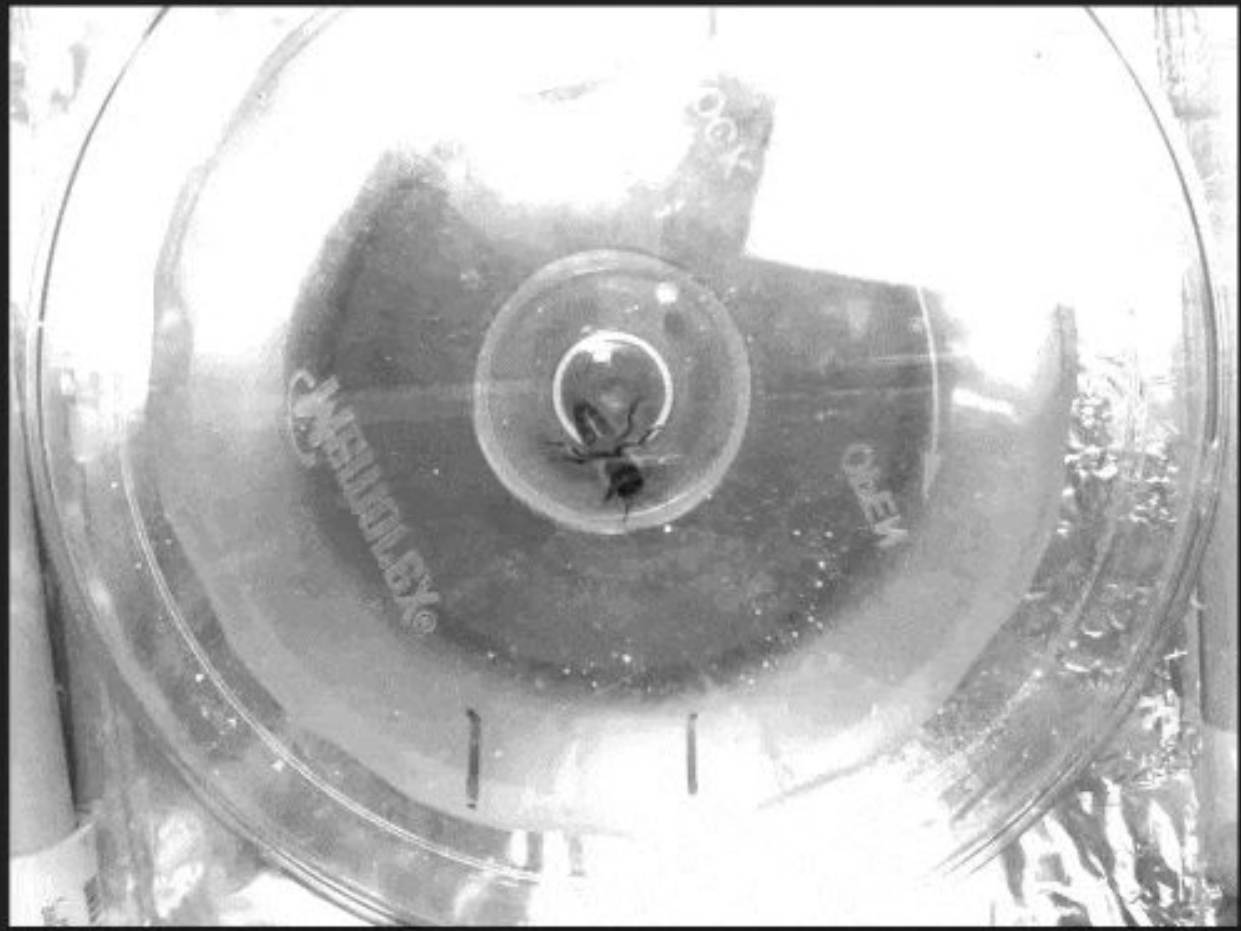
Model Architecture

- Used CNN (Alexnet); along with other architectures
- Multiple frames per sample -> added as channel dimension.



