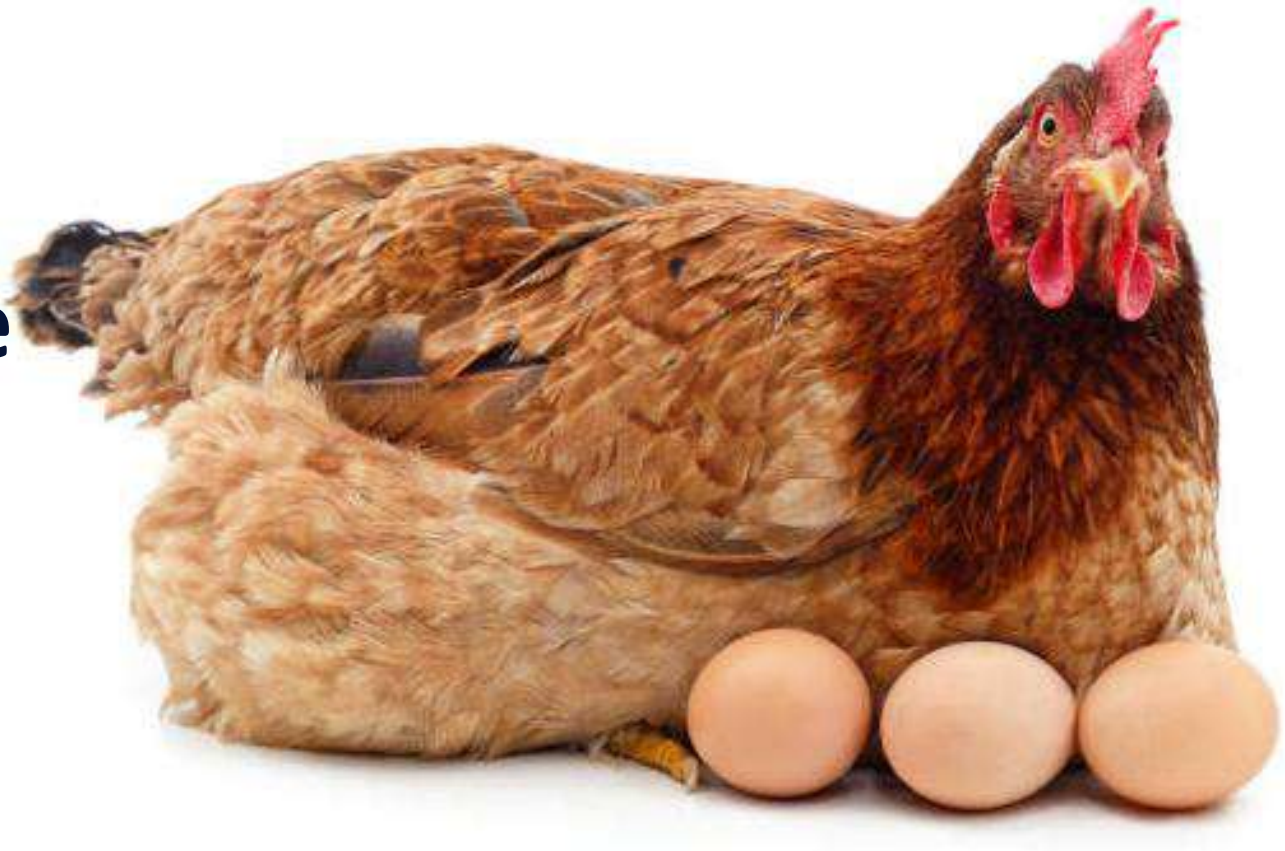
Newcastle University

AI-Powered Welfare Monitoring in Poultry Production



Enhancing Research and Farm Management

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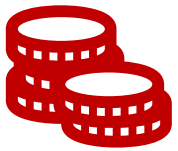
The Challenge: Poultry Welfare Monitoring

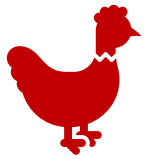
- Flock size & density
  - Up to 9 hens per m^3
- Limited ability to observe individuals
- Early welfare indicators difficult to detect
- Diverse environments
  - Housing Style/Layout
  - Access to outside
  - Enrichment
  - Individualised husbandry practices
- Require methods to improve visibility of potential problems
  - Early recognition
  - Longitudinal monitoring beyond manual ability
  - Resource Conscious
  - Adaptable

Why Piling?

