Automatic recognition of feeding and non-nutritive feeding behaviour in pigs using deep learning

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Overarching objectives

- **Automatically** monitoring the feeding associated behaviour of groups of pigs under **commercial conditions** without the need for **additional sensors** or **individual marking**

- A vision-based **early warning system** for health and welfare compromises in pigs

Feeding behaviour detection

- The feeding behaviour of pigs is an important indicator of their health status and growth potential
- A deviation from a set of daily pattern in feeding behaviour is often associated with an early symptom of disease
- Automatic behaviour recognition for pigs is one of the core problems in precision pig farming

Radio-Frequency Identification (RFID)

- Tagging is not routinely applied on commercial farms
- Loss of ear tags and tag damage
- Welfare issues
- Expensive surveillance option for large number of pigs
- The attachment and detachment of tags entails additional labour costs
- Loss of carcass value
- A more promising solution for pig monitoring is using camera-based techniques, as such approaches provide a low cost and non-invasive solution

Available systems

- Available systems often overestimate the actual time spent feeding due to the inability to identify and exclude non-nutritive visits (NNV) to the feeding area.

- The feeding behaviour is estimated based on assumptions (e.g. position, time spent, orientation of the animal).

The developed system

- Instead of processing the data of the whole pen, we only processed the data around the feeding trough

- The system is capable of distinguishing between feeding and NNV to the feeding area in a commercial set-up

- This system does not rely on pig tracking and it does not require additional sensors or individual pig marking for detection


Area of interest

Unlabeled Dataset

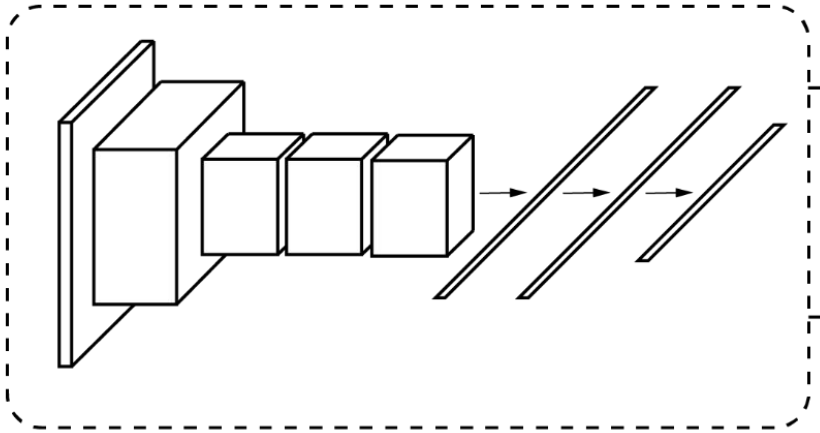
Manual annotation by
an animal behavior scientist

1 Feeding 1 NNV
2 NNV
2 Feeding
. . . . .
All possible scenarios

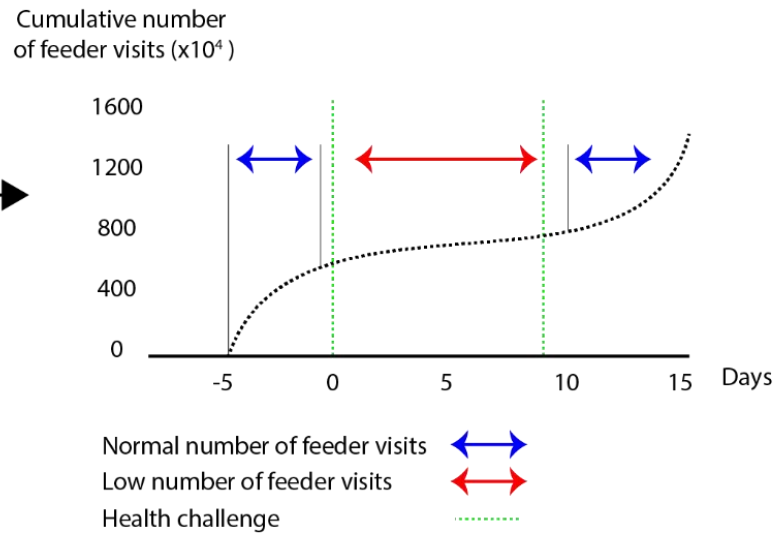
Labeled Set

Training and validating CNN model

Data stream from the
surveillance camera



Convolutional Neural Network (CNN)

