Training with Single Class Images and Generalizing for Multi-class Images Using Kasami Orthogonal Classification Layer

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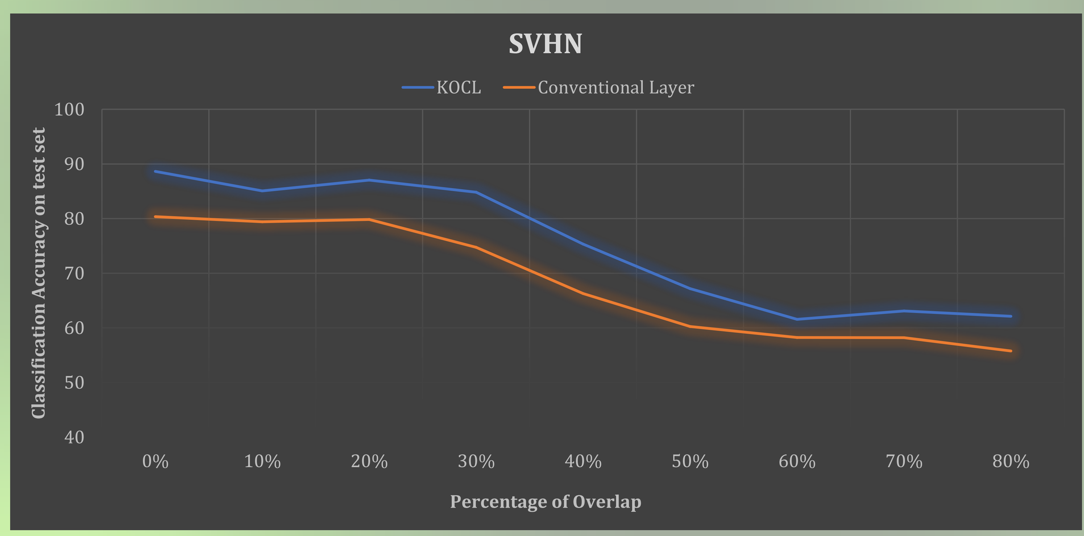
Introduction

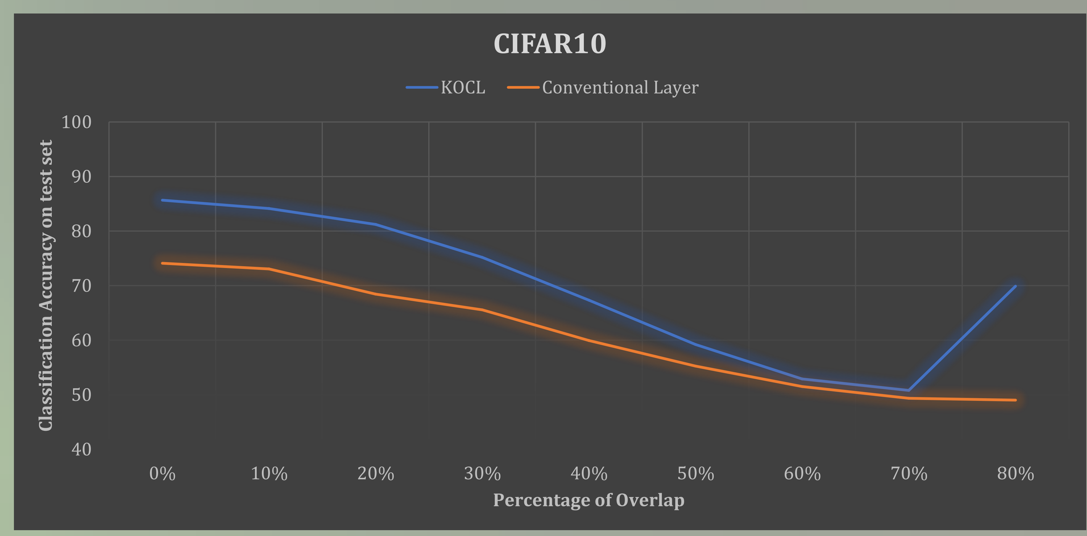
A Kasami Orthogonal Classification Layer (KOCL) for classification networks consists of a fully connected layer (just like a conventional classification/output layer) but with fixed non-trainable weights that are equal to a set of orthogonal Kasami codes. Each Kasami code among the set is assigned to one of the output neurons of the classification/output layer.