Collection of densely packed birds in the shed or on the range.



Costs the egg industry approx. £6.5 million/year in deaths.



Can lead to sublethal impacts on health.

Responsible for ~20% deaths.

Reduces production (economic losses of £1,202.31 for flocks of 3,000 organic flock and £4,028.05 for 16,000 free-range flock)

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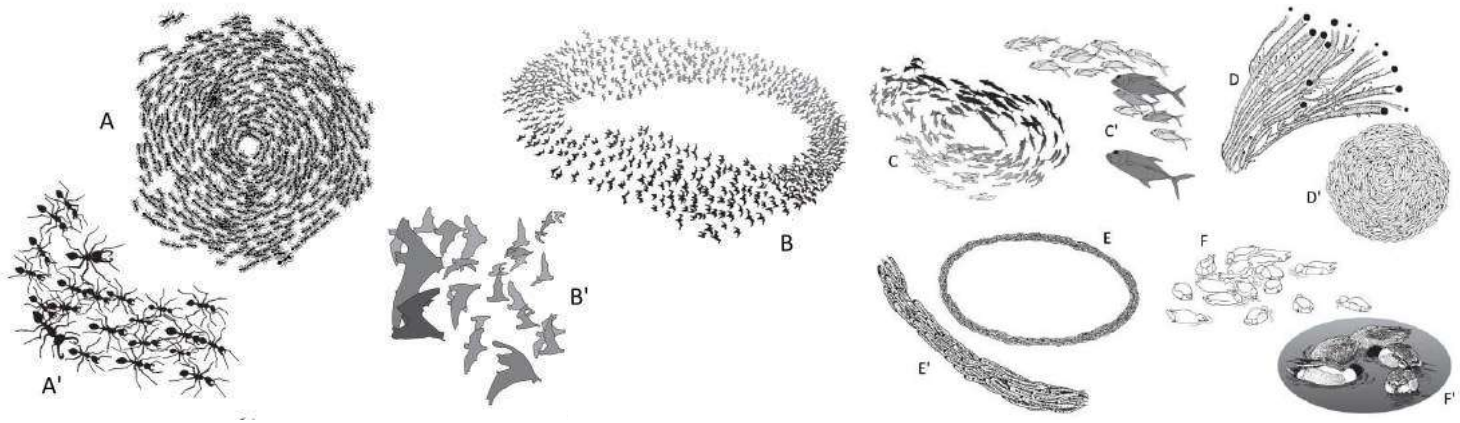
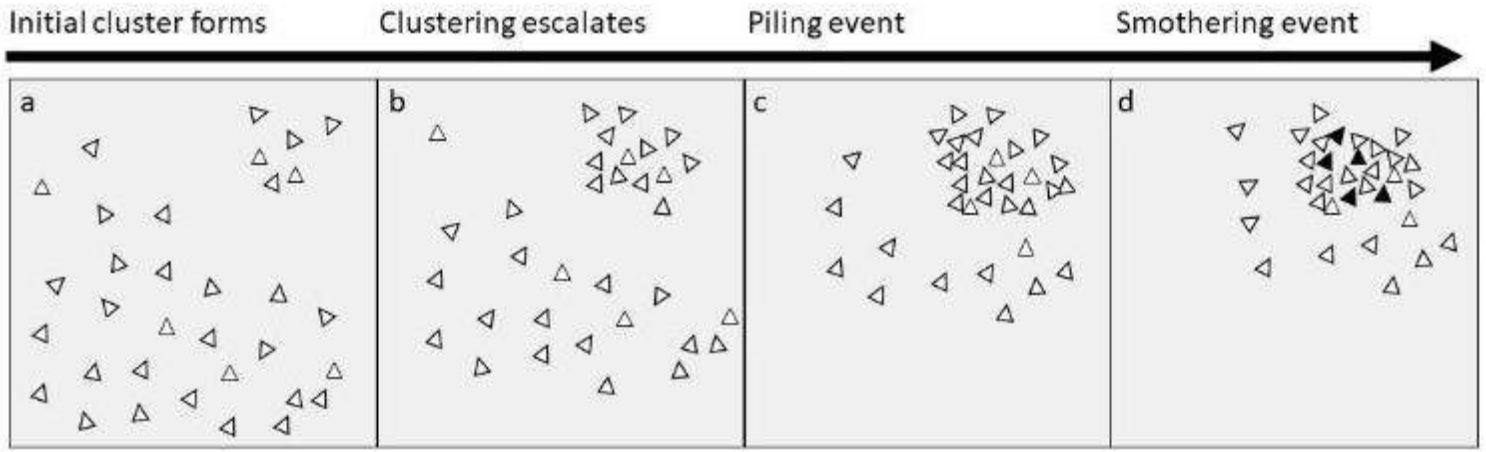
Why Piling?

