



Nondestructive Workshop

The Applications of Machine Vision in Animal Husbandry

Yan-Fu Kuo | November 7th, 2023

Lab of machine learning and machine vision
Dept. Biomechatronics Engineering
National Taiwan University



Food Security



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Traditional Farming



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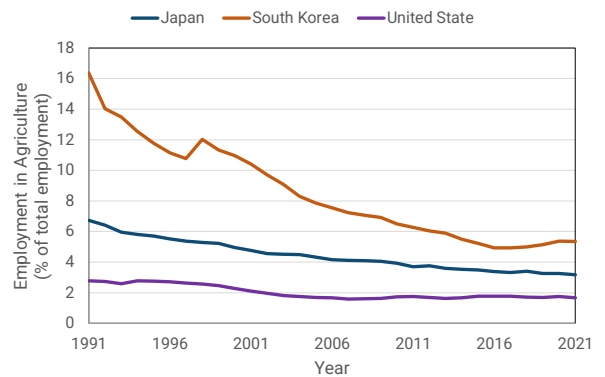
Why Machine Vision?

- Labor shortage and farmer aging

Births in Taiwan



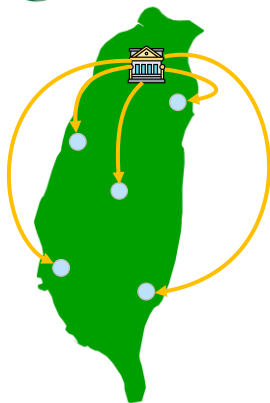
Employment in Agriculture



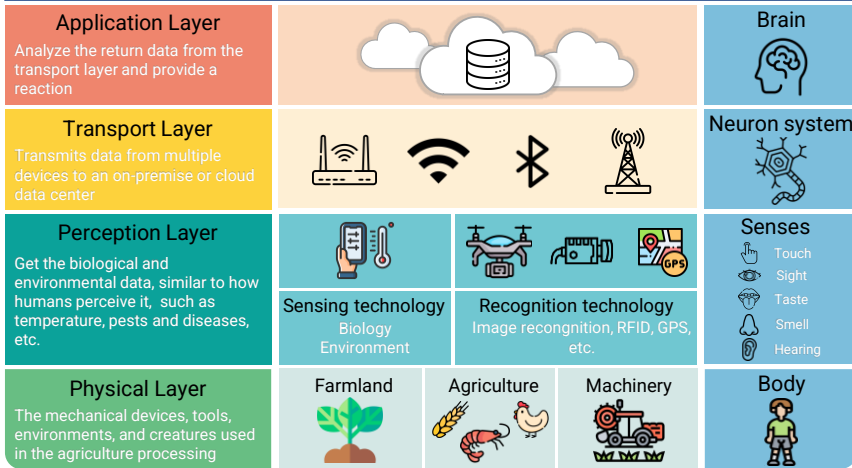
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Source: United Daily News, Taiwan; World Bank

Introduction – Rise of Smart Agriculture



Information and communication technology, IoT, big data, smart machine



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Source: Council of Agriculture, Executive Yuan. 2022.

What Machine Vision Can Do from Images?

1 Classification



Cardboard cut-out Human

AlexNet

VGG-16

ResNet-55

EfficientNet

2 Localization and Classification



Fast R-CNN

Faster R-CNN

YOLO v4

YOLO v5

3 Semantic segmentation



U-Net

FCN

DeepLabv3+

4 Instance segmentation



Mask R-CNN

MaskLab

YOLACT



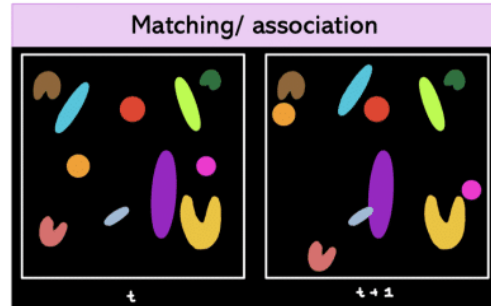
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What Machine Vision Can Do from Videos?