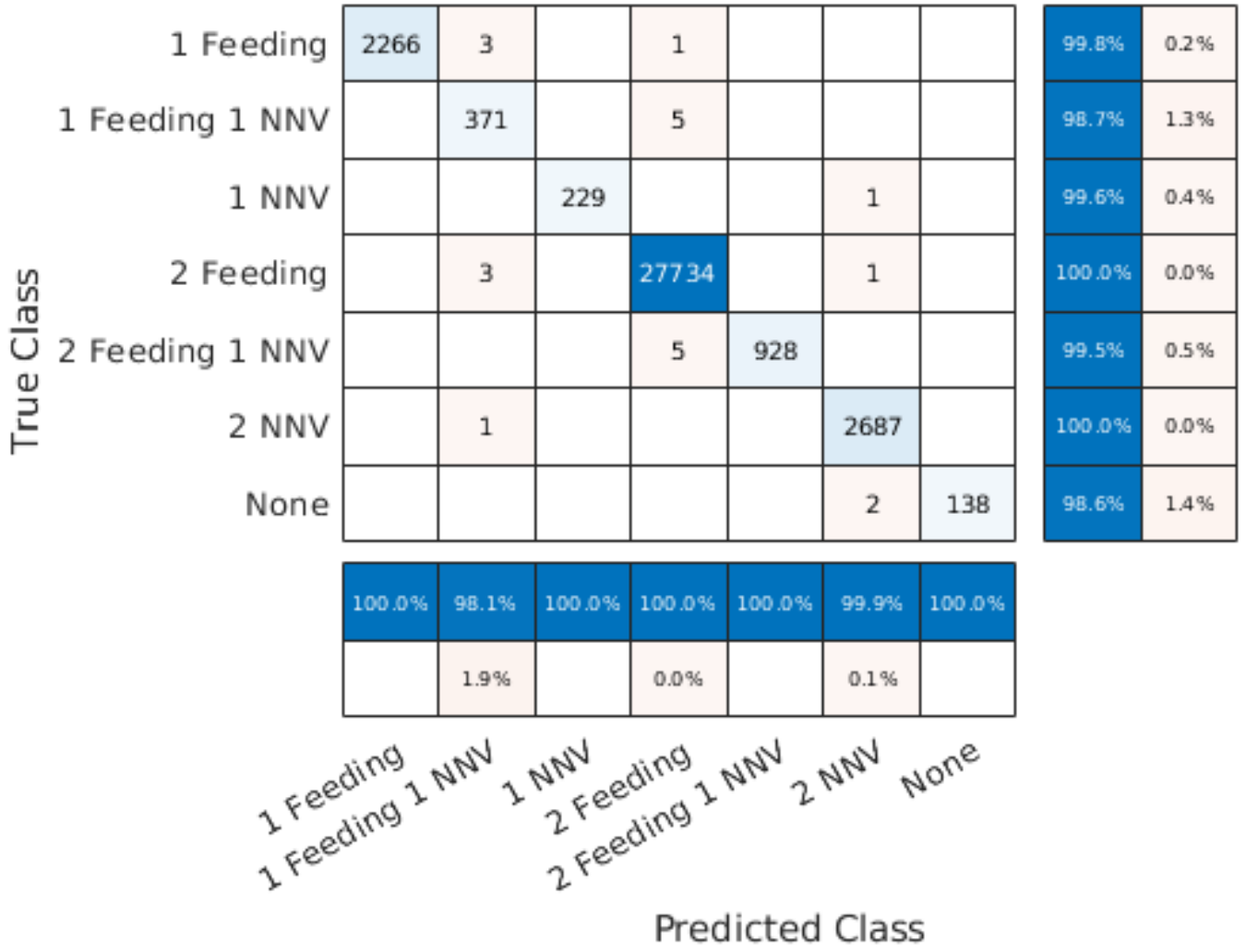


Demo (data from an independent trial)

Pen level → Feeding area → CNN visualisation

Results

- Accuracy (over 10-folds cross validation) = 99.4%
- Execution time (per frame) = 0.021 second
- The above was performed with the following specs:
- Core™ i7 @ 2.5 GHz
- 16 GB RAM
- NVIDIA GeForce GTX 970M



Visualising activations

Classification accuracies of the test data

- To further validate our model performance, we used an independent data set consisting of 7496 images from our surveillance video sequence for testing

Time point	Classification accuracy (%)
Baseline	97.671 ± 2.217
Day 4 food restriction	98.028 ± 1.834
Day returned to ad-libitum feeding	97.157 ± 3.352

