Predicting carcass cut yields in cattle from digital images using artificial intelligence

Speaker: Daragh Matthews
T. Pabiou, R.D. Evans, C. Beder, A. Daly

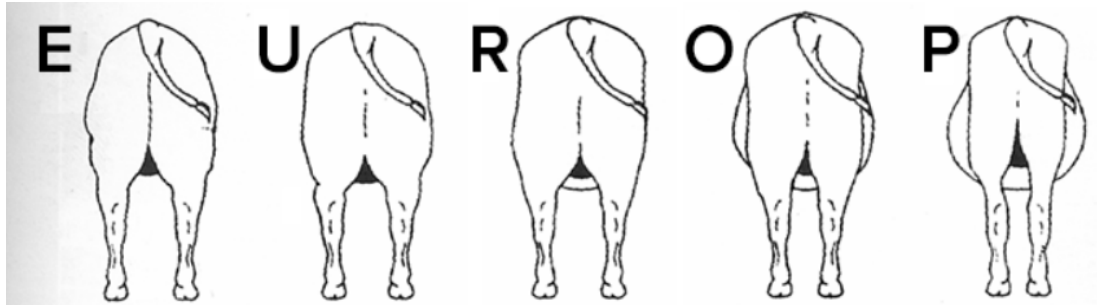
AgTech - it's in our DNA

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Automated in 2003 using Video Imaging Analysis (VIA)

Captures photo

428 VIA variables measuring carcass dimensions, contours and color



E-
2+

P+
3=

Department of Agriculture, Food and the Marine

Conformation score
Fat score
Carcass weight
Slaughter date

DOB, Pedigree, Breed, etc.

~ 70k Images

Slaney FOODS
The Beef Specialists

icbf

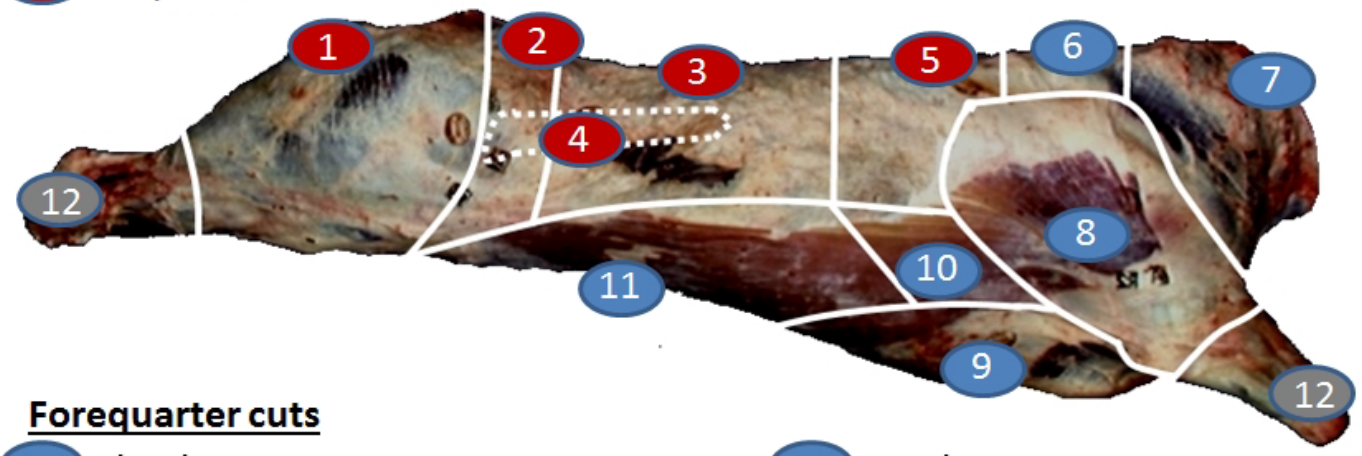
Objective

Predict Cut Yields from Carcass Images using Artificial Intelligence

Cut Groups

Hindquarter cuts

1. Round: Silverside, Topside, Knuckle
2. Rump
3. Striploin
4. Fillet
5. Cube-Roll



Forequarter cuts

6. Chuck
7. Neck
8. Fore-limb: blade, chuck tender, LMC
9. Brisket
10. Middle ribs
11. Flank & Bavette

Other cuts

12. Heel & Shank

Trimmings

Image from T. Pabiou et al. 2009. Genetic parameters for carcass cut weight in Irish beef cattle.