⑤ **Classification**
(Behavior recognition)



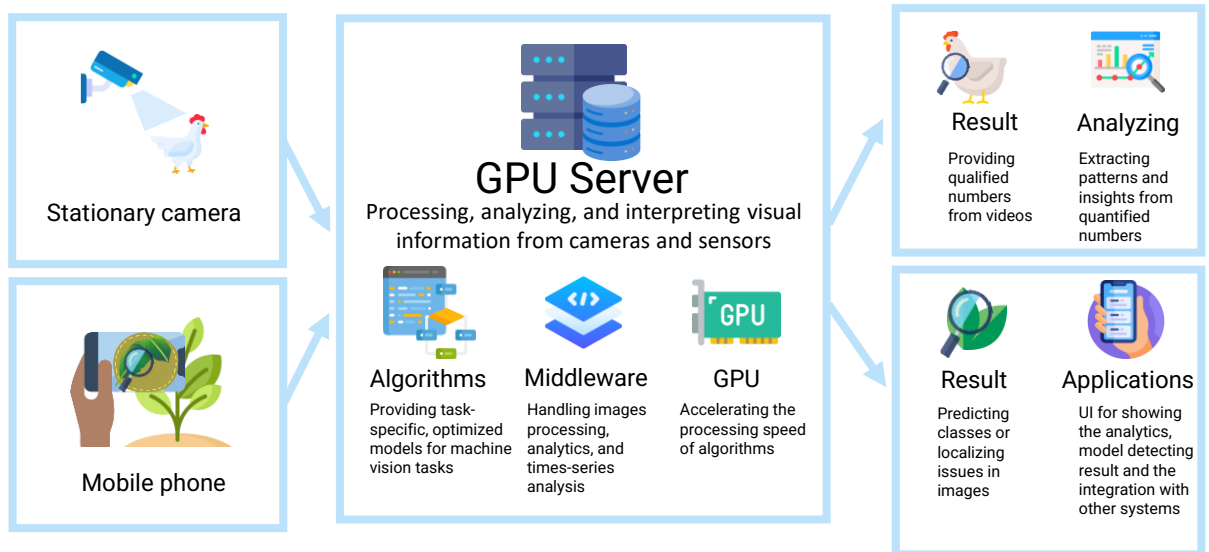
⑥ **Object tracking**



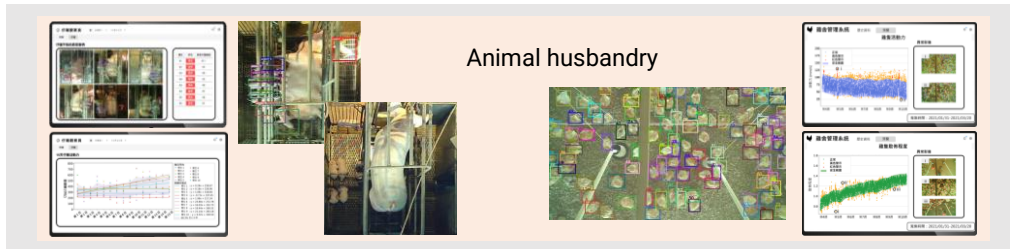
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Source: <https://focalplane.biologists.com/2023/06/01/tracking-in-napari/>

Machine Vision in Agriculture Production



Machine Vision Applications in Food Production



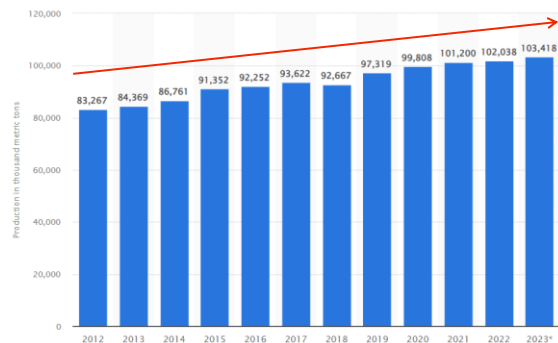
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Chicken Behaviors – Dispersion and Movement

- Worldwide chicken production exceeded 135 million tons in 2021
- Taiwan native chicken is a popular variety in the domestic market



Chicken meat production worldwide from 2012 to 2023 (in 1,000 metric tons)



Source: <https://www.statista.com/statistics/>



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Problems – Frequently Checking Chicken Status

- Taiwan native chickens have long raise periods (up to 12 weeks)
- Frequent patrol in chicken houses is required to observe chicken status
 - Laborious and time-consuming
 - Frequent entering chicken houses increases the risk of introducing pathogens (e.g., Avian Influenza)