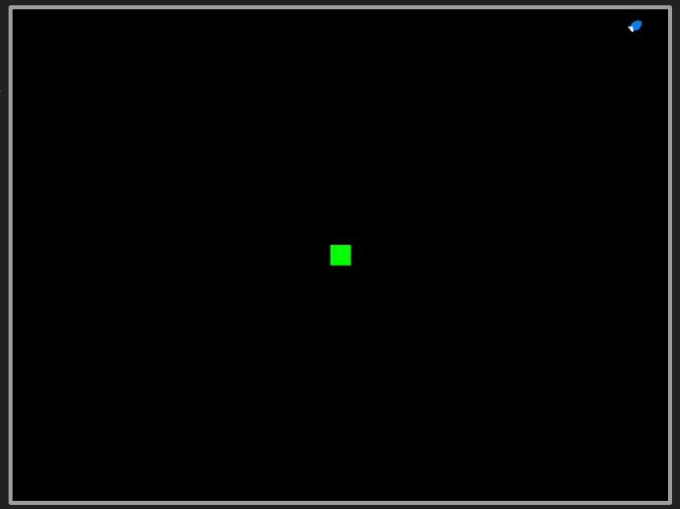
Grad-CAM plots

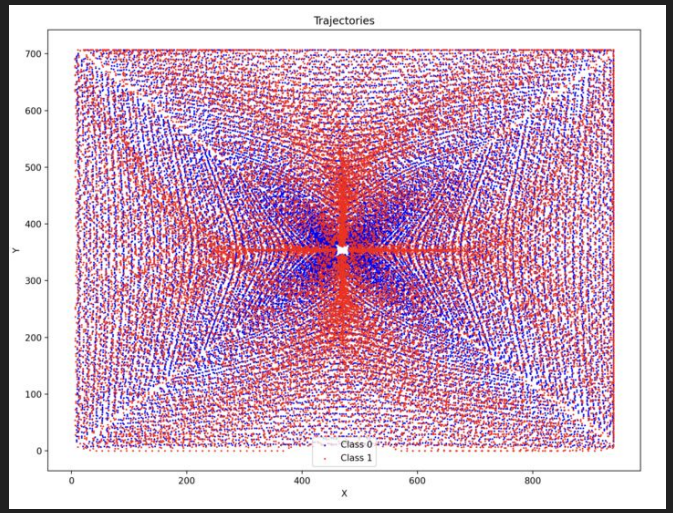
- Model Visualization tool
- Highlights regions that the model uses to learn
- Similar to heatmap
  - Blue - low significance
  - Red - high significance



Simulated Data

- 2 possible states: on/off
- Constant & normalized speed
- Varying features to increase data distribution
- 7 continuous frames per sample