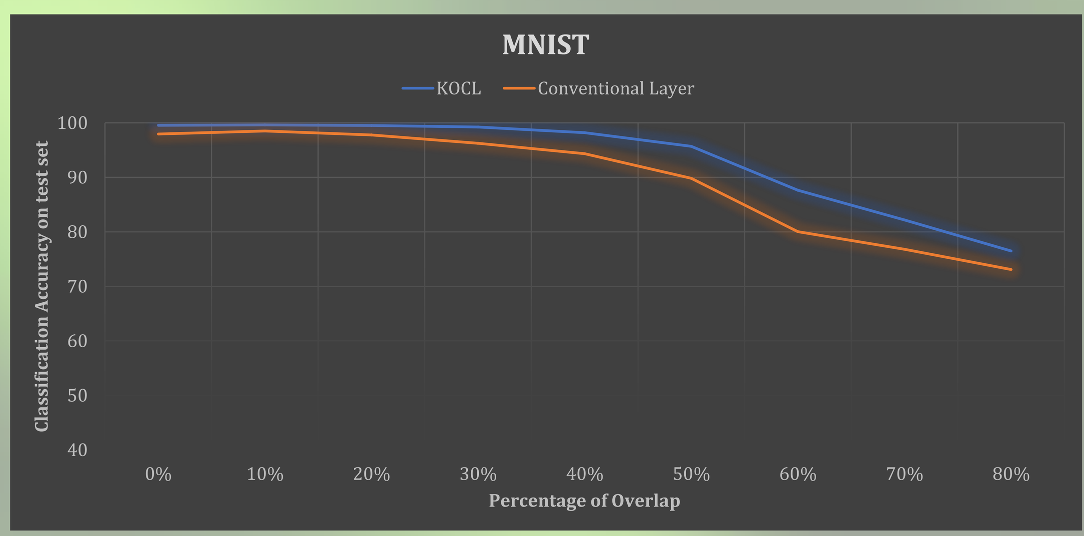
Benefitting from the orthogonal properties of Kasami codes, and considering that latent representations generated by the network for a data point that belongs to more than one class can be approximated as the sum of the individual latent representations learned during training for all the classes present in this multi-label data point, we trained neural networks only on single label images then tested it with multi-label images without additional multi-label training.

Experimental Results

A small CNN with 7 convolutional layers was constructed, using 3 VGG like blocks and a single point-wise convolutional layer at the end, was used in our experiments. Each of the 3 blocks consists of two convolutional layers with kernel size of 3X3, padding of 1, and a stride of 1. Batch normalization is applied after each convolutional layer, followed by ReLU nonlinearity. The spatial dimension is reduced by half at the end of each block using a 2X2 max pooling layer. The 3 VGG blocks are followed by a final layer of point-wise convolution where a kernel of size 1X1 is used to reduce the number of output feature maps. Finally, a global average pooling is applied to produce the output latent representation vector. This latent representation vector is then passed to either a conventional classification layer or KOCL depending on which setup is being tested.