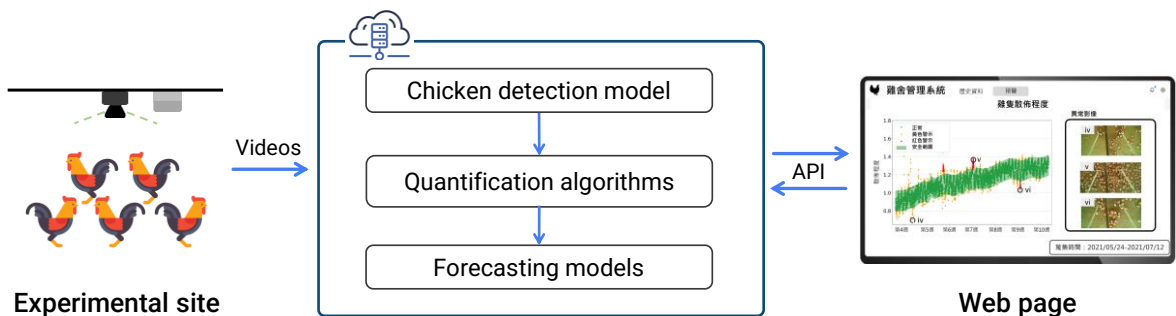
Photo taken in the experiment field. Yunlin, Taiwan.



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Solution – Automatic Monitoring and Warning

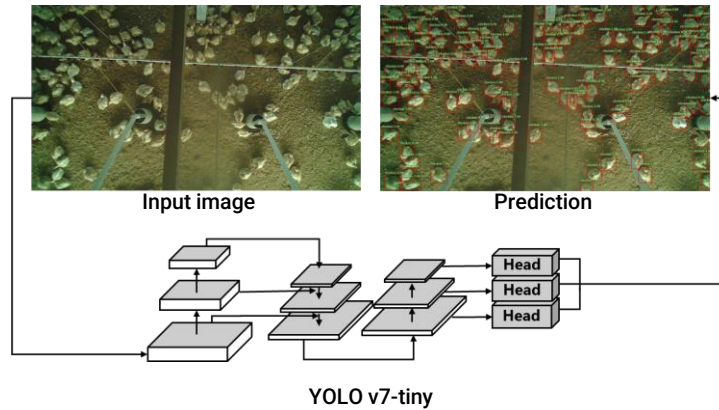
- Overhead cameras for monitoring chickens
- Deep learning and machine learning models for quantifying and monitoring chicken dispersion and movement



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Chicken Detection Model – YOLOv7-tiny

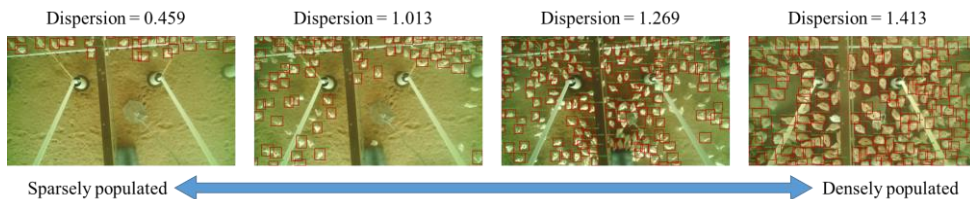
- The trained model achieved a mAP of 96.0%



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Dispersion and Movement Quantification Algorithms

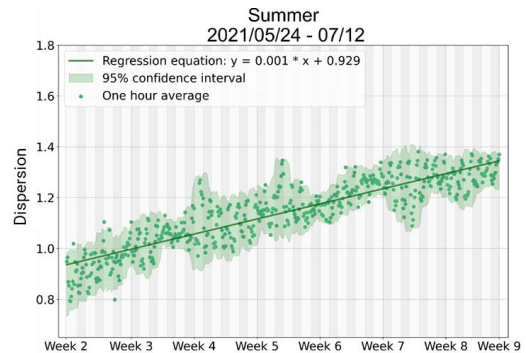
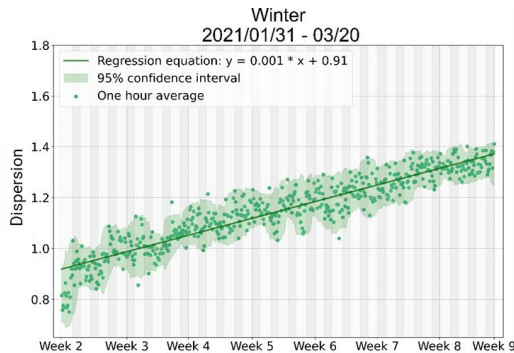
- Chicken dispersion was quantified using nearest neighbor index
- Chicken movement was quantified using simple online and realtime tracking



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Long-term Observation of Chicken Dispersion

