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Artificial intelligence (AI) and vision technology for improving efficiency and quality in meat production

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AIM

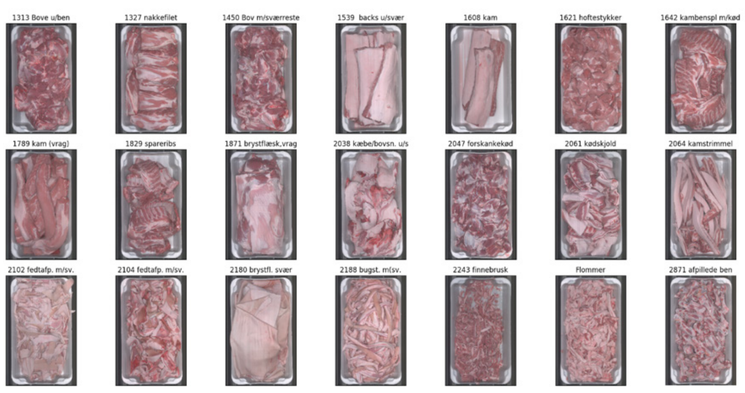
To investigate the application of AI for embedding expert knowledge into software algorithms to be able to automate complex processes in the meat industry. Here, we specifically report on the application of deep convoluted neural networks (CNN) for automatic recognition of main and by-products after deboning in the pig slaughterhouse with the aim of reducing the required manpower for product registration and destination.

METHODS

Our proprietary high-resolution multispectral vision platform, the DynaCQ, was used to capture images of crates with products. The product type for each crate was supplied by manual operator inspection and carefully verified to ensure valid training and verification image sets. Product types were grouped into 30 visually distinct categories, and a model based on the ResNet50 CNN architecture was trained on 700 images of each category and tested offline on additionally 300 images of each category. An online version of the network was implemented to run real-time in the DynaCQ hardware. The online version ran for 10 working days identifying 30.000 images, and this data was validated against the manual operator.

CONCLUSION

AI, specifically deep learning in combination with vision technology, is a powerful tool in meat production where the further automation of processes requires embedding expert knowledge into information and control systems. Specifically, we have shown that a neural network system can largely automate product recognition and destination in the plant thus reducing operator cost and at the same time potentially decreasing the number of erroneously identified products.



Examples of different products in the visually distinct categories automatically recognized by the system.

Example of operator working stations where product identification and registration takes place in the pig slaughterhouse. Automatic product recognition can reduce the number of operators required for this task.

DynaCQ - the Danish Technological Institute's proprietary high-resolution multispectral vision platform – is used for foreign object detection, quality assessment and automatic product recognition.

RESULTS

The precision, defined as the percentage of all test images assigned to the correct category, of the offline recognition was 97%. Using the Softmax classification score to qualify the prediction certainty the precision could be improved to 99% by removing 7% of the images with the lowest prediction certainty. This would require manual identification of the products in these crates.

For the online version the precision was 94%, which could be increased to 98% if 11% of the crates with the lowest prediction certainty were handled manually. The "true" reference product type in the crates was, however, the unverified operator determined type. It is expected that operators have a precision of about 98%, which could well account for some of the reduced precision of the online version compared to the online version.

Softmax value	Precision [%]	Manual inspection [%]
0.0	93.9	0.0
0.5	94.2	0.5
0.7	95.6	3.5
0.8	96.6	5.5
0.9	97.5	8.3
0.95	**98.0**	**10.9**

Results from the online test with approximately 30.000 crates over 10 days. By limiting automatic recognition to crates with a Softmax value over 0.95, precision can be increased from 94% to 98%. Here precision is determined by comparing the CNN prediction with the "true" operator determination. Operator precision is estimated to be about 98%.

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