Implementation

- **20%** food restriction for 4 days

- To ensure that we have consistent measures across various data frames. Indices of feeding and NNV were calculated as the followings:

$$\mathrm{Fi} = \frac{\sum_{k=1}^{N} FPF_k}{N} \quad (1)$$

$$\mathrm{NNVi} = \frac{\sum_{k=1}^{N} NPF_k}{N}. \quad (2)$$

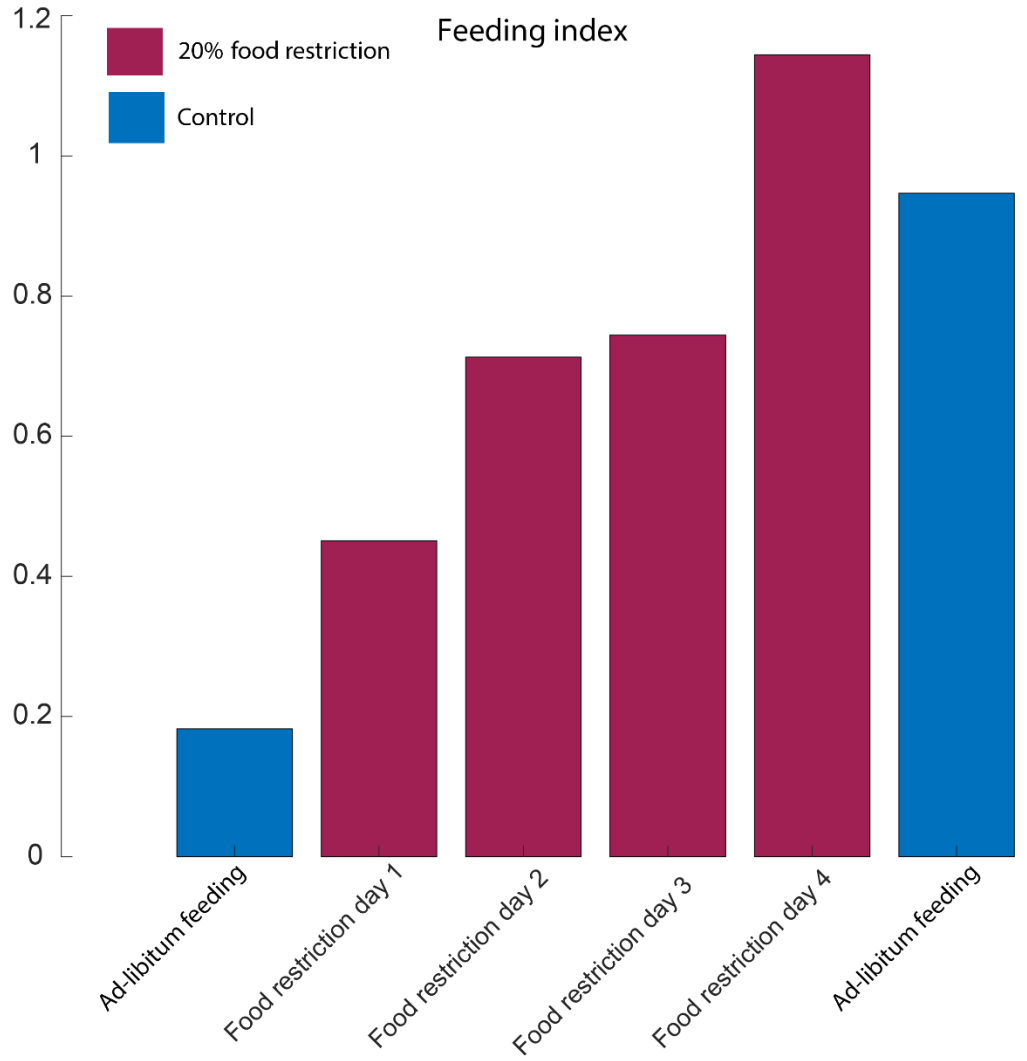
- Scores between 06:00-12:00 across trial

Food-restriction protocol

- **Feeding index** per day across the study period

- Despite less food than the pigs require being available, they are spending an increasing duration of time with their heads in the food trough

- When feeding returns to *ad-libitum* an immediate decrease in feeding index can be seen as the pigs are easily able to consume the full amount of food they require and thus have no need to make repeat trips to the food trough to check for further availability



