Addressing geographical domain shift for quantification of UK road verge biodiversity

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Introduction

Previous work on *DeepVerge* **[1]** demonstrated a method to remotely survey and classify biodiversity levels of roadside verges (Fig. 1) within Lincolnshire (Fig. 2) to an accuracy of 88.9%. This study tests the hypothesis that classification can be enhanced by replacing the nominal classifier with ordinal regression (Fig. 4), thereby leveraging the ordinal information contained within class labels when rank consistency is enforced **[2]**.

Unsupervised domain adaptation by back-propagation **[3]** was implemented (Fig. 7) using imagery from Norfolk's Roadside Nature Reserves (Fig. 3) to extend *DeepVerge* across geographical locales. Feature alignment between domains must be performed to learn similarities.

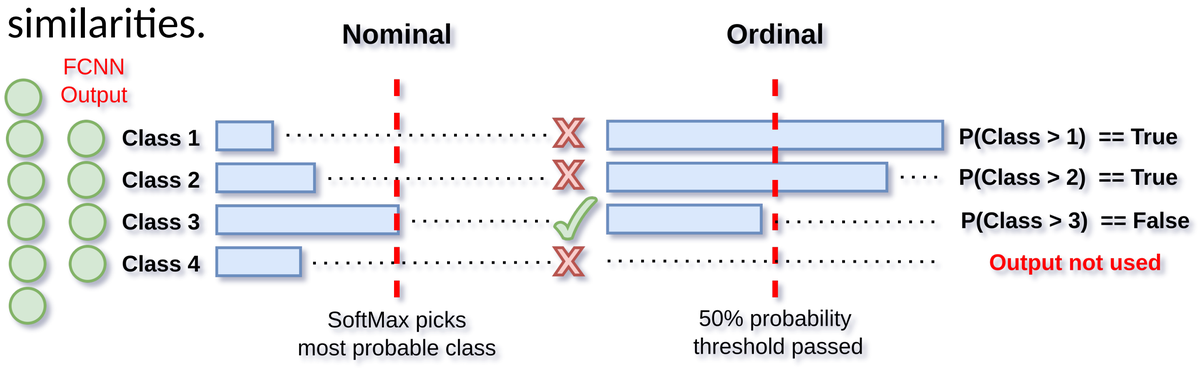

Fig. 4 Same class predicted - Nominal classes assume no relationship between each other whereas ordinal classes are progressively higher in value

Fig. 1 Goal: Classification of roadside verge biodiversity based upon the number of flower species

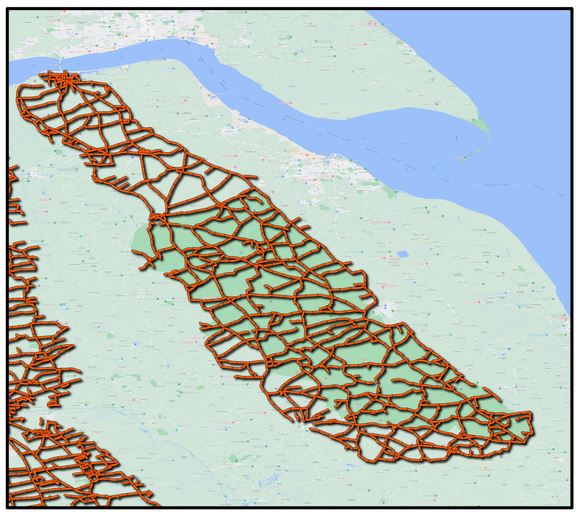

Fig. 2 Source: Lincolnshire road verge survey as used by *DeepVerge*. Accuracy 88.9% [1]