Roasting = Topside + Silverside + Knuckle + Rump

Grilling = Striploin + Fillet + Cube-roll

1. Phenotypic Data 

2. Carcass Images 

3. Phenotypic Data + 
Carcass Image Measurements 

=

=

=

Roasting
Grilling

1. Phenotypic Data

Phenotypic Data

Conformation score
Fat score
Carcass weight
Age at Slaughter
Breed
Slaughter month
Animal type

13 Regression ML algorithms

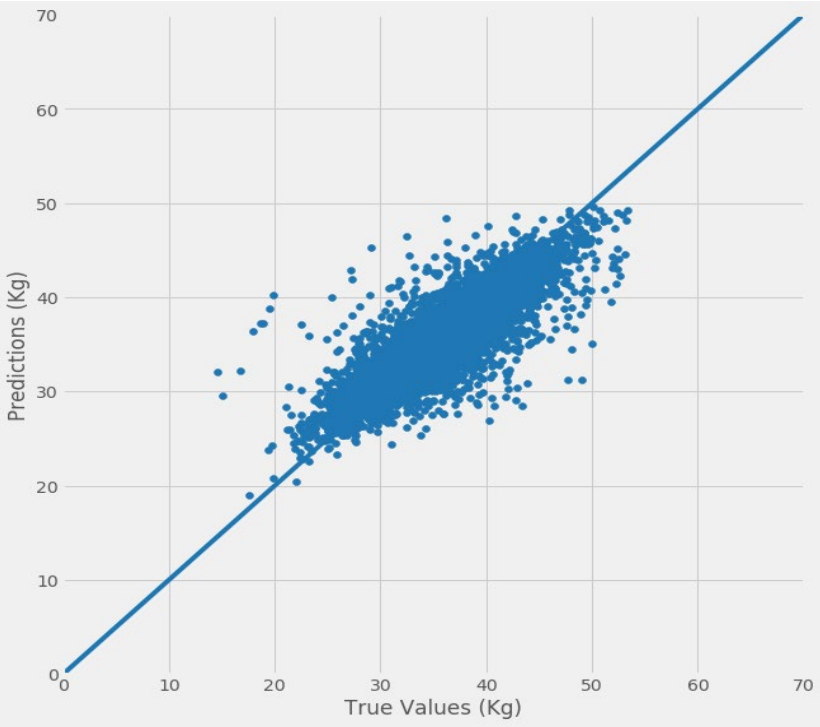
Linear
Ridge
SGD
Elastic Net
Lars
Lasso
Bayesian Ridge
kNN
Decision Tree
Random Forest
SVR
Gradient Boosting
AdaBoost