Training Results

- Shortcut learning
- Attempted Naive Bayes Classification, collapsed

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Confusion Matrix:
[[    0 29587]
 [    0 36360]]
Accuracy: 55.14%
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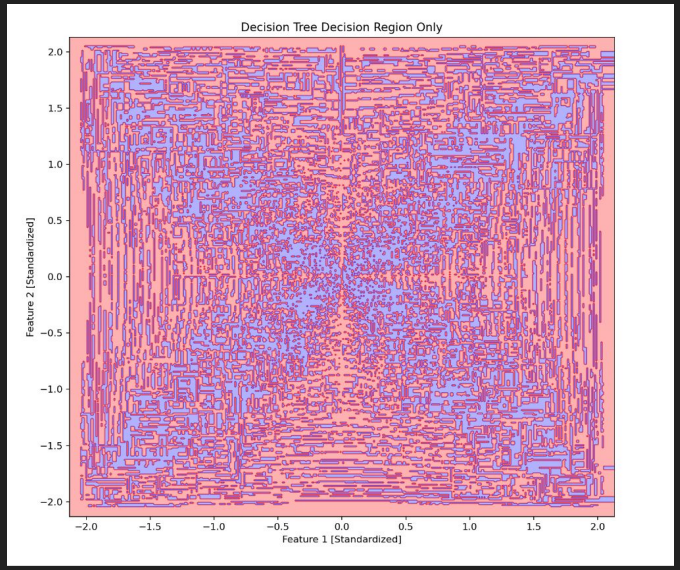
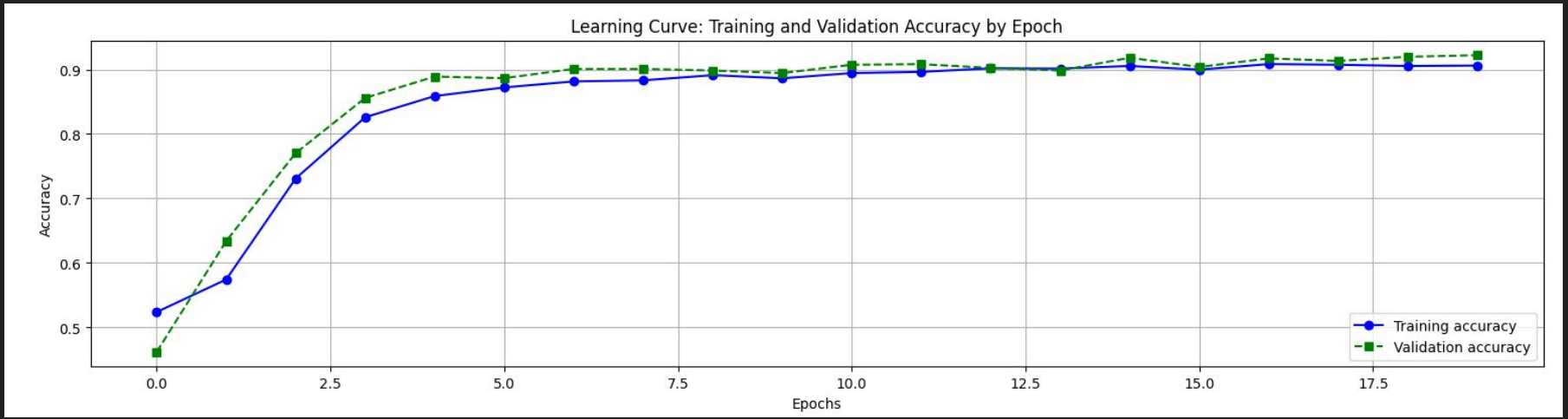
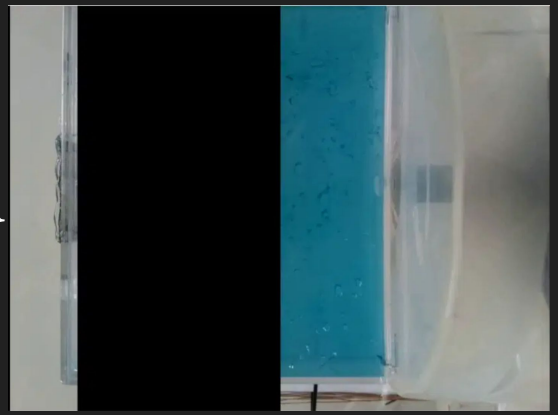




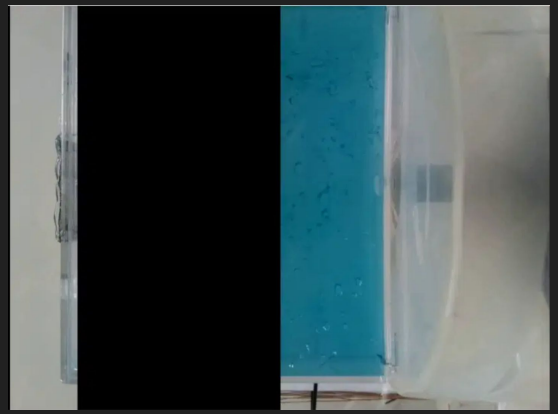
Real Data (Ants)

