**Application:** Currently in the United Kingdom, many abattoirs rely on subjective techniques (visual assessment) for grading carcasses. Video image analysis systems coupled with machine learning techniques have the potential to be adopted in abattoirs, offering an objective approach to classification.

**Introduction:** Mechanical grading can objectively classify beef carcasses, however, it is not widely adopted, often due to the infrastructure and equipment costs. Purpose-built imaging systems, requiring limited infrastructure, can extract 3D measurements of beef carcasses, which can be used to predict carcass characteristics, reducing cost. Objective classification can increase trust in the payment system and provide financial incentives for cattle to be finished at the target classification grade. This has the potential to reduce the number of over-finished cattle, increasing farm profitability and reducing greenhouse gas emissions.

**Materials and methods:** A time-of-flight camera, installed in a commercial abattoir in Scotland, captured 7-seconds worth of video per carcass, immediately prior to grading. Thirty-Five point cloud frames were captured per beef carcass and processed in real time, with algorithms developed by Innovent Technology Ltd., using Halcon Image Processing Library (MVTech Software GmbH, Munich, Germany). Forty-four 3D measurements were extracted from 285,109 images of 17,250 carcasses. The 3D measurements were averaged on a per carcass basis giving one data row per carcass, before being split into training and test datasets (70:30). The training dataset was used to build random forests (RFs) and artificial neural networks (ANNs), for the prediction of cold carcass weight (CCW), EUROP conformation class and fat class, using fixed effects (CCW, sex (steer or heifer), breed type (continental or British) and kill date) or fixed effects and the 3D measurements. Grid combinations of model parameters were used to optimise model performance. The best model was then used to predict the dependent variables from the test dataset. The R2 and RMSE for the predicted CCW values were calculated, and a confusion matrix was built to identify the number of correctly predicted classes for conformation and fat.

**Results:** Results for CCW, conformation and fat classes predicted using the best RFs and ANNs are displayed in Table 1. Including the 3D measurements improved accuracies across traits and techniques, compared to including only fixed effects. The best models resulted in moderate-high accuracy for the prediction of CCW (R2=0.72 for RFs, 0.68 for ANNs), conformation class (accuracy = 71% for RF, 77% for ANNs), and fat class (accuracy = 57% for RFs and ANNS).

Table 1. Prediction accuracies for random forests and artificial neural networks for the estimation of cold carcass weight, conformation, and fat class, using fixed effects (FE) and 3D measurements (3DM)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Random Forests | | Artificial Neural Networks | |
|  | FE | FE + 3DM | FE | FE + 3DM |
| **Cold Carcass Weight** | | | | |
| R2 (prediction accuracy) | 0.24 | 0.72 | 0.20 | 0.68 |
| RMSE (kg) | 36.48 | 22.10 | 36.86 | 23.81 |
| **Conformation** | | | | |
| Correctly classified classes (%) | 64% | 71% | 65% | 71% |
| Over/under-scored by one class (%) | 34% | 28% | 33% | 28% |
| **Fat** | | | | |
| Correctly classified classes (%) | 55% | 57% | 55% | 57% |
| Over/under-scored by one class (%) | 40% | 28% | 28% | 30% |

The increased accuracy for conformation and CCW, resulting from including the 3D measurements, suggests a strong relationship between the 3D measurements and these traits. Including the 3D measurements for the estimation of fat class resulted in a relatively small increase (2%) over the fixed effects model, suggesting that the measurement add minimal predictive power.

**Conclusion:** Three-dimensional imaging technology and machine learning techniques (random forests and artificial neural networks) can be used to predict cold carcass weight, conformation class and fat class, in line with EUROP classification standards, with moderate-high accuracy. The machine learning techniques resulted in improved prediction accuracies compared to previous multiple linear regression models, built using the same dataset (Nisbet et al. 2024).

**Acknowledgements:** The authors acknowledge funding from Scotland’s Rural College (SRUC) and the Agricultural and Horticultural Development Board (AHDB)

**References:** Nisbet, H., Lambe, N., Miller, G., Doeschl-Wilson, A., Barclay, D., Wheaton, A., and Duthie, C-A. 2024. Meat Science 209 (March), 109391