HeatSense: Data-driven climate change adaptation in poultry

Data-Driven Discoveries in a Changing Climate Investment Theme

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A changing climate

BBC

World breaks hottest day record twice in a week

24 July 2024

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Georgina Rannard
Climate reporter

The Guardian

European heatwave forecast to hit peak as health warnings issued

Tourists and residents swelter in heat as temperatures rise to 44C in Spain, with forest fires in Greece and Croatia

United Nations | UN News
Global perspective Human stories

Heatwave deaths increased across almost all Europe in 2023, says UN weather agency

By Angela Symons with AP

Published on 04/08/2023 - 8:45 GMT+2

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What happens if the world gets too hot for animals to survive?

By Matthew Huber | July 20, 2022

Heat stress hits livestock too: How can we adapt our food systems for better animal welfare?

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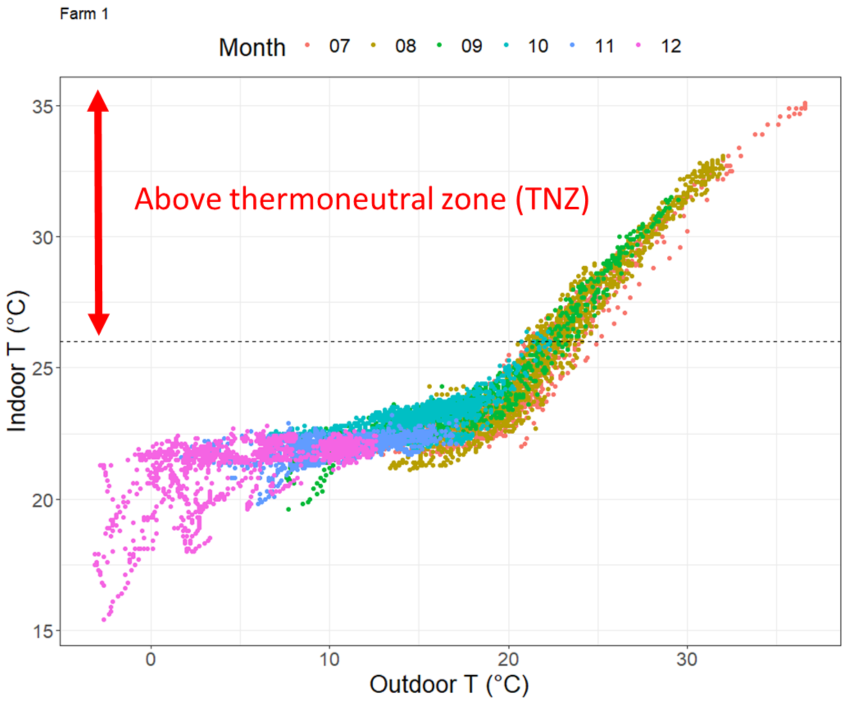
Animals kept in controlled environments?

- Heat stress is also important indoors

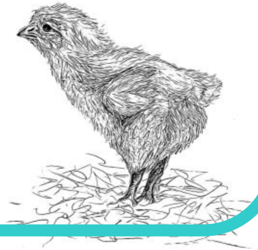


Fodor et al., 2023

heat stress: Mortality (↑) + Performance (↓) + Animal welfare (↓) + Costs of production (↑) = Sustainability of livestock production (↓)

Both short-term and long-term solutions for climate change adaptation needed

- Heat stress (HS)
  - Short-term adaptation — Automated early detection of HS — Adaptive cooling in barns
  - Long-term adaptation — Breeding potential: GxE interactions



→ Tools or directions for well-adapted future poultry production

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The team

- WLR – Livestock and Environment
- Wageningen Environ-mental Research
- WLR – Animal Health and Welfare
- WLR – Animal Breeding and Genomics
- WU – Adaptation Physiology
- WU – Biometris
- WU – Animal Breeding and Genomics
- WU – Agricultural Biosystems Engineering


















Automated early detection of HS

- Changes in behaviour first indicator of potential heat stress
  - Drinking
  - Lying laterally

- Can serve as input for fast detection of heat stress and automated cooling

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Automated early detection of HS