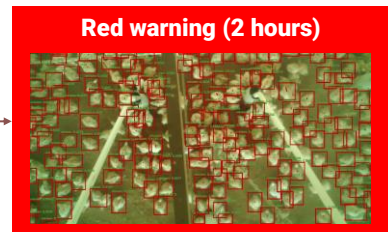
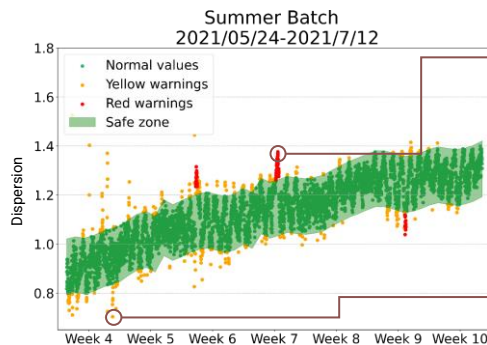
- Two batches of chickens were observed – winter and summer
- Chicken dispersion increased gradually – moving average model



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Warning of Chicken Dispersion

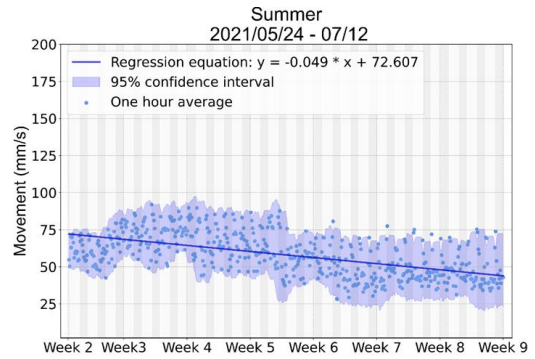
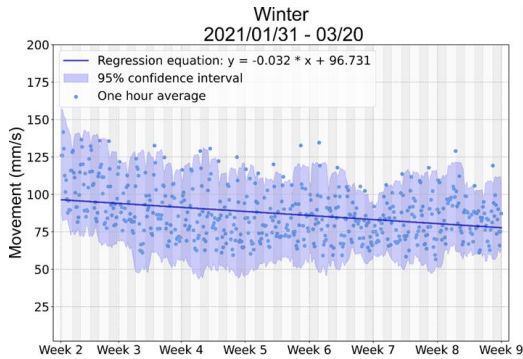
- Dispersion was modeled using a moving average model – ARIMA
- ARIMA achieved a MAPE of 3.71%



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Long-term Observation of Chicken Movement

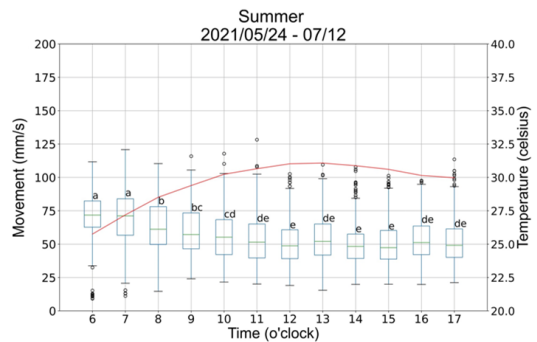
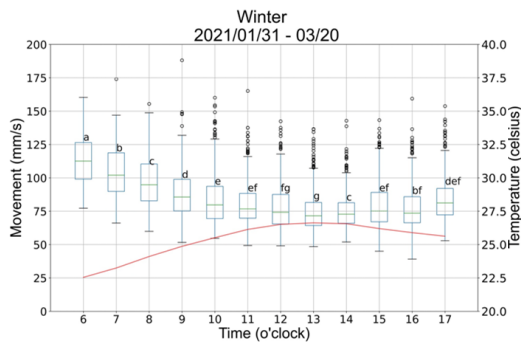
- Chicken movement decreased gradually – moving average model



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Daily Patterns of Chicken Movement

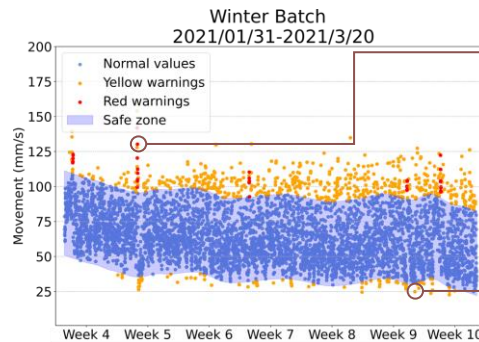
- Opposite trend between chicken movement and indoor temperature



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Warning of Chicken Movement

- Movement was modeled a moving average model – SARIMAX
- SARIMAX achieved a MAPE of 13.39%



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Lactating-related Behaviors of Sows and Piglets

- Worldwide pork production exceeded 114 million tons in 2022
- Demanding for pork in the domestic market is strong