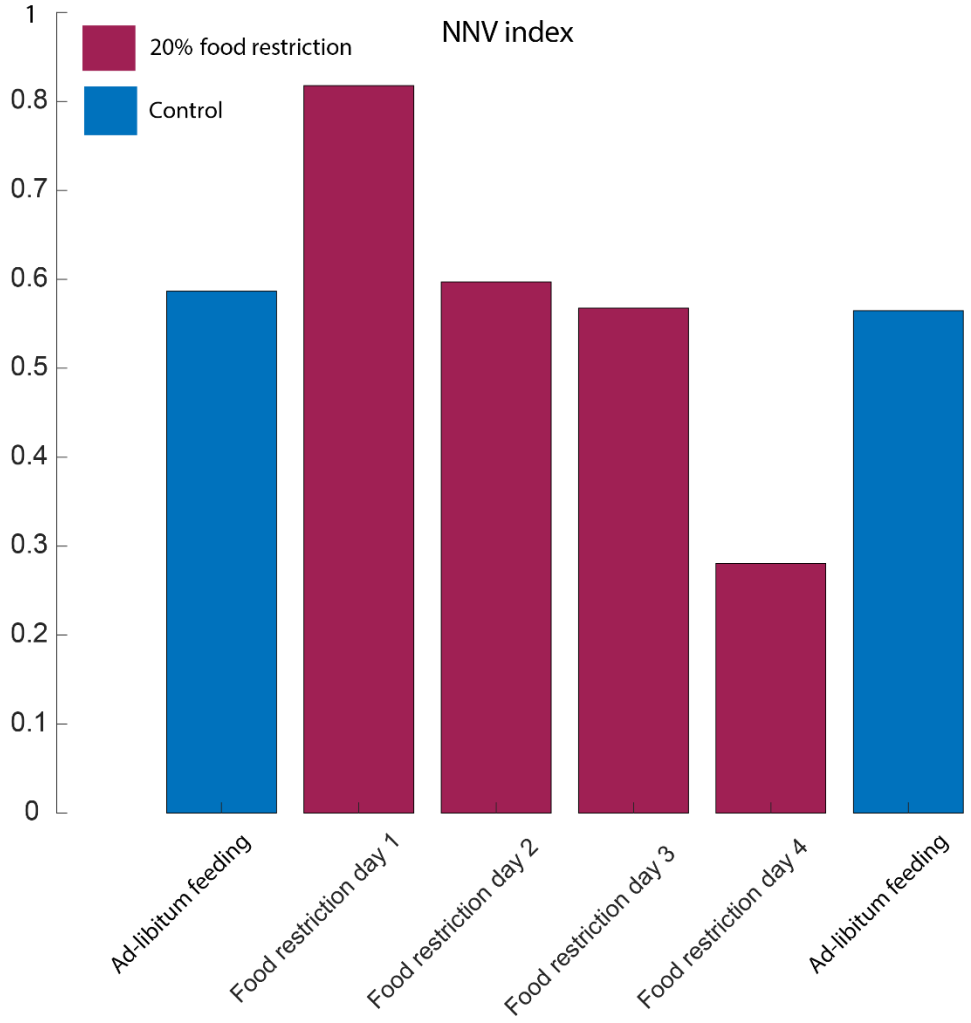
Food-restriction protocol

- **NNV index** per day across the study period

- Immediately following food restriction an increase can be seen in the duration of time spent performing NNVs as the pigs enter the feeing area and are unable to feed due to limited resource availability.

- By day 4, the pigs will be at their most hungry and therefore also likely lacking in energy so reduce further the number of visits they make to the feeding area, likely to conserve energy.

- When *ad-libitum* feeding is restored, the duration spent performing NNVs is equivalent to that of baseline as this behaviour returns to control levels.