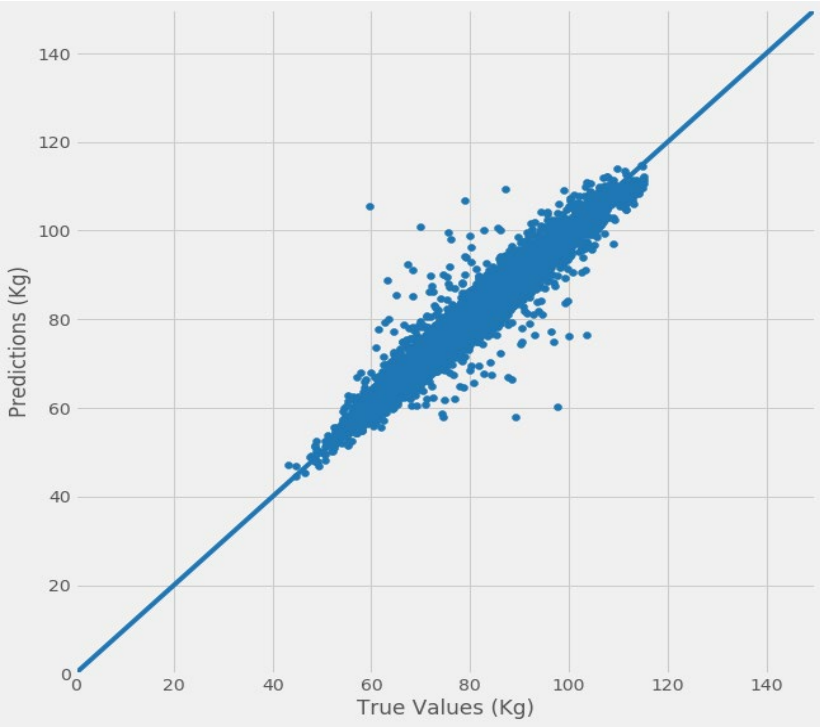
3 Best Performing Models

Hyper-parameter Optimisation using GridSearchCV

Ridge
Bayesian Ridge
Gradient Boosting

1. Phenotypic Data Results





Grilling Cuts	
RMSE:	2.94 kg
RRMSE:	8.4%
R^2:	0.70

Roasting Cuts	
RMSE:	3.23 kg
RRMSE:	4.1%
R^2:	0.93

2. Carcass Images

```
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        [110, 104,  99],
        ...,
        [ 16,  22,  29],
        [ 16,  22,  32],
        [  4,   8,  16]],

       [[ 49,  42,  31],
        [ 38,  37,  30],
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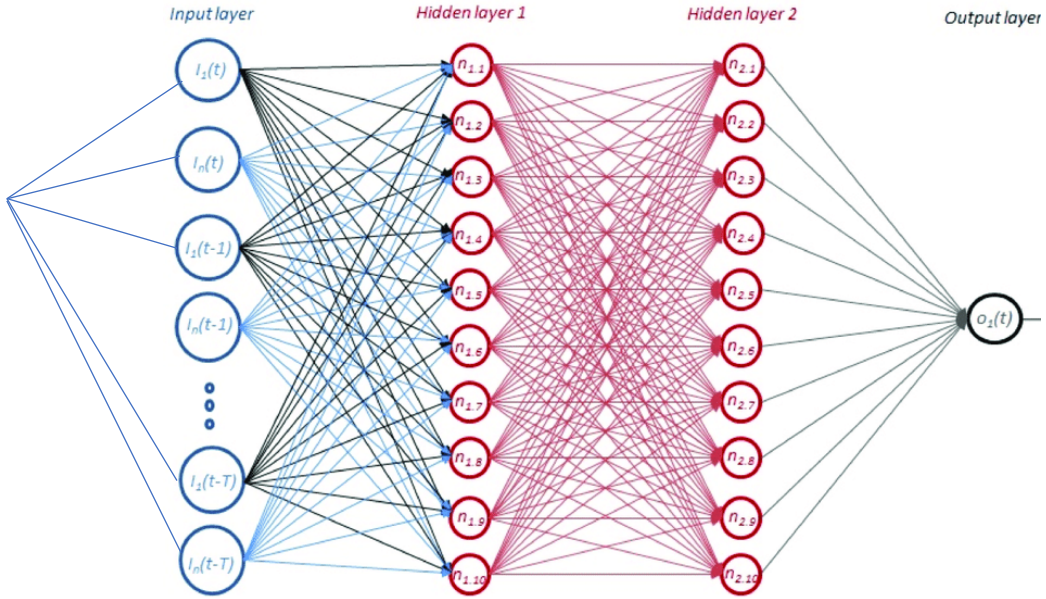
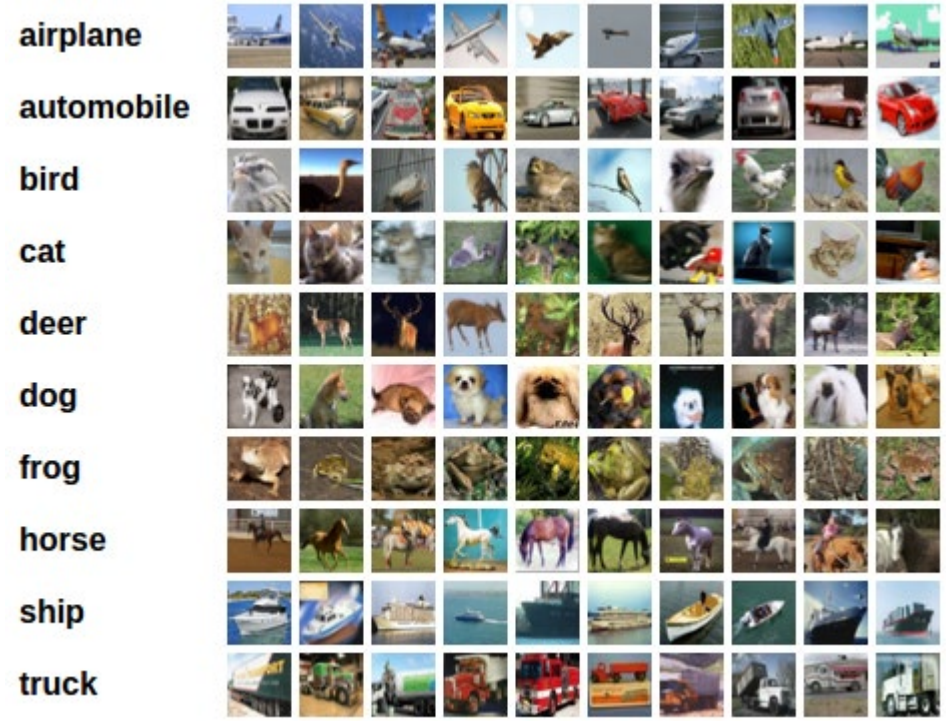


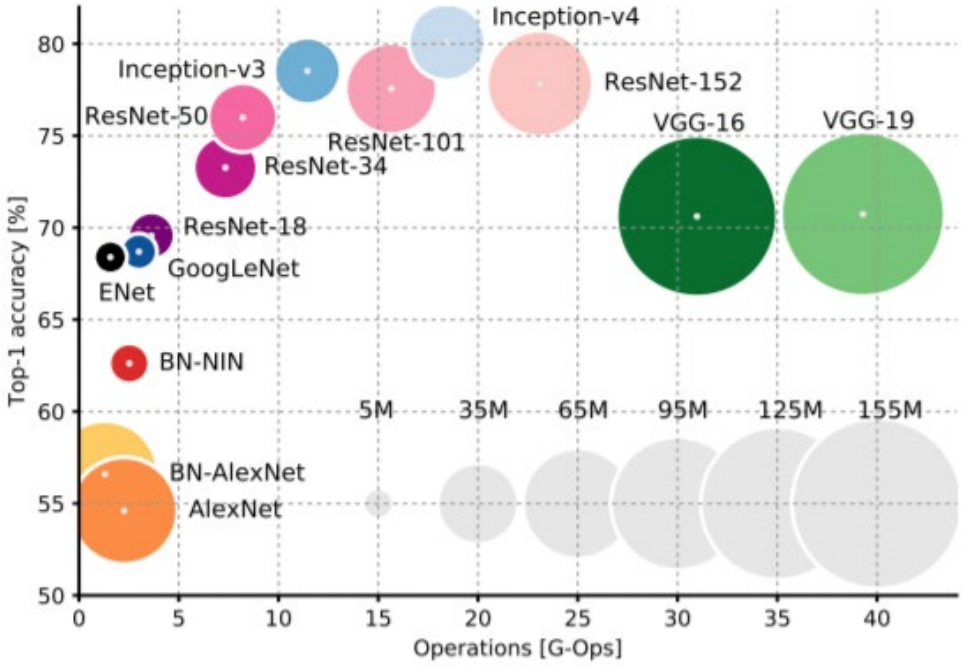
CNN Architecture Decisions!!

Variable	No. of Options
No. of Hidden Layers	∞
No. of neurons/kernels in every layer	∞
Filter size	1 to Image size
Pool size	1 to Image size
Stride length	1 to Image size
Padding	2