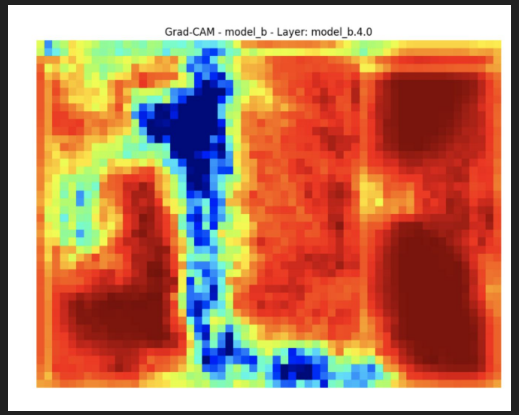
- Acrylic case filled with Ants and food-gel
- Unfamiliar environment
- Recorded camera data + trained on
  - Uncropped
  - No background
  - Control

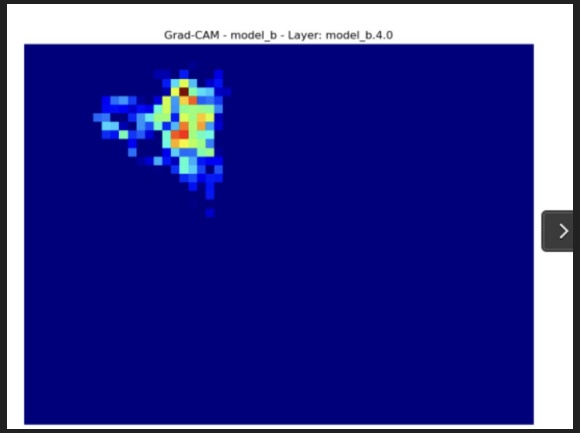


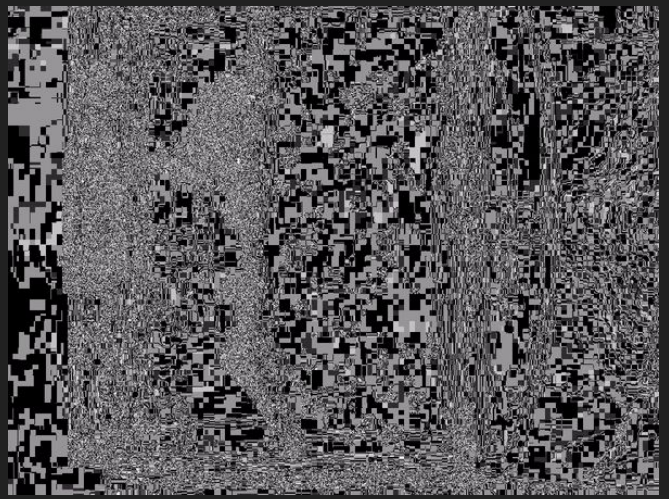
Training Results

- ~90% accuracy (Suspiciously high)
- Potential underlying issues
  - Lighting
  - Model not focusing on ants
- Addressing issues:
  - Background subtraction
  - Cropping
  - Grad-Cam analysis
  - Control Cropping