Production of pork worldwide from 2013 to 2023 (in million metric tons)

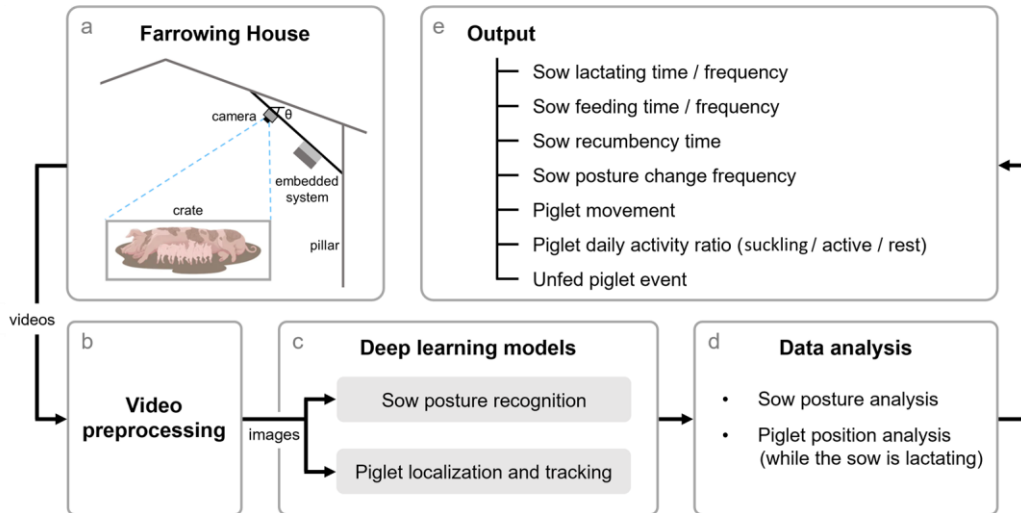


Source: <https://www.statista.com/statistics/>



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Solution – Automatic Monitoring



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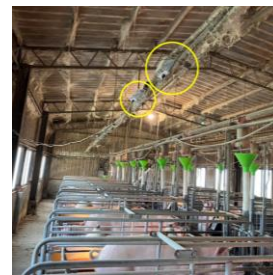
Video Collection

- Totally 10 thousand hours of videos
- Acquired between 8AM and 6PM
- Length of 30 s and frame rate at 5 fps
- Resolution: 960 x 540 pixels
- Transmitted to the cloud server and converted to images

Tainan farm

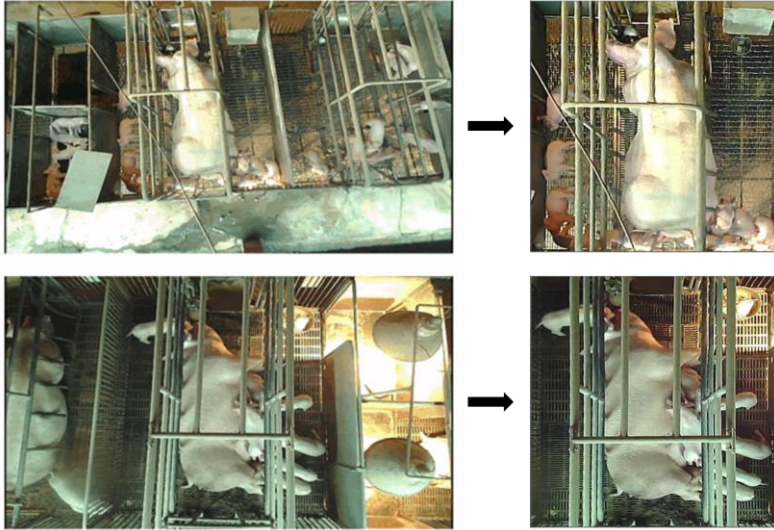


New Taipei farm



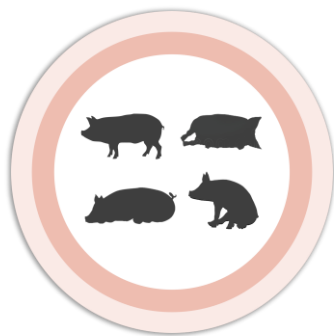
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Image Preprocessing

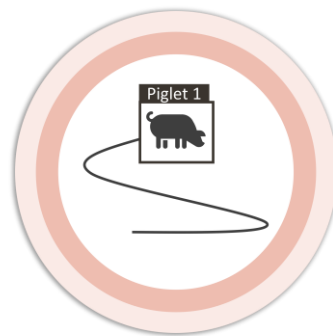


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Two Deep Learning Models – Sow and Piglet