ImageNet

>14 M labeled images
>20 k categories
>500 images per category



ImageNet Visual Recognition Challenge

Annual since 2010
CNN's have won since 2012
Model's are open source

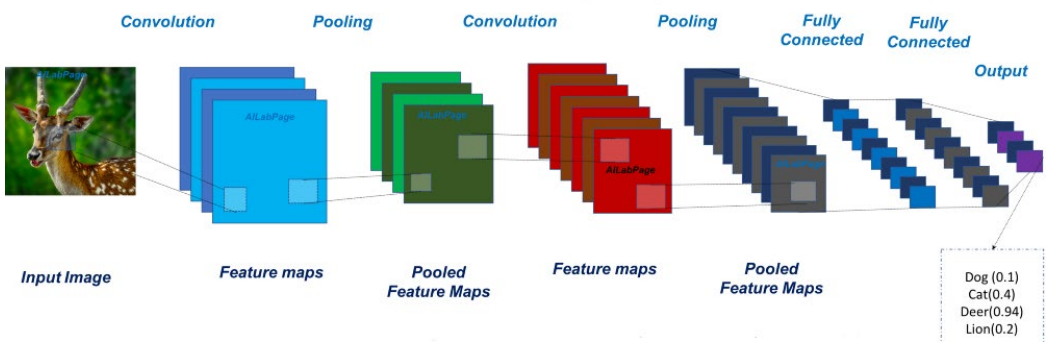
Graph from A. Canziani et al. 2017. An analysis of deep neural network models for practical applications

Pre-trained Models

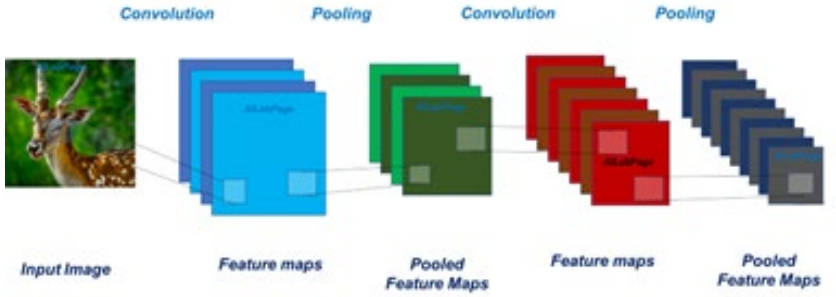
- Deep Learning models available with pre-trained weights
- Can be used for prediction, feature extraction or transfer learning

Model	Size	Top-1 Accuracy	Top-5 Accuracy	Parameters	Depth
Xception	88 MB	0.790	0.945	22,910,480	126
VGG16	528 MB	0.713	0.901	138,357,544	23
VGG19	549 MB	0.713	0.900	143,667,240	26
ResNet50	98 MB	0.749	0.921	25,636,712	-
ResNet101	171 MB	0.764	0.928	44,707,176	-
ResNet152	232 MB	0.766	0.931	60,419,944	-
ResNet50V2	98 MB	0.760	0.930	25,613,800	-
ResNet101V2	171 MB	0.772	0.938	44,675,560	-
