Automation of poultry egg counting through neural network processing of the conveyor video stream

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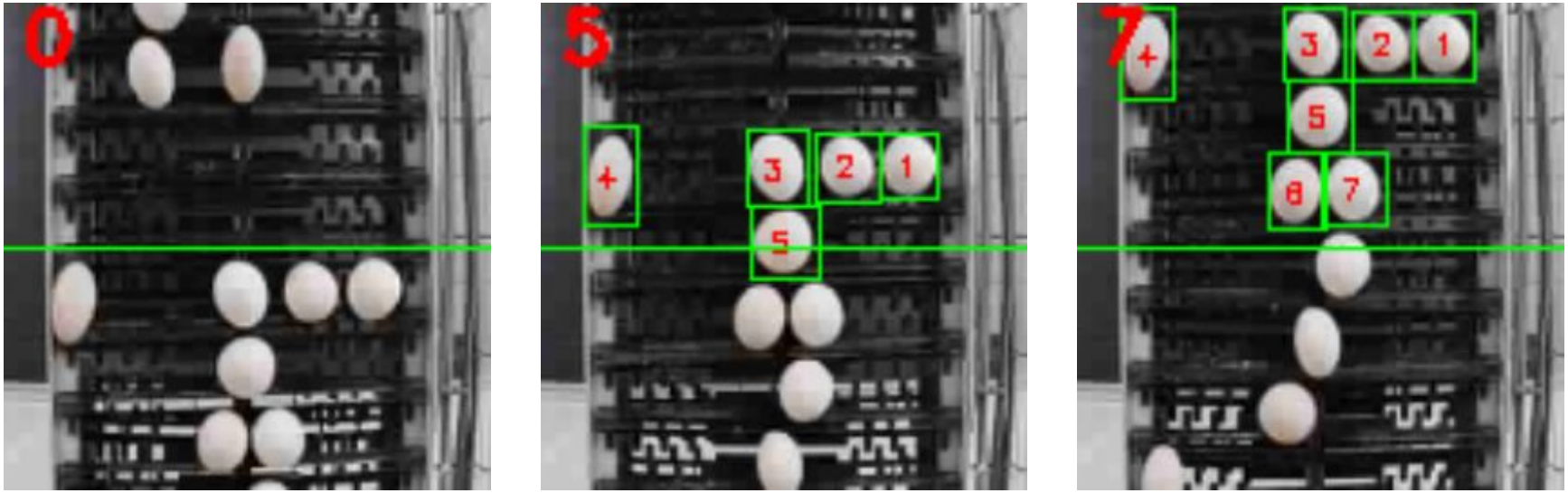
Outline

- Problem definition
- Existing approaches
- Our method
- Results

Problem definition: input – conveyor video stream

time

Problem definition: output – egg counts



Problem definition: requirements

- High accuracy > 99.7%
- Real-time processing
- Cheap in deployment (mid-range hardware)

Existing approaches: egg counting

Main types of existing approaches:

- Industrial infrared egg counters (e.g., [1]) – rather expensive equipment
- Traditional computer vision based methods (e.g., [2]) – not flexible or robust
- Machine learning based solutions – no prior academic work

Existing approaches: machine learning object detection

Seminal frameworks:

- YOLO [3]
- R-CNN [4]
- SSD [5]

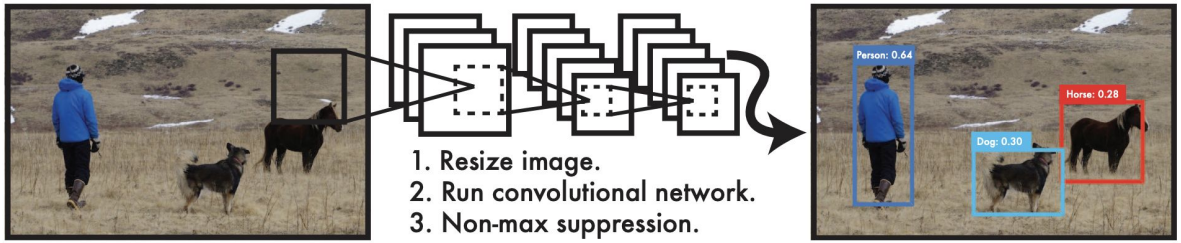


Figure 1. The YOLO detection system [3]