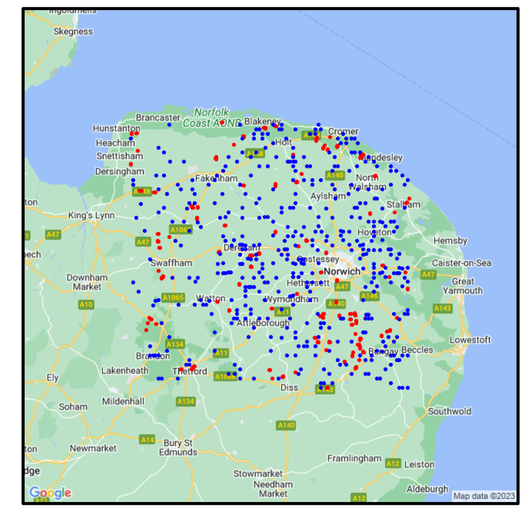

Fig. 3 Target: Norfolk RNRs (red) and non-RNRs (blue)

Ground truth check and domain adaptation

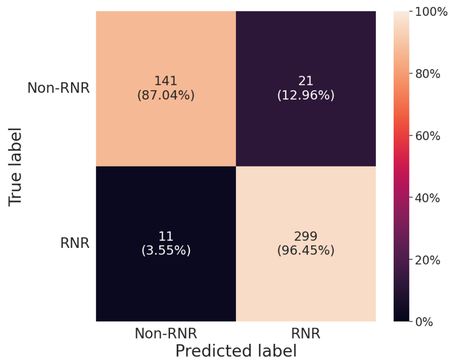

Fig. 5 Ground-truth test of Norfolk - Differentiating between Roadside Nature Reserves (RNR) and non-RNRs: Accuracy 93.02%

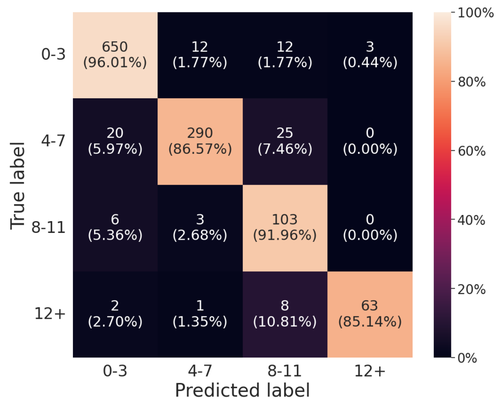

Fig. 6 Adapting Lincolnshire domain with Norfolk: Accuracy 92.3%

Ordinal regression results

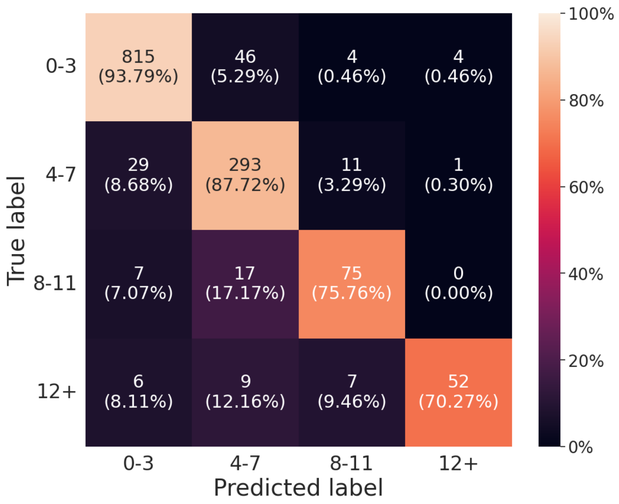

Fig. 8 Lincolnshire fine tuned with ordinal regression. Accuracy 89.75%

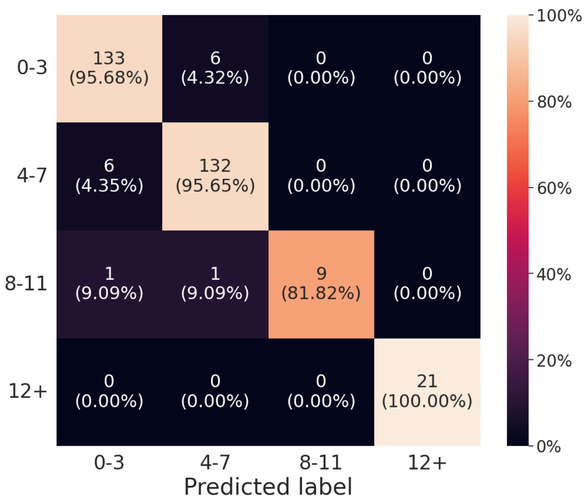

Fig. 9 Norfolk fine tuned with ordinal regression. Accuracy 95.46%

Domain adaptation with ordinal regression

As class labels are learned via standard back-propagation the feature learning is adapted based upon the domain through gradient reversal.