ResNet152V2	232 MB	0.780	0.942	60,380,648	-
InceptionV3	92 MB	0.779	0.937	23,851,784	159
InceptionResNetV2	215 MB	0.803	0.953	55,873,736	572
MobileNet	16 MB	0.704	0.895	4,253,864	88
MobileNetV2	14 MB	0.713	0.901	3,538,984	88
DenseNet121	33 MB	0.750	0.923	8,062,504	121
DenseNet169	57 MB	0.762	0.932	14,307,880	169
DenseNet201	80 MB	0.773	0.936	20,242,984	201
NASNetMobile	23 MB	0.744	0.919	5,326,716	-
NASNetLarge	343 MB	0.825	0.960	88,949,818	-
EfficientNetB0	29 MB	-	-	5,330,571	-
EfficientNetB1	31 MB	-	-	7,856,239	-
EfficientNetB2	36 MB	-	-	9,177,569	-
EfficientNetB3	48 MB	-	-	12,320,535	-
EfficientNetB4	75 MB	-	-	19,466,823	-
EfficientNetB5	118 MB	-	-	30,562,527	-
EfficientNetB6	166 MB	-	-	43,265,143	-
EfficientNetB7	256 MB	-	-	66,658,687	-

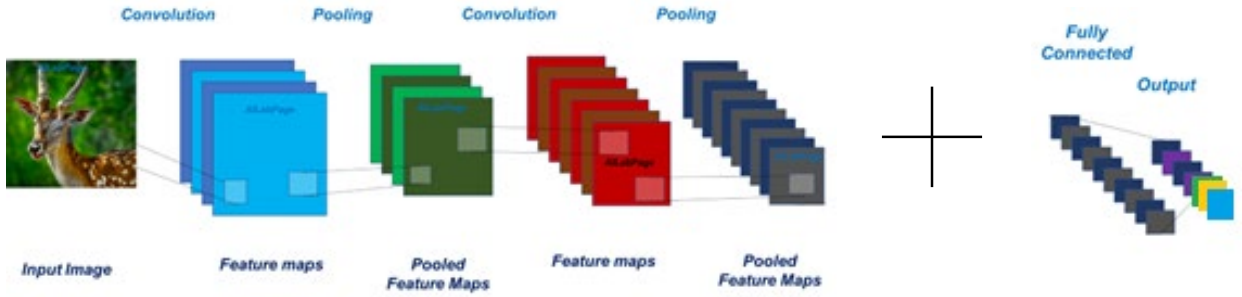
Transfer Learning



Pre-Trained CNN



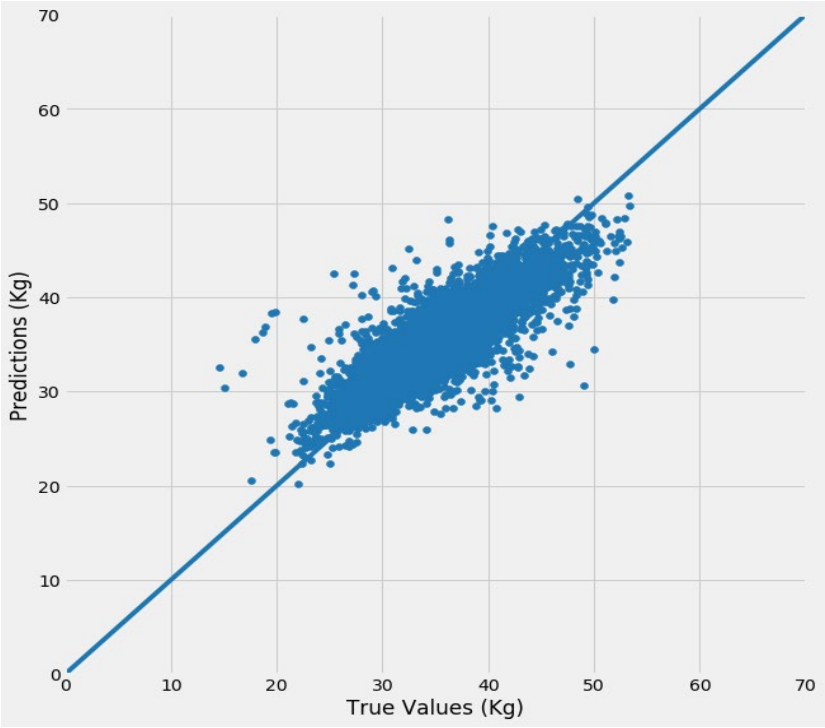
Remove Top Layers

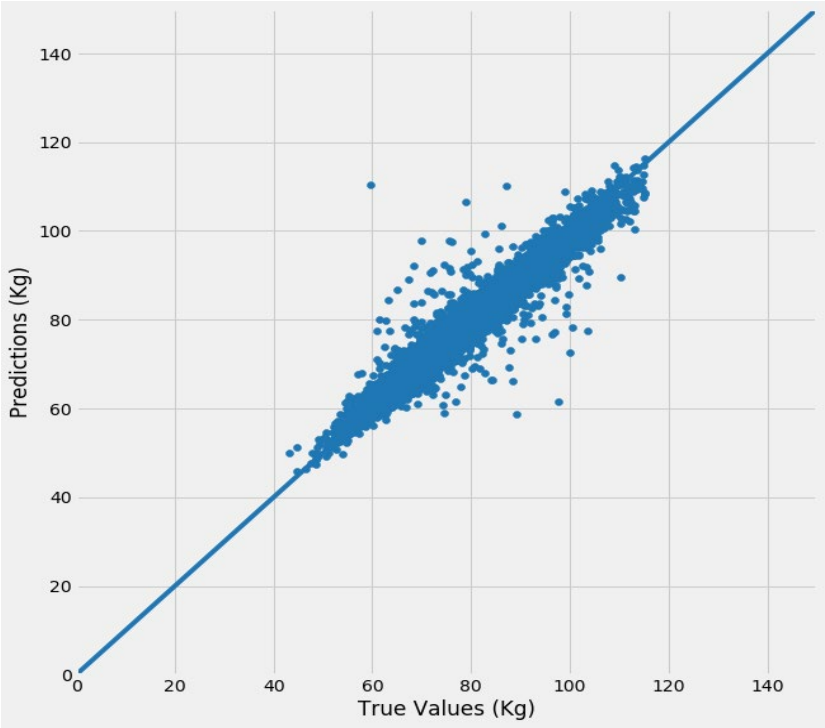