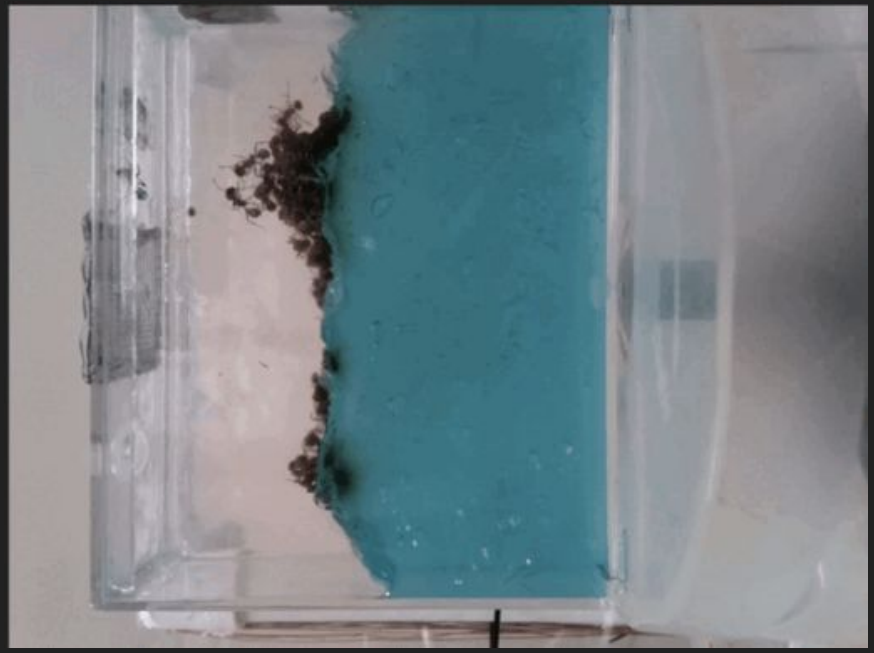






Conclusions + Realizations

- Promising results; further analysis is required
- Model is susceptible to shortcut learning
  - Easily affected by covariates
- Imperative that data is “clean”
  - Eliminate potential covariates
- Working with large data has limitations



```
Accuracy: 0.8441747572815534
Class 0 precision=0.9067617662240157, recall=0.7347528517110267
Class 1 precision=0.8451539428212378, recall=0.9157872340425532
Class 2 precision=0.7537437603993344, recall=0.94375
Evaluating model.
Evaluation confusion matrix:
label 0:[19318, 3702, 3280]
label 1:[1551, 21521, 428]
label 2:[434, 238, 11328]
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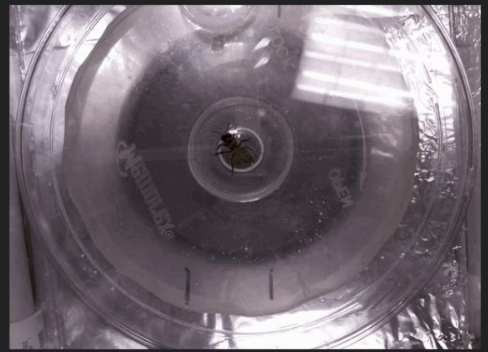
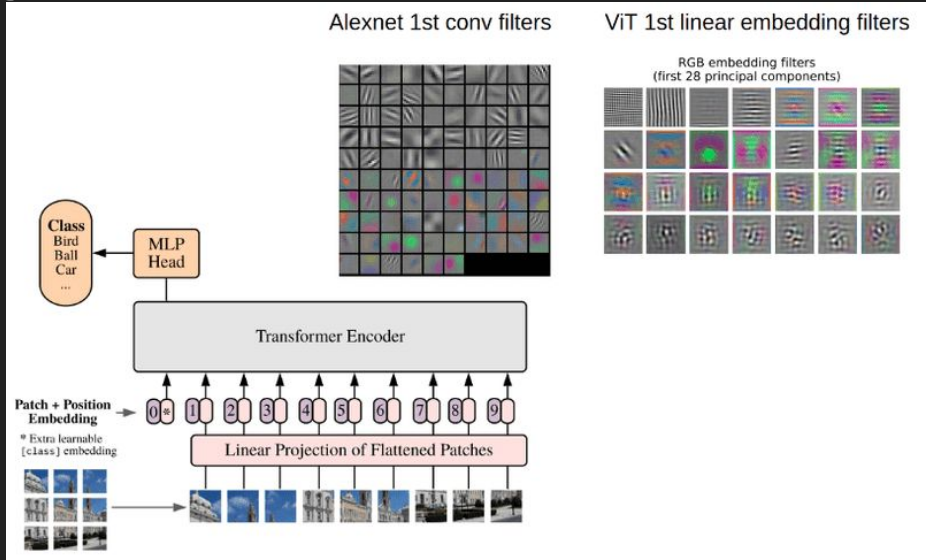


Future Work

- Reduce AI shortcut learning
  - Reduce noise
  - Make experimental setup closer to ‘ideal/perfect’ conditions
- Explore different models
  - Temporal capabilities



Thank you!

Any Questions?