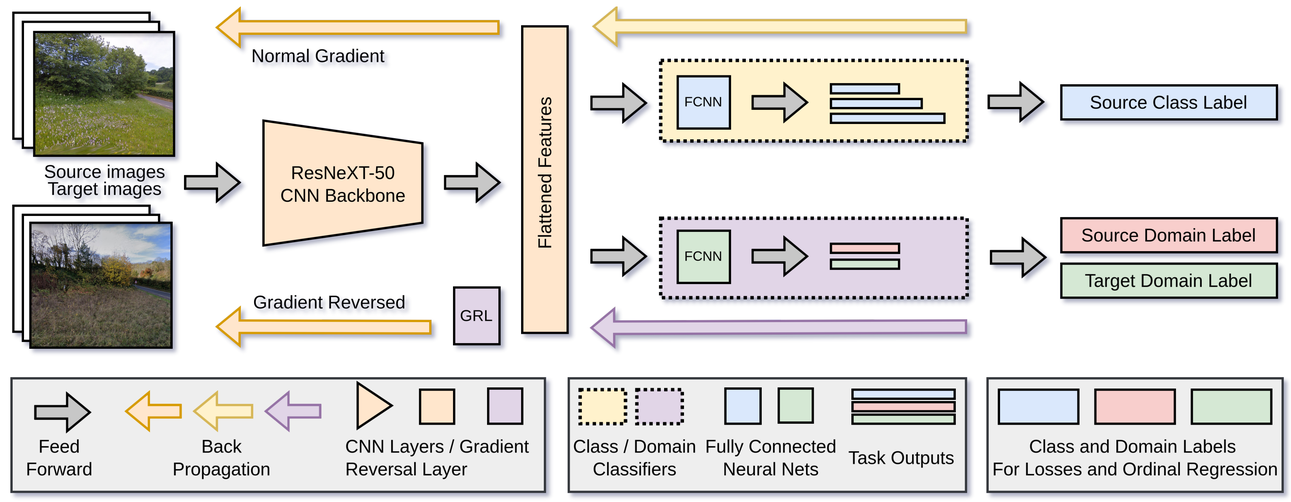

Fig. 7 Convolutional Neural Network with ordinal regression for class labels and similarity between domains learning via gradient reversed back-propagation **[3]**

Conclusions from MSc (work continues with PhD)

Fine tuning *DeepVerge* for ordinal regression on both Norfolk and Lincolnshire domains (Fig. 8 and 9) show very good results individually. Applying domain adaptation of Lincolnshire with Norfolk (Fig. 6) results in a good 92.3% accuracy for Lincolnshire but a poor 41.3% for Norfolk. It is currently postulated that class features require aligning rather than overall domain features, or that Norfolk class label ground truth is incompatible, or wrong, despite ground truth checks (Fig. 5).

References

[1] Perrett, A., Pollard, H., Barnes, C., Schofield, M., Qie, L., Bosilj, P. and Brown, J.M., 2023. DeepVerge: Classification of roadside verge biodiversity and conservation potential. Computers, Environment and Urban Systems, 102, p.101968.
[2] Shi, X., Cao, W. and Raschka, S., 2023. Deep neural networks for rank-consistent ordinal regression based on conditional probabilities. Pattern Analysis and Applications, pp.1-15.
[3] Ganin, Y. and Lempitsky, V., 2015, June. Unsupervised domain adaptation by backpropagation. In International conference on machine learning (pp. 1180-1189). PMLR.

Information

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** Verge and map imagery (Figs. 1,2,3 & 7) courtesy of Google Maps API