Sow posture
recognition model
(SPRM)

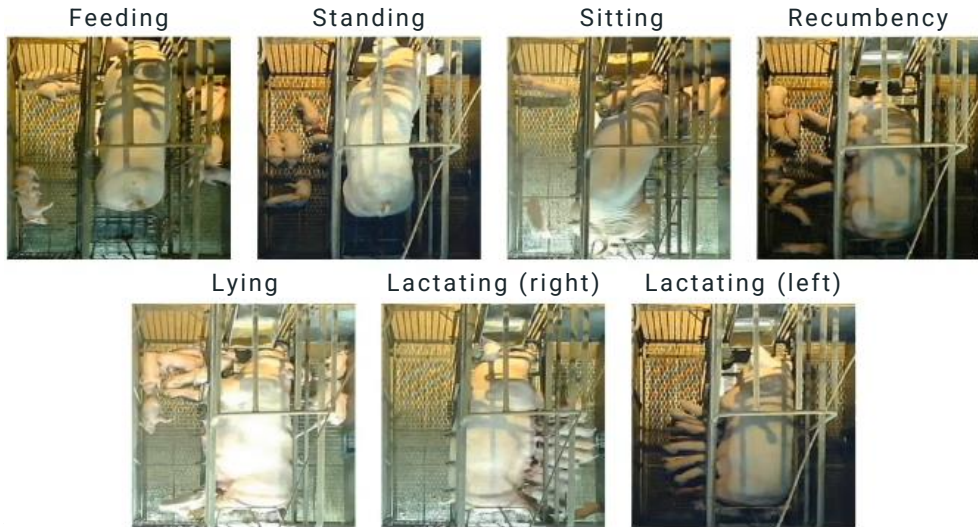


Piglet localization
and tracking model
(PLTM)



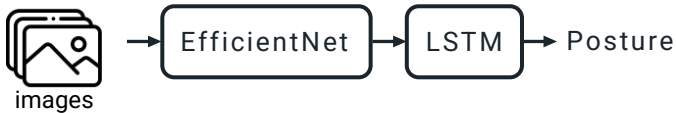
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Seven Sow Postures



Sow Posture Recognition Model (SPRM)

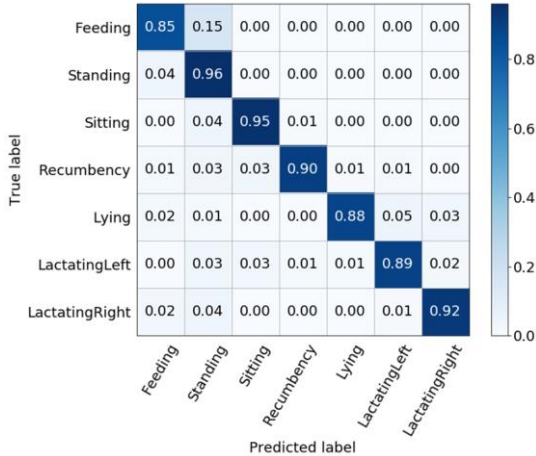
- EfficientNet + LSTM
- Predict postures using consecutive images (i.e., videos)



Posture	Training	Test
Feeding	272	91
Standing	231	77
Sitting	233	78
Recumbency	377	126
Lying	217	72
Lactating (right)	215	72
Lactating (left)	219	73
Total	1764	589



Performance of SPRM



Posture	Precision	Recall	F1-score
Feeding	0.93	0.84	0.88
Standing	0.90	0.96	0.93
Sitting	0.98	0.91	0.94
Recumbency	0.86	0.96	0.91
Lying	0.98	0.93	0.95
Lactating right	0.99	0.92	0.95
Lactating left	0.85	0.96	0.90
Overall	0.93	0.93	0.92