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  - **Drinking**
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- Can serve as input for fast detection of heat stress and automated cooling

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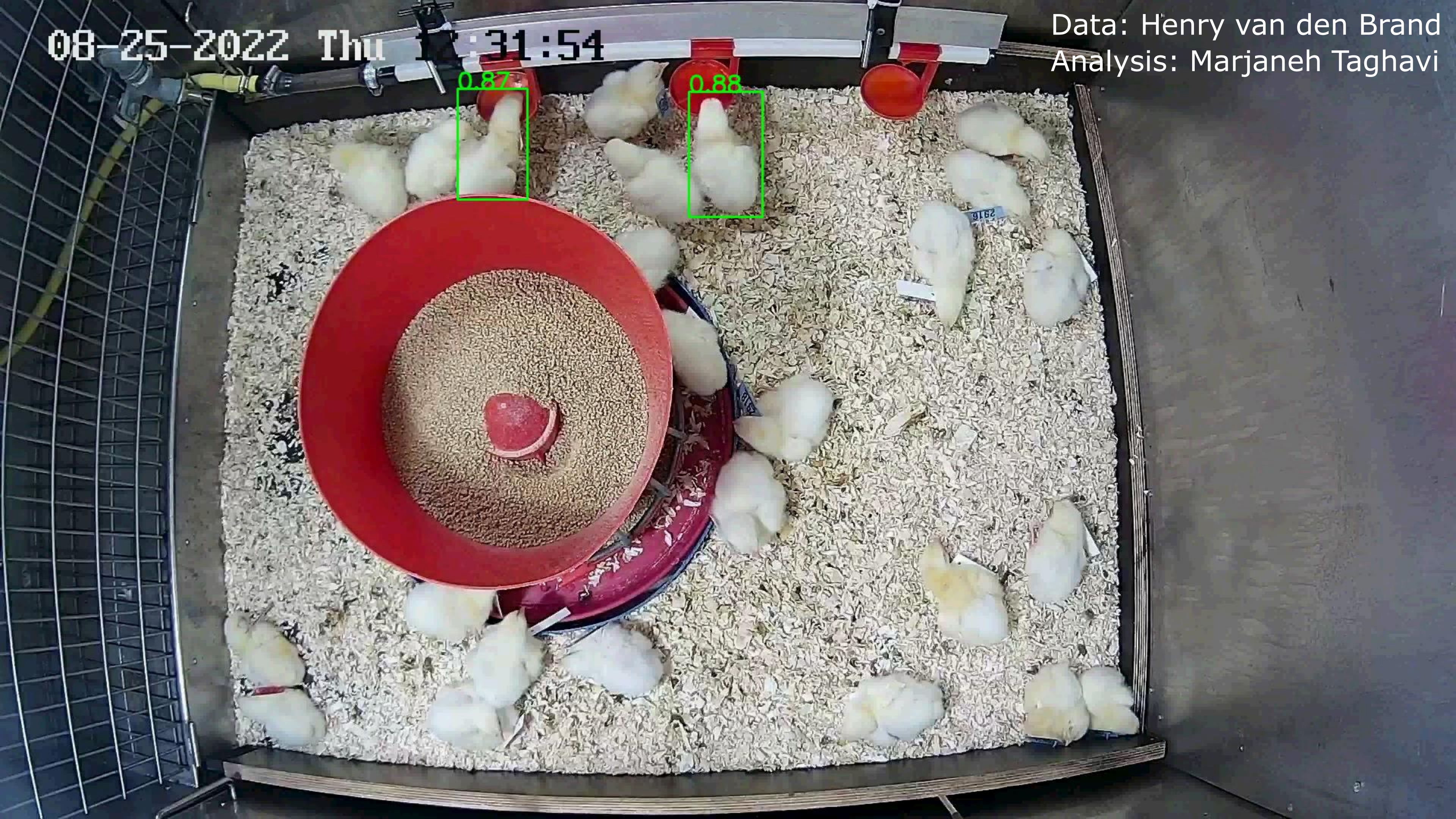
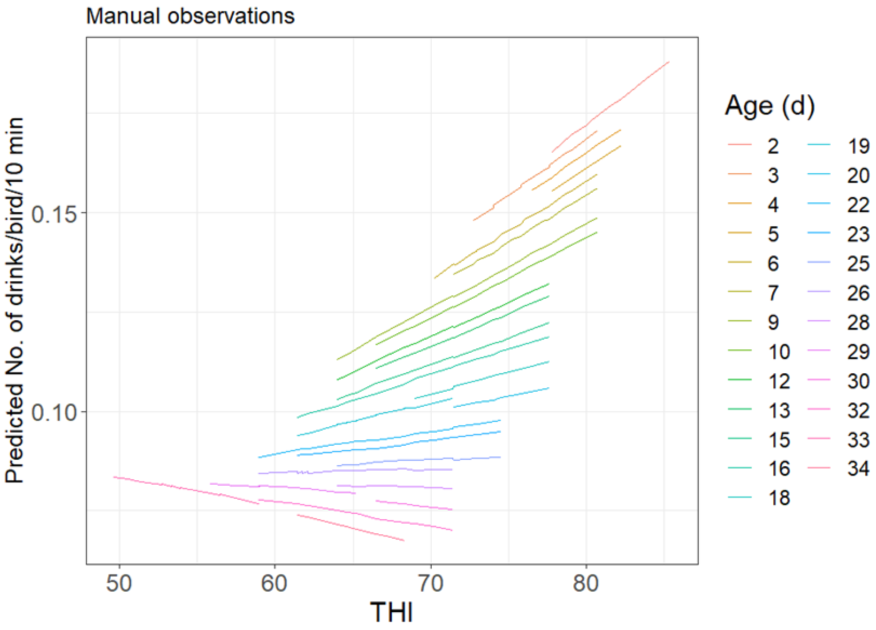
Automated detection of drinking behaviour