- Vortexing behaviour
- Unpredictable
- Smothering
- Welfare effects
- Production reduction
- Staff effects
- Can be disrupted



Reproduced from Delcourt et al. (2016) The Quarterly Review of Biology 91(1):1-24



Methodology: Dataset

- 3 weeks of video collected from 8am to 8pm
- 10 flocks (brown, free-range, laying hens, UK farms).
- 18 to 72 weeks of age (mean = 37)
- Videos frames labelled as "Piling" or "Non-Piling" (Armstrong *et al.* 2023).
- 4 to 185 piles per flock (mean = 92)
- 49,908 total frames (33,669 Piling and 16,239 Non-Piling).
- 8 Flocks Training (39,676 Frames), 2 Flocks Testing (10,232 Frames)
    - Random subsamples from each used in Training / Testing

Dataset	Flock ID	Piling	Non-Piling
Training and Validation	A	1576	789
	B	511	240
	C	6449	2653
	D	3031	1155
	E	2532	1299
	G	3133	3259
	I	5247	2184
	J	3760	1858
	Total frames	26239	13437
Testing	F	4801	2058
	H	2629	744
	Total frames	7430	2802

06-07-2022 Wed 16:36:17
right near

17-07-2022 Sun 18:28:15
right near

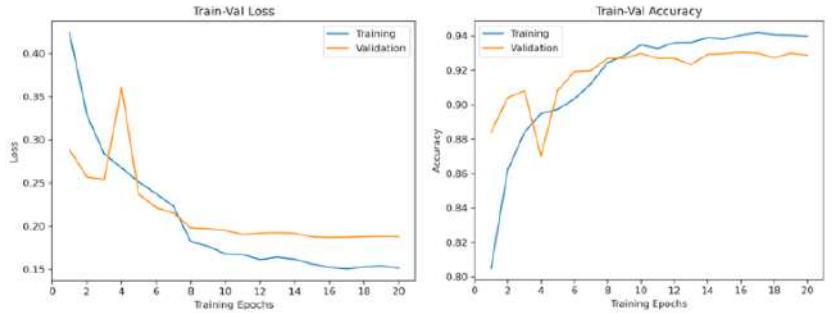
10-07-2022 Sun 16:55:02
left middle

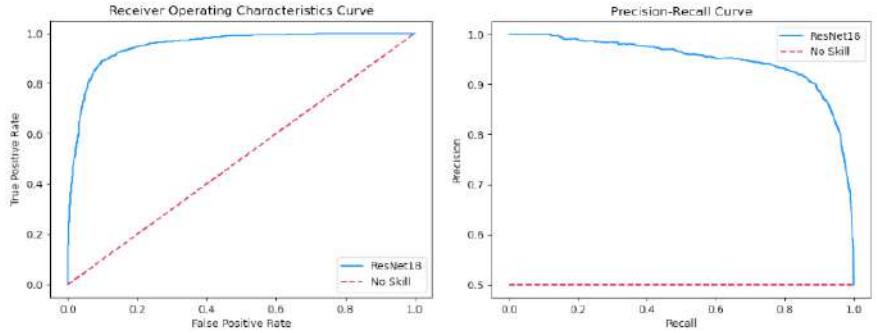
12-08-2022 Fri 15:20:37
Camera 01

01-11-2021 Mon 14:07:40
Camera 09

Methodology: AI Model & Results

- ResNet Convolutional Neural Network (CNN).
  - Established with image tasks
  - Low complexity
  - Widely available for transfer learning
- Peak Training Performance:
  - Accuracy: 0.9305
  - Cross-Entropy Loss: 0.1867
- Validation Performance:
  - Accuracy: 0.87
  - Precision: 0.94
  - Recall: 0.80
  - Specificity: 0.95