Accuracy: 91.36%

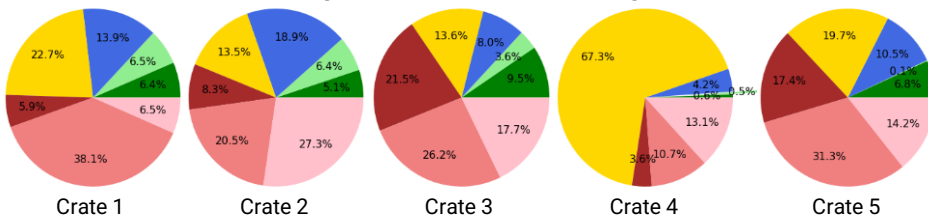
Inference speed: 0.77 clips per second



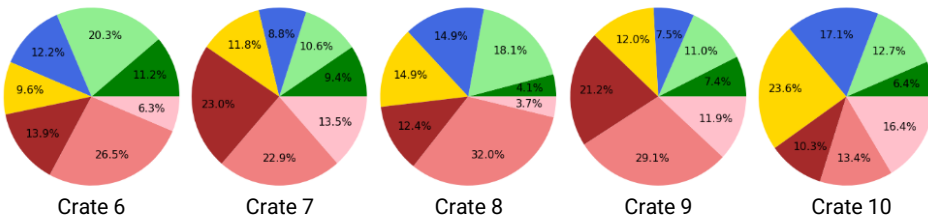
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Sow Posture Analysis (Statistics of 10 Days)

Farrowing crate in Tainan farrowing house



Farrowing crate in New Taipei farrowing house



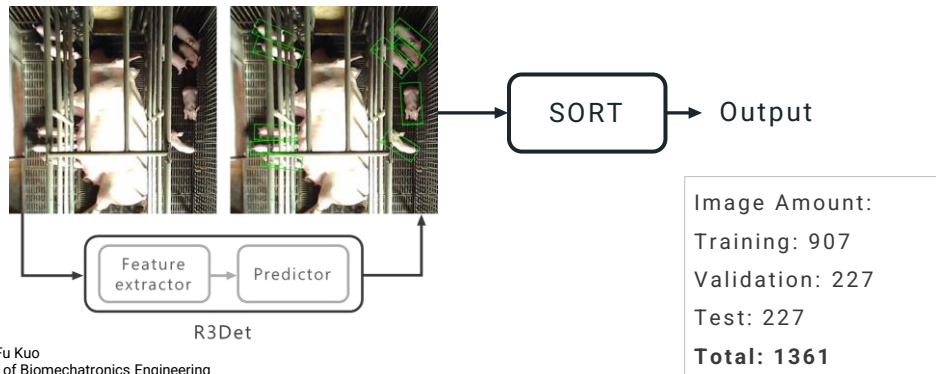
- Feeding
- Standing
- Sitting
- Sternal or ventral recumbency
- Lying
- Lactating on the left side
- Lactating on the right side



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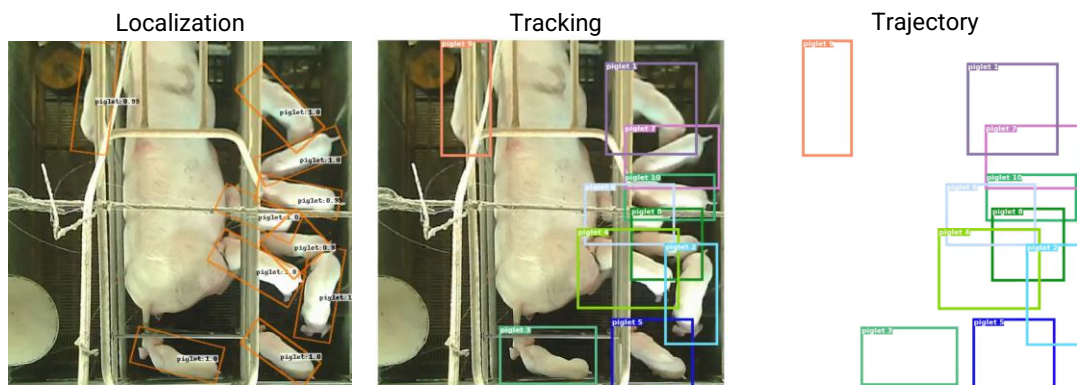
Piglet Localization and Tracking Model (PLTM)

- Piglet localization using R3Det (Refined Rotation RetinaNet)
- Piglet tracking using SORT (simple online and realtime tracking)