- Model trained on bounding box detection
    - Training data: 532 frames
    - Validation set: 176 frames

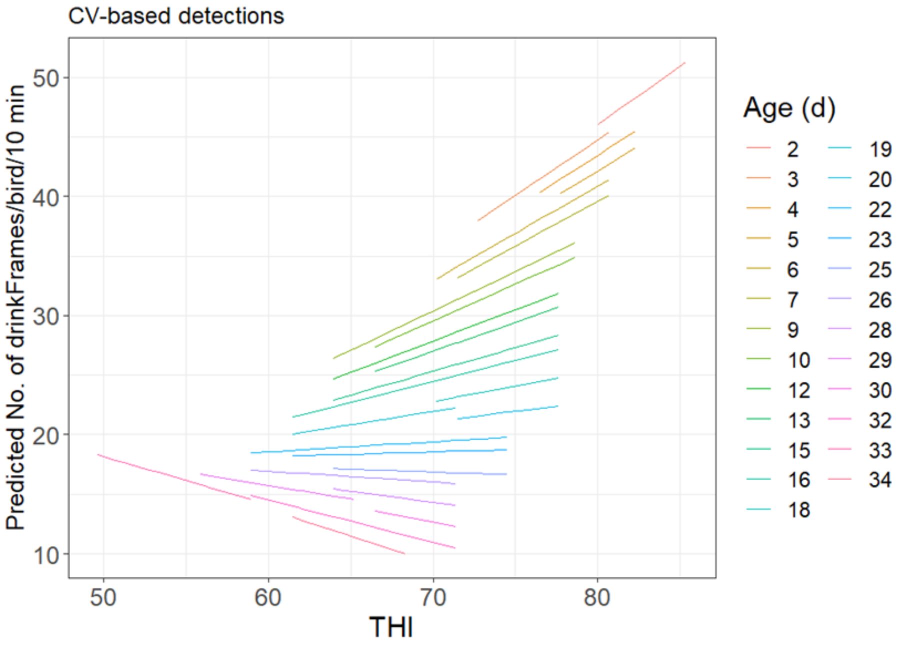

08-25-2022 Thu
:31:54
Data: Henry van den Brand
Analysis: Marjaneh Taghavi
0.87
0.88