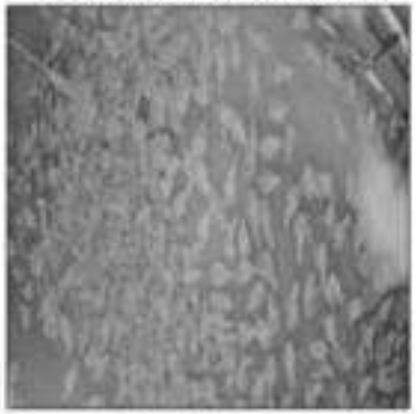




		True	
		Piling	Non-Piling
Predicted	Piling	2006	139
	Non-Piling	494	2361

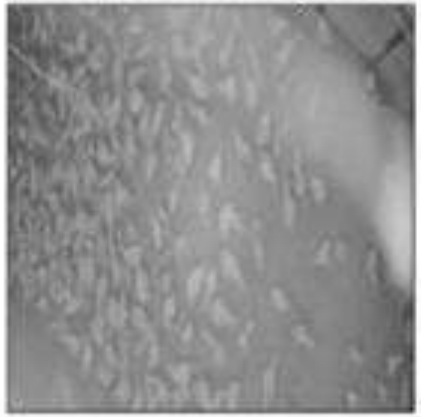
Misclassification Examples

Predicted: NONPILING, Actual: PILING
Prediction Probability: 0.90

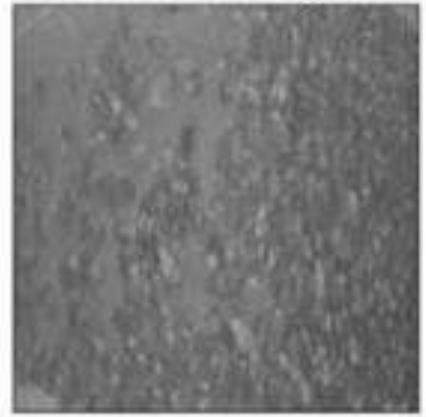


Predicted: NONPILING, Actual: PILING
Prediction Probability: 0.77

Predicted: PILING, Actual: NONPILING
Prediction Probability: 0.73

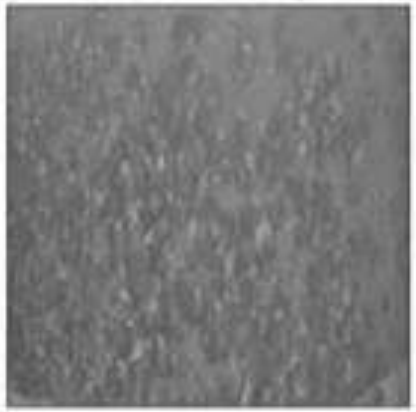


Predicted: PILING, Actual: NONPILING
Prediction Probability: 0.52

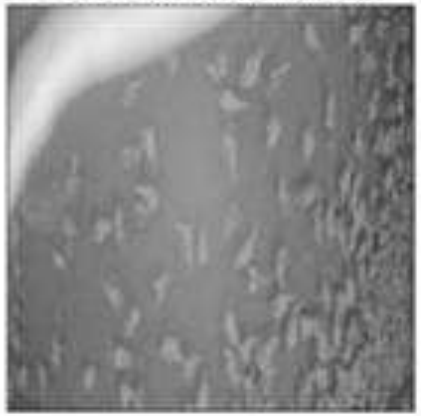


Predicted: NONPILING, Actual: PILING
Prediction Probability: 0.67

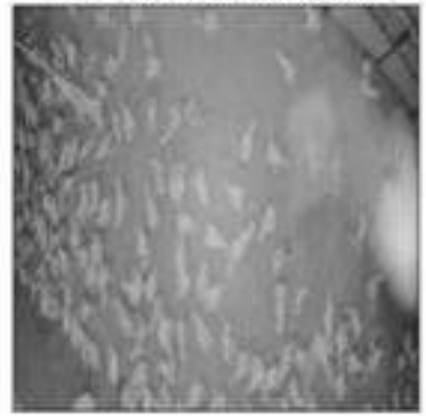
Predicted: NONPILING, Actual: PILING
Prediction Probability: 0.84



Predicted: PILING, Actual: NONPILING
Prediction Probability: 0.89

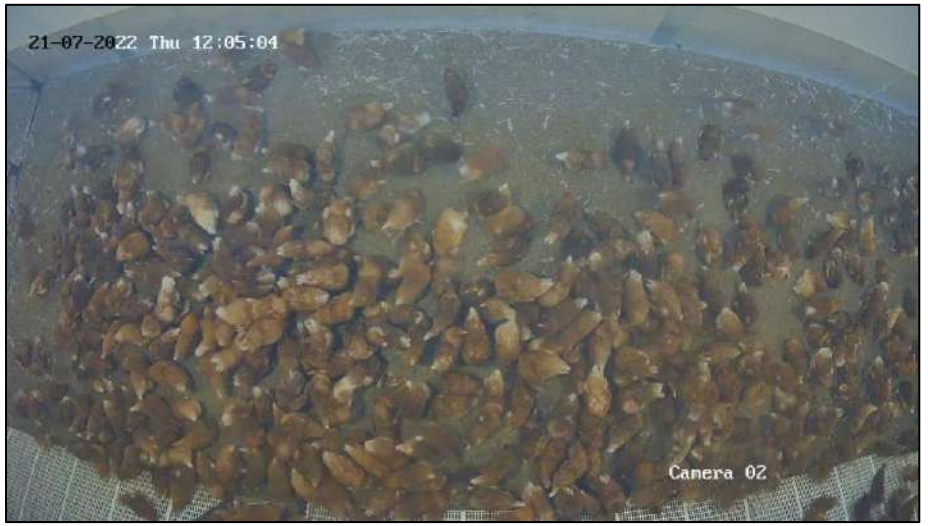


Predicted: PILING, Actual: NONPILING
Prediction Probability: 0.85



Discussion: Viability

- Demonstrated viability of approach
- Good performance across flocks
- Misclassification causes?
  - Image quality
  - Flock-specific characteristics
  - Ambiguous cases
  - Lack of temporal information
- What about the piles not captured?



Discussion: Future Development & Considerations

- Future Development:
  - Video rather than single frames
  - Include additional data
    - Standard welfare measures
    - Environmental monitoring
    - Bioacoustics
    - Production measures
- Unanswered Questions:
  - Generalisability?
  - Frequency of piles vs potential for harm
  - Impact of 0 Piling?

Acknowledgements

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H.E. Gray, R. Davies, A. Bright, A. Rayner, L. Asher. Frontiers in Veterinary Science 7, 616836

Any Questions?