Add Problem Specific Top Layers

Retrain on Carcass Images

2. Carcass Images Results



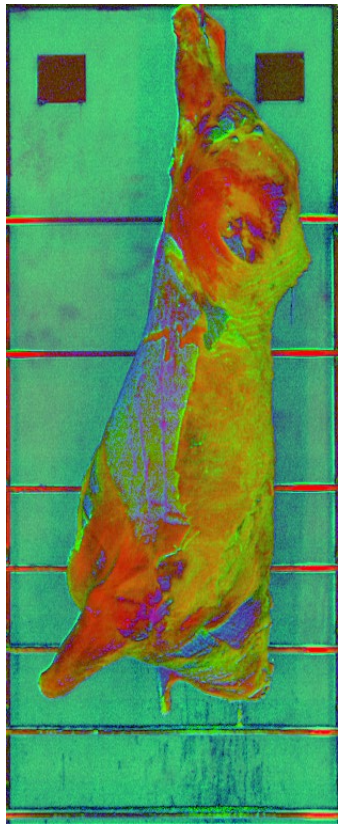


Grilling Cuts		1. Phenotypic
RMSE:	2.84 kg	vs 2.94 kg
RRMSE:	8.1%	vs 8.4%
R^2:	0.72	0.70

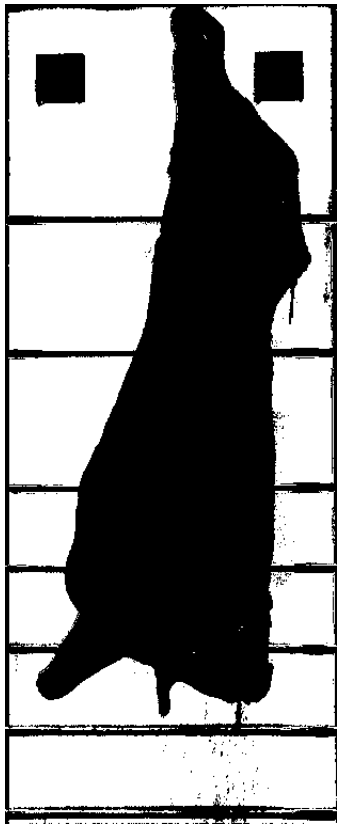
Roasting Cuts		1. Phenotypic
RMSE:	3.26 kg	vs 3.23 kg
RRMSE:	4.2%	vs 4.1%
R2:	0.93	0.93

3. Phenotypic Data + Carcass Image Measurements

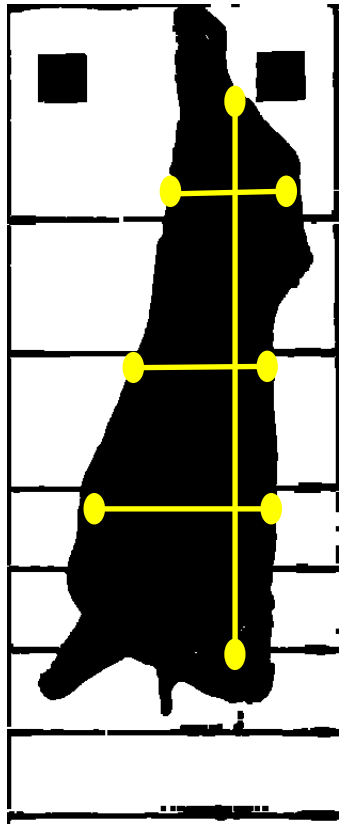
RGB



HSV



Mask



Transform

> 340 measurements

3. Carcass Image Measurements

Carcass Measurements

+

Phenotypic Data
Conformation score
Fat score
Carcass weight
Age at Slaughter
Breed
Animal purpose
Slaughter month
Animal type

13 Regression ML algorithms

Linear
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Hyper-parameter Optimisation using GridSearchCV

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Bayesian Ridge
Gradient Boosting