Comparison with manual observations

Manual observations



CV detections



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Adaptive cooling strategy in barns

- Part 1: Build upon existing closed barn cooling models to include
  - short-term weather predictions
  - animal behaviour observations
  - animal physiological input
- Part 2: Develop an adaptive control system that makes real-time decisions to determine when and how to activate cooling systems

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Part 1: modelling indoor climate (1)

- **Observation variables (**Solar radiation I_s (Wm^{-2}), Temp in/outside $T_i/T_o(℃)$, ventilation rate $R_a(m^3s^{-1})$**)**

- The indoor climate is computed by:

$$dT_i/_{dt} = p_1T_i^2 + p_2T_i + p_3T_o + p_4R_aT_i - p_5R_aT_o + p_6I_s$$

  - p_1, p_2, p_3, p_4, p_5, p_6 need to be calibrated

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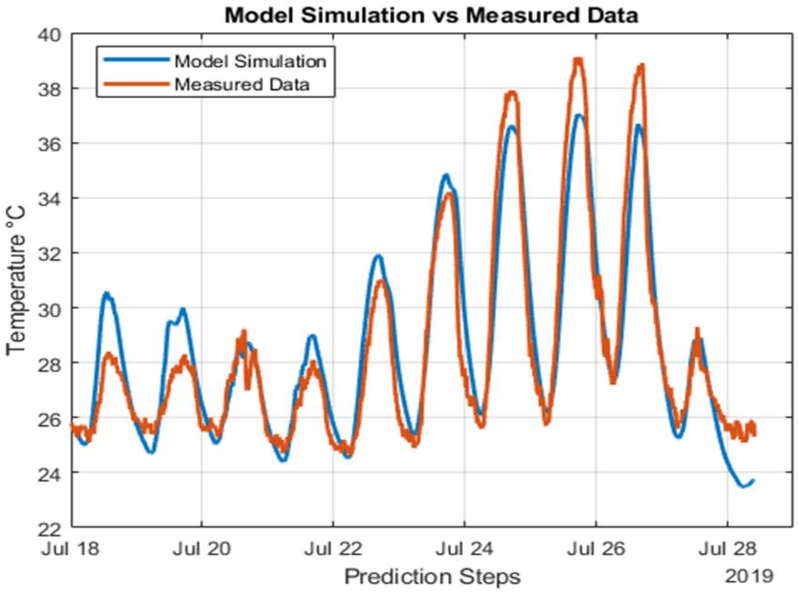
Part 1: modelling indoor climate (2)

- Training with 1500 data points
  - Max temp prediction error 3.8951 °C
  - Average prediction error 0.7015 °C



