Eggs By the Dozen

An Algorithmic Solution to Fast and Accurate Ruminant Fecal Parasite Detection

James Baker, Aiden Ha, Donghwa Shin, Tommy Williams, Eddie Xiao

University of Virginia ENGINEERING

Client Problem Definition

Problem Definition

- Susan Skalak of Ringadal Farm needs an efficient solution for monitoring parasites in her sheep, particularly barber pole worms.
- Relies on expensive veterinarian services with delays up to two weeks for results.

Background

- Traditional fecal examination methods are time-intensive and require specialized skills.
- Fecal egg counting methods include FLOTAC and McMaster, with FLOTAC showing superior performance (G.G. Alowanou et al., 2021; Bosco et al., 2014).
- FLOTAC offers higher accuracy but requires more complex procedures and equipment (Cringoli, G., 2004).

Contemporary Advances

- Automation in fecal egg counting aims to reduce manual labor, save time, and eliminate human error.
- Early automation efforts faced challenges in differentiating parasite eggs from fecal particles.

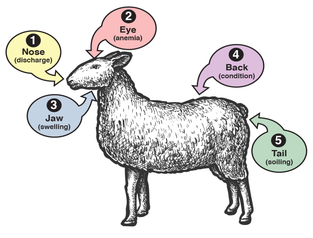

Figure 1:
Typical Signs of Parasite Infection

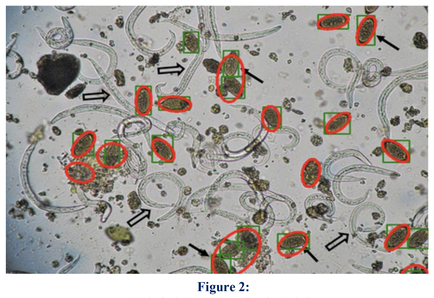

Figure 2:
Helminth Egg Detection in Debris

Methods and Approach to Design Process

Basic Solution Design Structure

- Generates a binary image based on an algorithmically optimized intensity threshold
- Extracts elliptical contours with features optimized to the general shape of fecal parasite eggs (Fig 3)

Quantifying Error

- Based on Shalak's criteria to minimize type 2 error, we derived the following error equation, using precision of correct guesses, false positives, and misses.

$$\text{Total Error} = \sum_{i=1}^{N} \begin{cases} \frac{1}{10} \cdot d_i & \text{if guess } i \text{ is correct} \\ 5 & \text{if guess } i \text{ is incorrect} \end{cases} + 20 \cdot P$$

where:

N is the total number of "observed: parasites.
d_i is the distance from the correct center for the i-th guess.
P is the number of undetected parasites.

Fine-Tuning the Thresholding Protocol

- The error function was used to experimentally improve the thresholding function using a testing method that searched for the optimal threshold parameter.

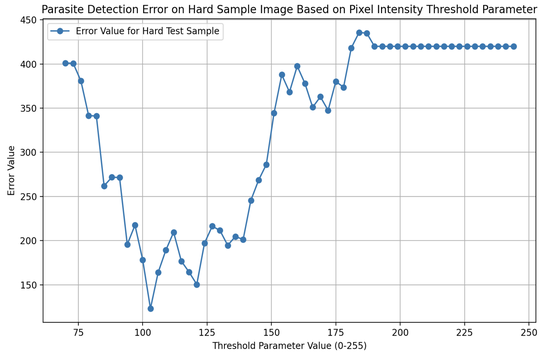

Figure 3:
Parasite Detection Error on Hard Sample Image Based on Pixel Intensity Threshold Parameter

Test Results and Conclusion

Our algorithm was tested on 4 infected samples and 1 healthy sample. There was an 18.3% average percent error in egg count, and the correct health condition was correctly identified in all five samples, speaking to the practical success of our algorithm. More testing is necessary, but our results are very optimistic.