Our method

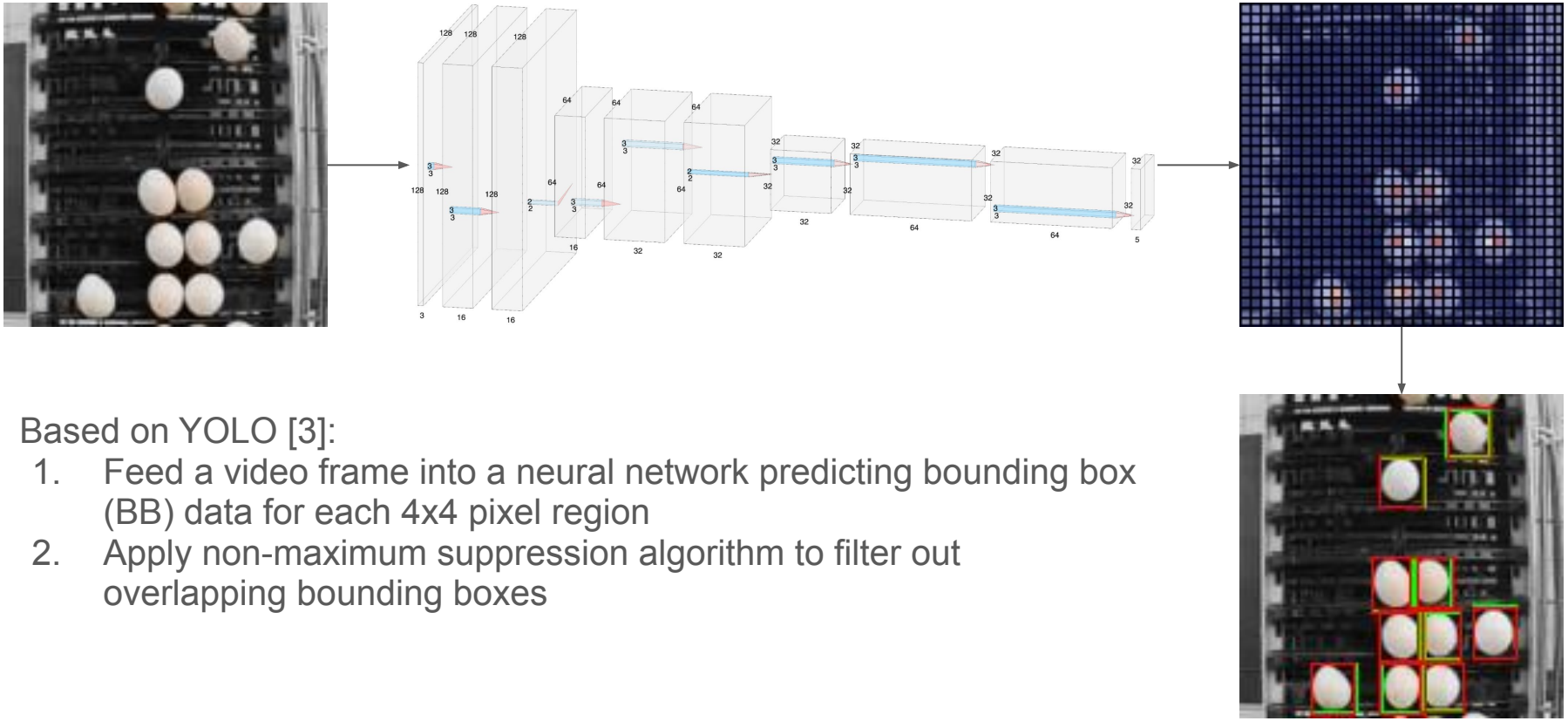
Three main steps:

- Obtaining an annotated dataset
- Building and training the egg detection neural network
- Building the egg tracking algorithm

Our method: annotated dataset

- Image level annotation: 2000 images of a conveyor belt, where each egg is highlighted by the bounding box
- Video level annotation: one hour long video of a running conveyor, where timestamp of every egg passing a middle of the frame is recorded

Our method: egg detection neural network



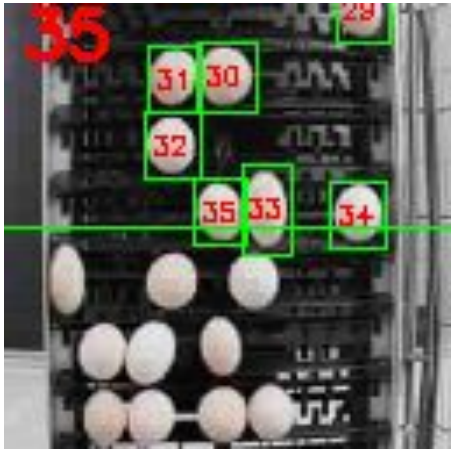
Based on YOLO [3]:

1. Feed a video frame into a neural network predicting bounding box (BB) data for each 4x4 pixel region
2. Apply non-maximum suppression algorithm to filter out overlapping bounding boxes

