Recognizing Bengali Word Images - A Zero-Shot Learning Perspective

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Motivation

- Deep-learning-based methods are very popular and successful in different classification tasks
- It demands labeled data for proper training and can only deal with "seen" class samples
- LSTMs can recognize "unseen" word classes, but requires fully transcribed text lines and sometimes a language model
- Labeling data demands human intervention, hence costly
- "Zero-shot learning" (ZSL) algorithms with proper feature and class attribute signature can counter this situation and we proposed a ZSL based method here for handwritten recognition.

Novelty/Challenges

- Zero-Shot Learning(ZSL) mainly has been explored for object detection
- To the best of our knowledge there is no work on any Indic script word recognition in ZSL perspective
- Signature/Semantic attribute space is very rich in object domain with information on colour and texture but such information is absent in handwritten text

Dataset Details

- 250 different word classes of place names in the State of West Bengal in India
- Data collection form contains 8 classes with space to provide 3 samples of handwriting for each class.
- Elastic morphing based off-line data augmentation

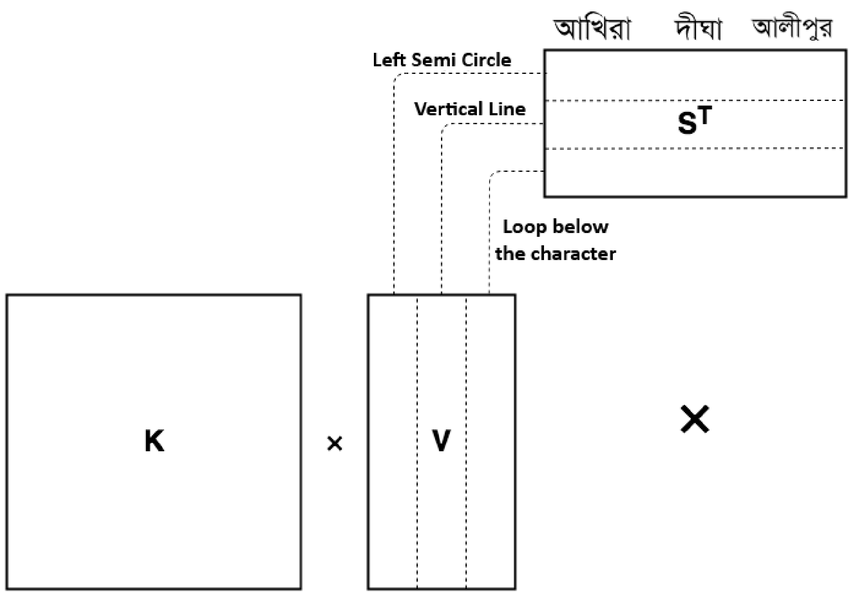
Training, testing & validation data after data augmentation

Data	Fold 0	Fold 1	Fold 2	Fold 3	Fold 4
Training	47360	47412	47300	47340	47370
Validation	11790	11800	11774	11780	11790
Testing	14796	14736	14868	14820	14787

Methodology

জোড়াবাগান অনধিরামপাড়া দরিয়াপুর কালীঘাট

The basic shape attributes marked in red in different Bengali characters



- Learning – is the mapping of basic shape attributes and deep
- features in matrix "V":

$$V = (K^T K + \gamma I)^{-1} KY\, S(S^T S + \lambda I)^{-1}$$

- K is a regular kernel matrix for example "Gaussian", "Polynomial" etc
- λ makes the instances on the attribute space more invariant
- The value of γ balances the values of signature attribute
- Classification - calculated per instance 'k' in K,where K could be a Gaussian Kernel