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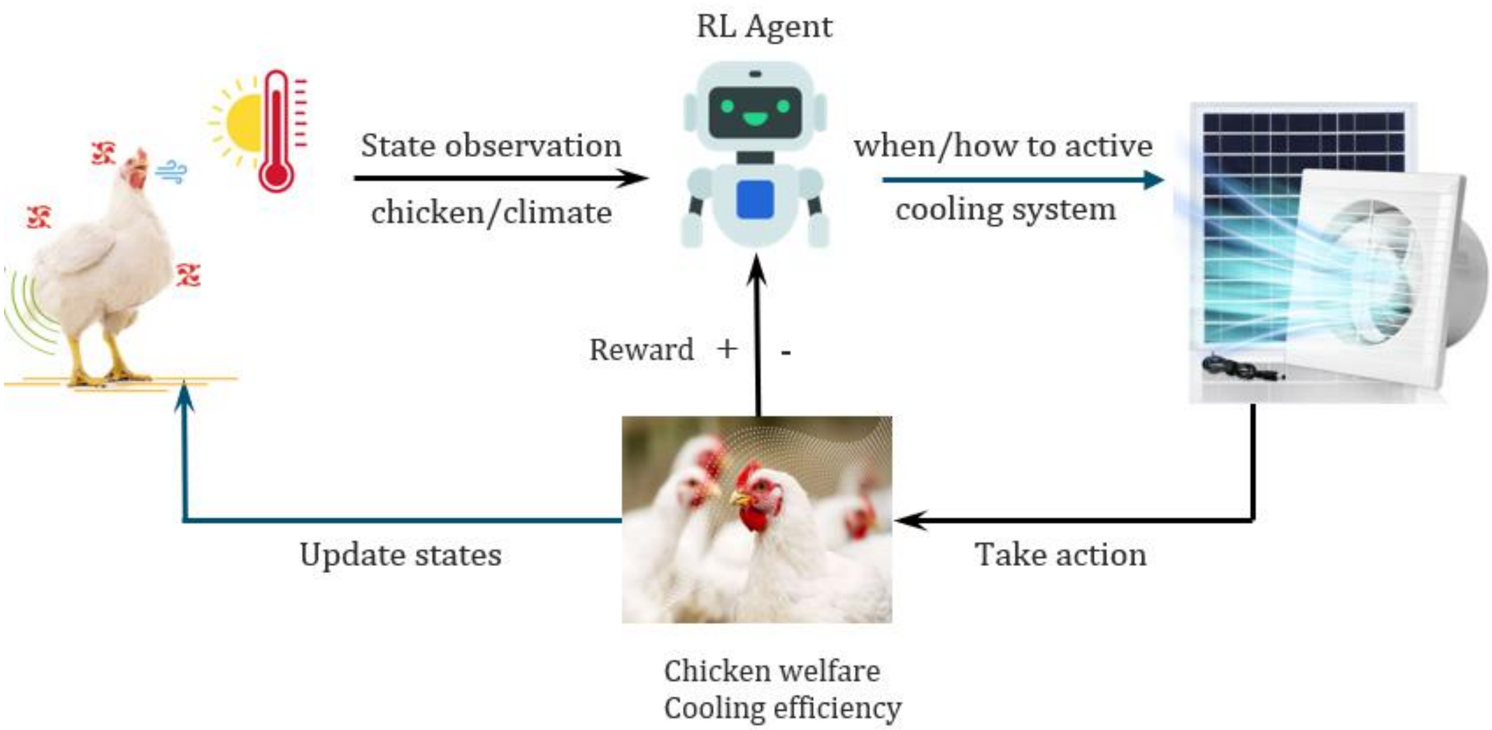
Part 2: reinforcement learning (1)



Part 2: reinforcement learning (2)

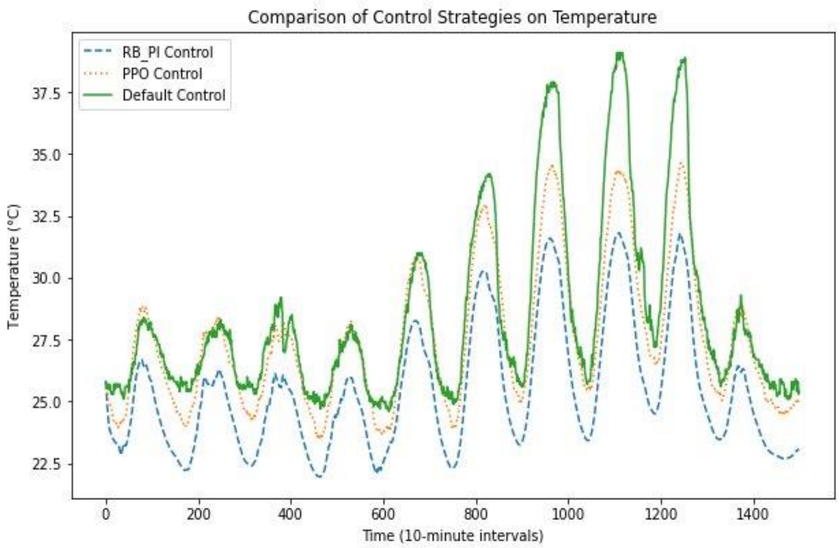
- Reinforcement learning method *proximal policy optimalization*
  - Ventilation [0-81], Evaporation [0,1]
  - Reward