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Performance of PLTM



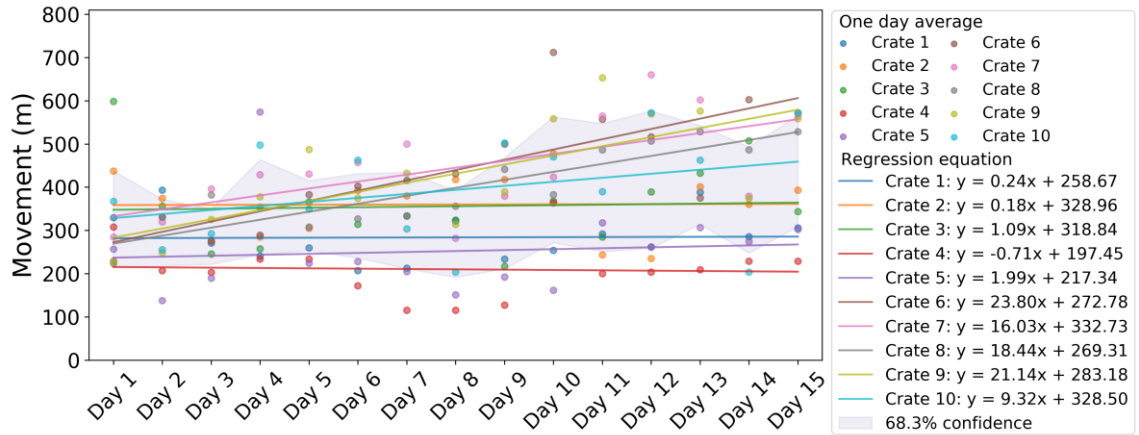
Precision: 0.93; Recall: 0.91; F-1 score: 0.92; AP: 89.11%; MOTA: 94.6% (SORT)



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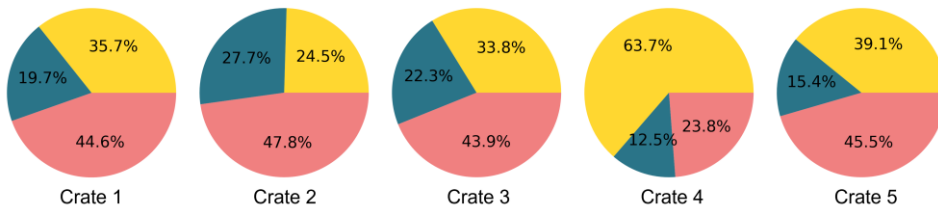
Long-term Piglet Movement Analysis

- Piglet movement variation in the first 15 days

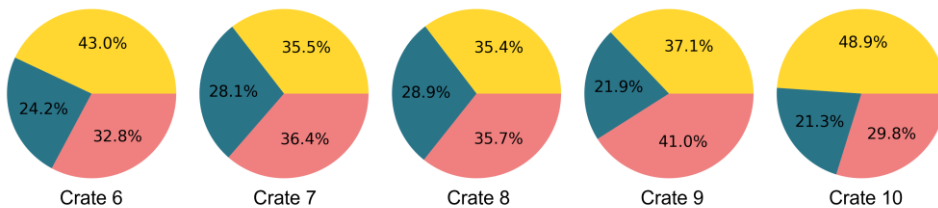


Piglet Behavior Analysis (Statistics of 10 Days)

Farrowing crates in Tainan farrowing house



Farrowing crates in New Taipei farrowing house



● Suckling ● Active ● Rest

Unfed Piglet Detection

- Detecting unfed piglets by combining SPRM and PLTM



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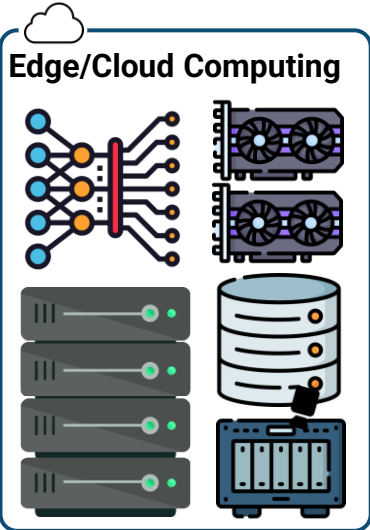
Model Inference Choice – Edge, Fog, and Cloud



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Source: <https://www.dilepix.com/en/blog/cloud-fog-edge-computing-data-protection>

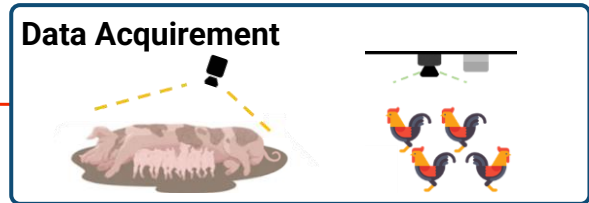
Summary



5G



5G



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Lab of Machine Learning and Machine Vision



Network Attached Storage

Storing massive of images and videos collected from various sites



Compute Capability

Accelerating the training of deep learning models and hosting trained deep learning models



Independent Workspace

Providing independent environments for convenient software development and model training



Service Host (& User Interface)

Functioning as an inference servers for various trained models and



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Acknowledgement



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Thanks for Listening

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