Our method: egg tracking algorithm

Centroid tracking based method:

- Maintains a set of bounding boxes (BBs) currently present in the frame
- Updates BBs positions based on the newly ones predicted by the network
- Increases egg counter when some BB passes the middle of the frame



Results: egg detection network

Treated as a binary classification task:

- If predicted BB has an *Intersection over Union* (*IoU*) score with the ground truth BB greater than 0.5, it is treated as true positive classification
- The accuracy is measured as the area under the Precision - Recall curve, aka. *Average Precision* (*AP*)

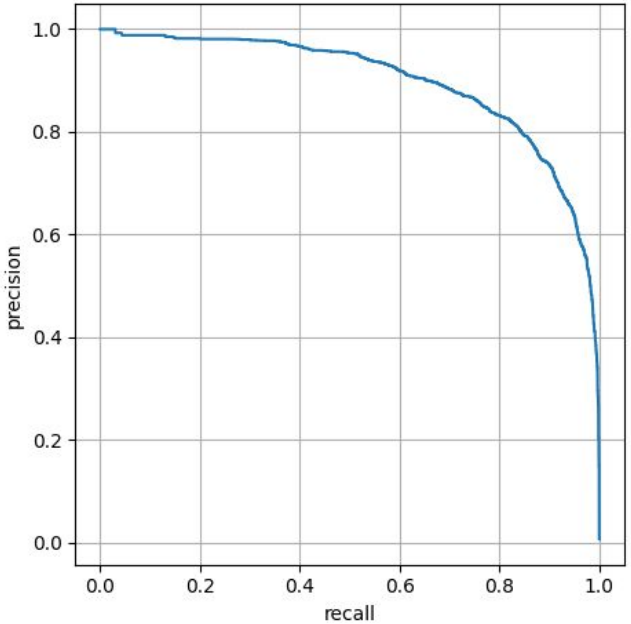


Figure 2. Precision - Recall curve on the test image set. ***AP = 89.75%*.**

Results: counting system accuracy

- Count accuracy (*CA*) is measured with the following formula:

$$CA = \left(1 - \frac{|C_{\text{true}} - C_{\text{pred.}}|}{C_{\text{true}}}\right) \cdot 100\%$$

- Besides the final accuracy, we also compute the mean accuracy over the all timestamps.

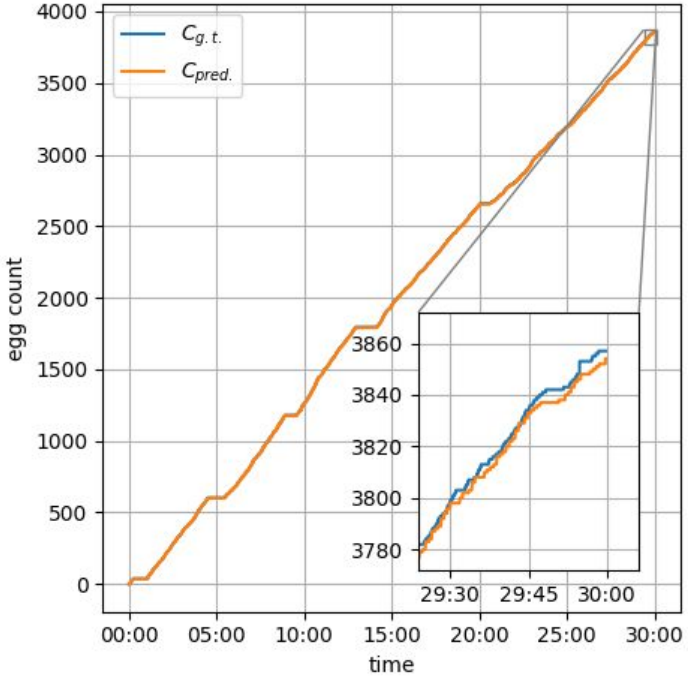


Figure 3. True and predicted egg counts for a test video clip. **Mean *CA* = *99.45%*. Final *CA* = *99.92%*.**

Results: time and cost efficiency

Hardware requirements are mild:

- System operates with a regular IP camera mounted over a conveyor
- GPU is required for training the model but not for inference
- Processing a 30-minute video takes about 10 minutes (on a 4 core 1.7 GHz Intel i5-4210 CPU)

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References

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[3] J. Redmon, S. Divvala, R. Girshick and A. Farhadi, "You only look once: Unified, real-time object detection," Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 779--788, 2016.

[4] S. Ren, K. He, R. Girshick and J. Sun, "Faster r-cnn: Towards real-time object detection with region proposal networks," arXiv preprint arXiv:1506.01497, 2015.

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