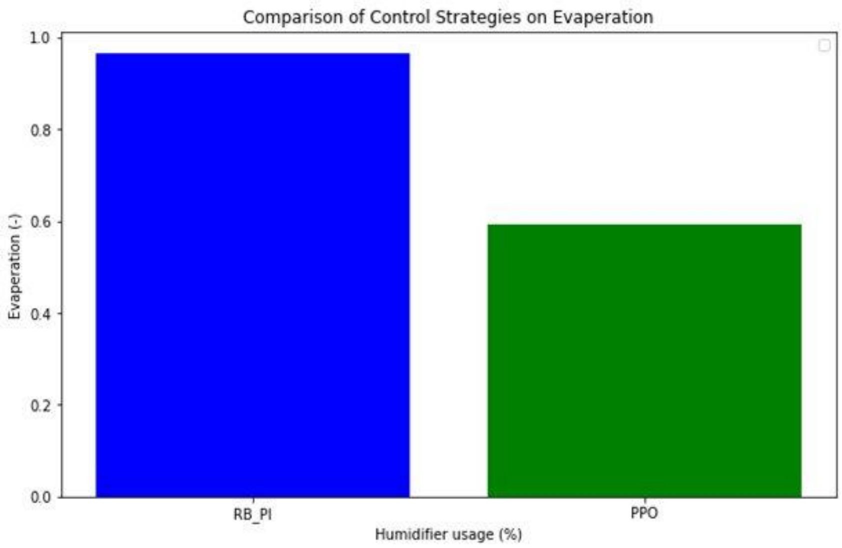
$$R = -r_{temp} - r_{evap} - r_{energy}$$

- Baseline (rule-based)
  - Full speed ventilation & evaporative cooling

Part 2: reinforcement learning (3)

- Heat stress with every control strategy
- Rule-based control best at avoiding heat stress but high energy cost



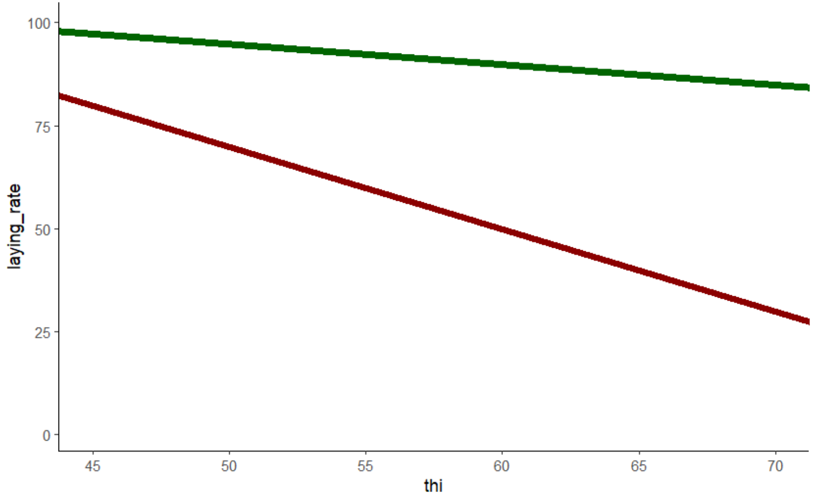


Limitations and next steps

- Indoor climate model without
  - heat emission from birds
  - humidity model
  - considering chicken drinking/lying behaviors
- The full cooling capacity is smaller than the summer heat
- RL control actions have too many oscillations
- RL reward function and RL agent still need improvements

Breeding potential: GxE interactions

- What is the effect of temperature (or THI) on laying rate?



Green = not sensitive
Red = sensitive

Variation in slopes → differences in temperature sensitivity between sire families

Parameter of interest:

$$\frac{\textit{variation due to slopes}}{\textit{variation due to intercepts}}$$

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Outreach in the project

- Presentations
  - Computer Vision and Robotics Parcours, Wageningen
  - EAAP conference, Florence
  - Dutch poultry farmer organisation, Wageningen

- Manuscripts in preparation

ELSEVIER
Poultry Science
Volume 103, Issue 8, August 2024, 103901

Research Note: Effects of high barn temperature on group-level dispersion and individual activity in broiler chickens

Continuation

- Currently investigating opportunities for setting up a follow-up Public Private Partnership and/or KB project

Thank you!

HeatSense project

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