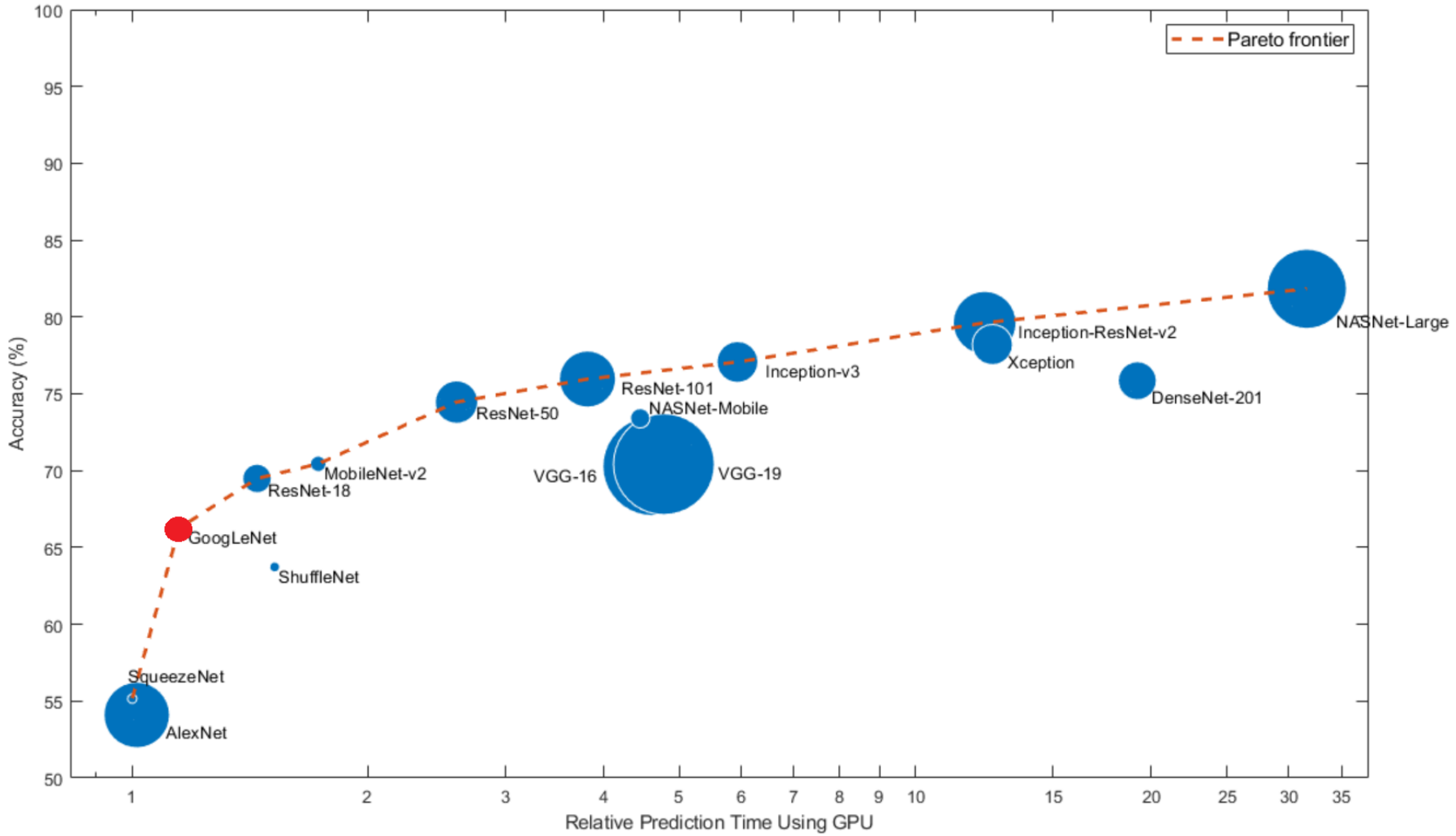
Conclusion

- We have developed a method to obtain feeding and NNV behaviour under commercial settings automatically.

- The proposed method can operate in real-time processing up to 50 frames per second, and it does not require pig marking.

- Our feed detection system can detect and exclude pigs NNV to the feeding trough.

Thank you !!


Pareto frontier
Accuracy (%)
Relative Prediction Time Using GPU
100
95
90
85
80
75
70
65
60
55
50
1
2
3
4
5
6
7
8
9
10
15
20
25
30
35
NASNet-Large
Inception-ResNet-v2
Xception
Inception-v3
DenseNet-201
ResNet-101
NASNet-Mobile
ResNet-50
VGG-16
VGG-19
MobileNet-v2
ResNet-18
GoogLeNet
ShuffleNet
SqueezeNet
AlexNet

Network	Depth	Size	Parameters (Millions)	Image Input Size
alexnet	8	227 MB	61.0	227-by-227
vgg16	16	515 MB	138	224-by-224
vgg19	19	535 MB	144	224-by-224
squeezenet	18	4.6 MB	1.24	227-by-227
googlenet	22	27 MB	7.0	224-by-224
inceptionv3	48	89 MB	23.9	299-by-299
densenet201	201	77 MB	20.0	224-by-224
mobilenetv2	53	13 MB	3.5	224-by-224
resnet18	18	44 MB	11.7	224-by-224
resnet50	50	96 MB	25.6	224-by-224
resnet101	101	167 MB	44.6	224-by-224
xception	71	85 MB	22.9	299-by-299
inceptionresnetv2	164	209 MB	55.9	299-by-299
shufflenet	50	6.3 MB	1.4	224-by-224
nasnetmobile	*	20 MB	5.3	224-by-224
nasnetlarge	*	360 MB	88.9	331-by-331