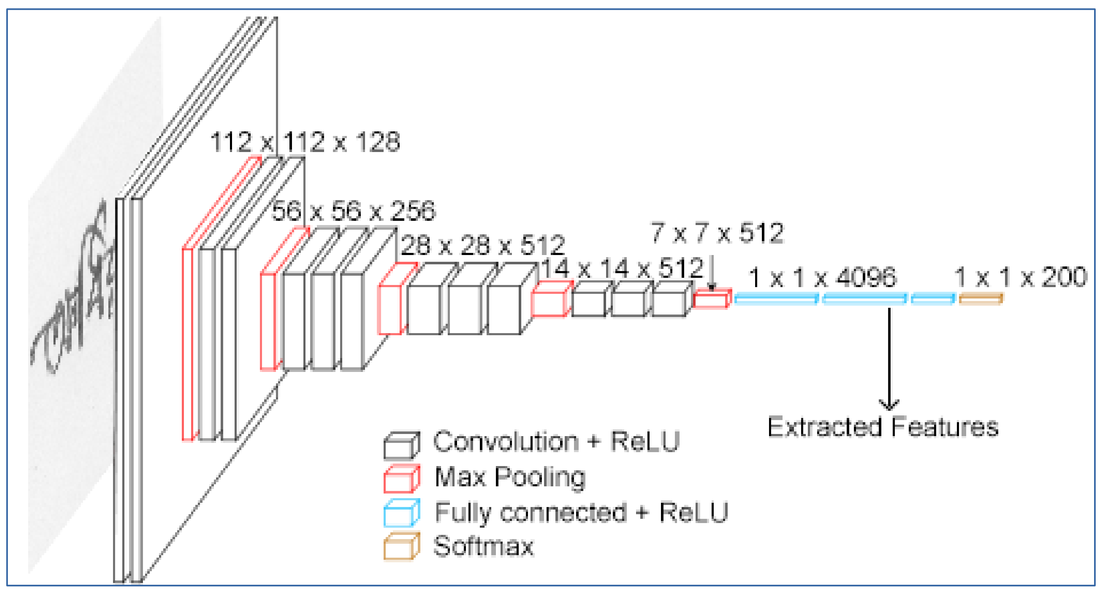
$$\underset{\text{Argmax}}{kVS_i^T}$$

- S_i is the signature attribute of i^{th} test class

Experimental Framework

- Five-fold cross validation with 50 test classes in each fold
- Different CNN architectures to generate features for word recognition.
  - training from scratch
  - no data-flipping inside the architecture
- Features were extracted from output of FC1 layer of VGG16

- For InceptionNet, XceptionNet and ResNet, features were extracted from the average pool layer
- Deep-learned features along with shape attribute signature features are being to the Zero-shot learning algorithm.



Schematic diagram of our customized VGG16 architecture as used in our experiment.

Results and Discussion

Performance with respect to different signature attributes

Sig. Attribute	Fold 0	Fold 1	Fold 2	Fold 3	Fold 4
S-Alph.	23.88%	32.35%	33.15%	29.66%	19.88%
4S-Sp.-Alph.	49.89%	39.06%	48.98%	49.06%	50.53%

Performance with respect to different CNN architecture as the feature extractor

Architecture	Fold 0	Fold 1	Fold 2	Fold 3	Fold 4
GoogleNet	35.09%	41.32%	30.28%	28.64%	39.66%
ResNet152	29.26%	28.52%	35.88%	26.07%	27.36%
XceptionNet	44.76%	35.45%	41.43%	38.21%	44.57%

Comparison

Performance of AREN on same data

Method	Fold 0	Fold 1	Fold 2	Fold 3	Fold 4
AREN	26.41%	27.24%	31.61%	25.11%	30.31%
Our Method	49.89%	39.06%	48.98%	49.06%	50.53%

Conclusions

- "Unseen" word class images could be recognized using "Zero-shot" learning techniques with shape strokes as attribute signatures
- Efficacy of different CNN architectures were analyzed in the context of ZSL-based word image recognition

References

1.Bernardino Romera-Paredes and Philip Torr, "An embarrassingly simple approach to zero-shot learning," in Proc 32nd In ICML, Lille, France, 2015.
2. Guo-Sen Xie et al. "Attentive region embedding network for zero-shot learning," in Proc. CVPR, 2019.