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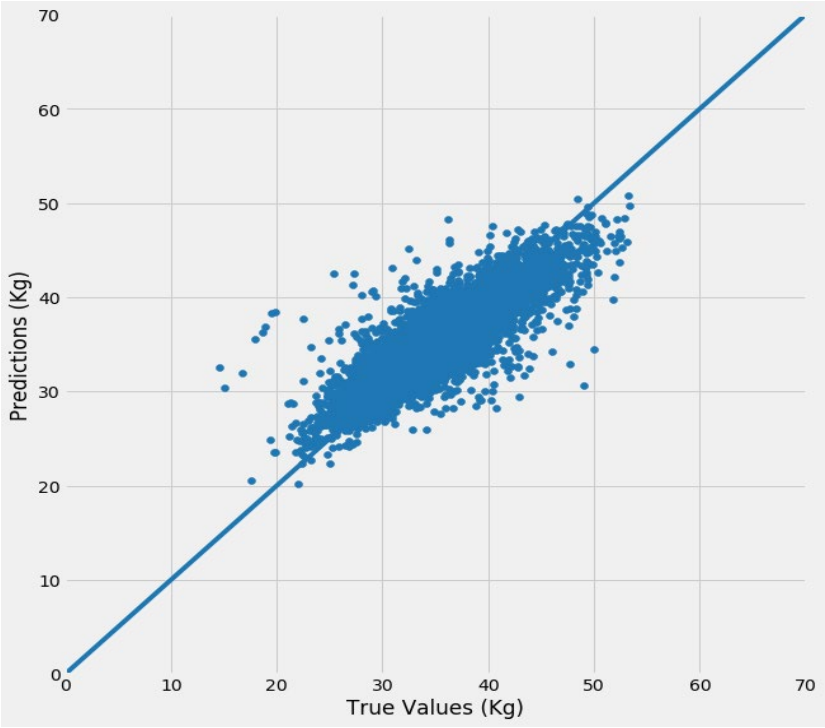
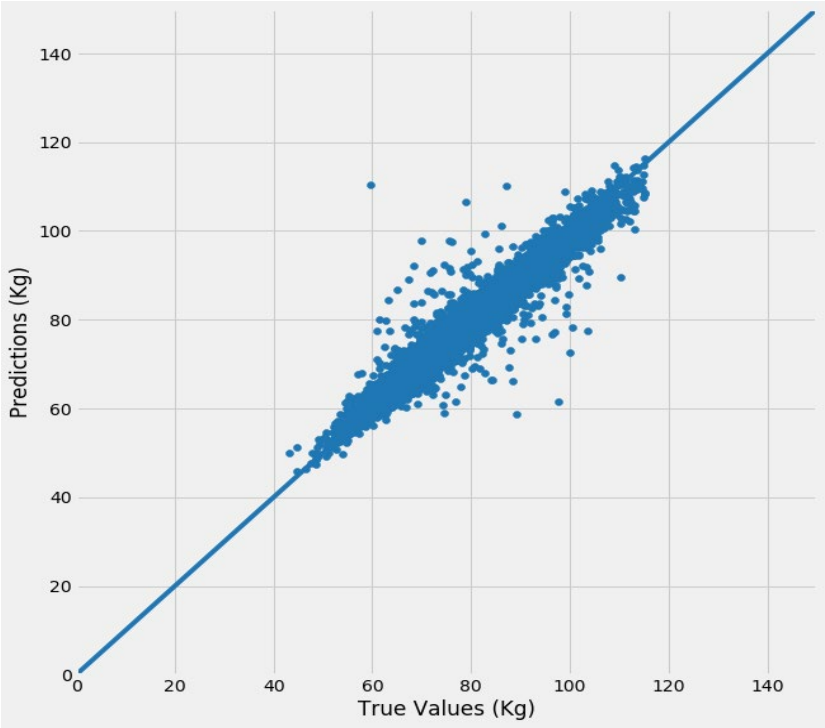
Bayesian Ridge
Gradient Boosting

3. Carcass Measurement Results





Grilling Cuts		1. Phenotypic
RMSE:	2.78 kg	vs 2.94 kg
RRMSE:	7.9%	vs 8.4%
R^2:	0.73	0.70

Roasting Cuts		1. Phenotypic
RMSE:	3.07 kg	vs 3.23 kg
RRMSE:	3.9%	vs 4.1%
R2:	0.94	0.93

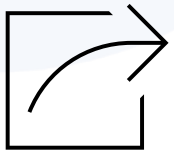
Summary

Approach	Data	Algorithm	Grilling		Roasting	
			RMSE	R^2	RMSE	R^2
1	Phenotypic	Gradient Boosting	2.94	0.70	3.23	0.93
2	Carcass Images	Deep Learning	2.84	0.72	3.26	0.93
3	Carcass measurements + Phenotypic	Gradient Boosting	2.78	0.73	3.07	0.94

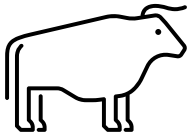
Conclusions

Deep Learning applied to carcass images can predict as well as phenotypic data

Transfer learning is essential for smaller datasets



Domain expertise models outperformed Deep Learning



Our Farmer & Government Representation

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Irish Creamery Milk Suppliers Association

Feirmeoirí Aontaithe na hÉireann
The Irish Farmers' Association
IFA

Our AI & Milk Recording Organisations

DoveaGENETICS

MUNSTER BOVINE
Collectively Improving Farm Life

PROGRESSIVE GENETICS

TIPPERARY CO-OP

Our Herdbooks

IRISH LIMOUSIN Cattle Society

MRI Cattle Society of Ireland
Meuse Rhine Issel -- Milk & Muscle!

AYRSHIRES

THE IRISH ABERDEEN-ANGUS ASSOCIATION

IRISH SIMMENTAL

EASBB

THE IRISH MOILED CATTLE SOCIETY

JERSEY CATTLE ASSOCIATION OF IRELAND

Parthenais

BLONDE D'AQUITAINE

IHHFA
Irish Charolais Cattle Society

IRISH BELGIAN BLUE

Droimeann Cattle Society

IRISH SHORTHORN SOCIETY LTD.

ISP

SALERS Cattle Society of Ireland

IRISH HEREFORD BREED SOCIETY

IRISH AUBRAC

MONTBELIARDE

Ireland's native dairy breed

Norwegian Red Cattle Society

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