Worm egg count	Comment	Action
50-350 eggs per gram	Light infestation	Treatment not necessary
400-600 eggs per gram	Moderate infestation	Anthelmintic treatment may be beneficial
650-1000+ eggs per gram	Heavy infestation	Anthelmintic treatment necessary

Table 1:
Worm Egg Count Per Gram Interpretation of Individual Samples

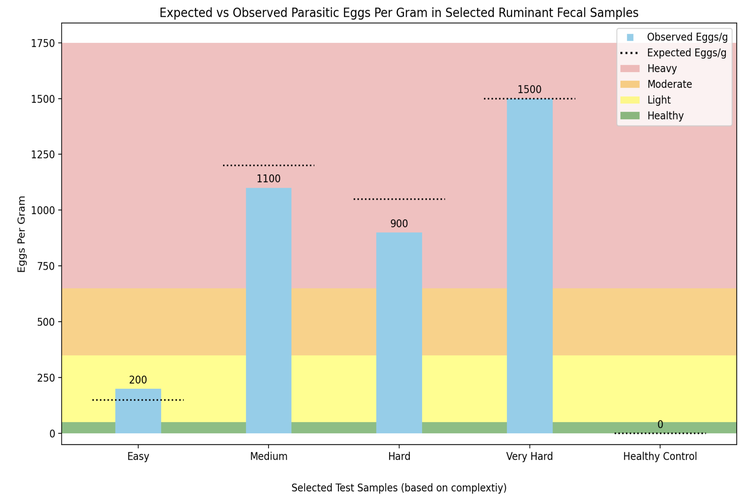

Figure 4:
Expected vs. Observed Parasitic Eggs Per Gram in Selected Ruminant Fecal Samples

Success Criteria & Limitations

Objective of the Team:

To create a reliable, accurate and cheap method to detect and count parasite eggs in fecal samples of goats and sheep, that specifically minimizes undetected, infected goats.

The success of the solution will be determined by:

1. Overall testing cost <$16 per test.
2. Timely and reliable results, faster than two weeks.
3. Be as or more accurate than the current parasite detection method.
4. Solution should have the capability to run natively.

(S. Skalak, personal communication, February 21, 2024)

Beta-Version Software Details

- Feature extraction algorithm leveraging OpenCV and a novel parameter optimization algorithm.
- Hosting on a live website at https://eggbydozen.adaptable.app

Success Metric Analysis

✔ $0 Cost Per Test and is accessible to anyone.
✔ Displays results in less than 10 seconds.
✔ Correctly diagnoses ruminant health condition (in terms of infestation severity) for all test samples.
✔ Web-Hosted and Native Application versions available.

Future Work

Next Steps

1. **More Data, More Testing:** The next logical step for our team is to apply our algorithm on a larger, real-world scale. This will certainly give us more insights, because data was a major setback in this project.
2. **Expand Parasite Detection:** Currently predominantly searching for barber worms (haemorcus contortus), the project can be expanding to search for features seen in other egg types
3. **Mobile Application Deployment:** Begin development of mobile application in order to improve user accessibility and marketability.

Citations:

Alowanou, G.G., Adenilé, A.D., et al. (2021). A comparison of Mini-FLOTAC and McMaster techniques in detecting gastrointestinal parasites in West Africa Dwarf sheep and goats and crossbreed rabbits. Journal of Applied Animal Research.
Bosco, A., Rinaldi, L., Maurelli, M., Musella, V., & others. (2014). The comparison of FLOTAC, FECPAK and McMaster techniques for nematode egg counts in cattle. Acta Parasitologica.
Cringoli, G. (2004). *FLOTAC, a novel apparatus for a multivalent faecal egg count technique.* Parassitologia, 46(4), 381-384.
Sustainable Control of Parasites in Sheep. (2022, September). Faecal Egg Count (FEC) monitoring. https://www.scops.org.uk/workspace/pdfs/2-7-2-faecal-egg-counts.pdf