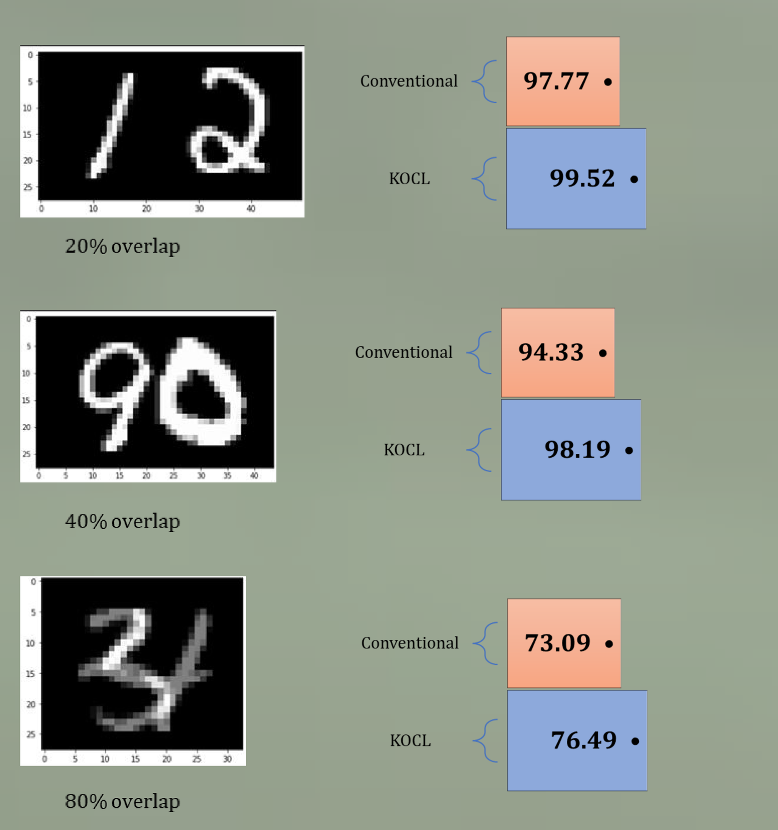




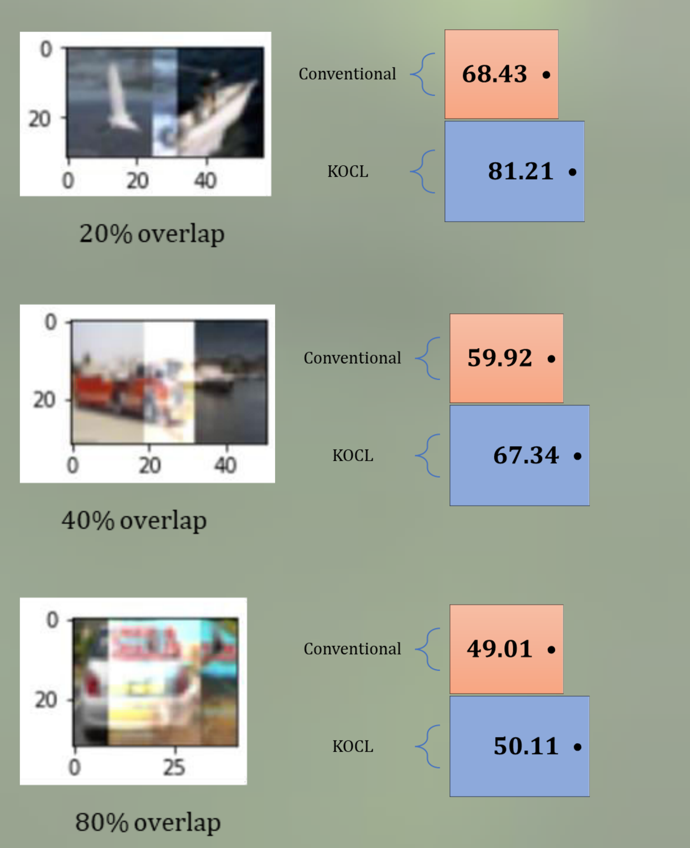
A set of 4 orthogonal Kasami codes each with length 15 bit

Code A	1	1	1	1	-1	1	-1	1	1	-1	-1	1	-1	-1	-1
Code B	-1	-1	1	-1	1	1	1	-1	1	1	1	1	1	1	-1
Code C	1	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1	-1	1	1
Code D	-1	1	-1	-1	-1	-1	1	1	-1	1	-1	-1	1	-1	1

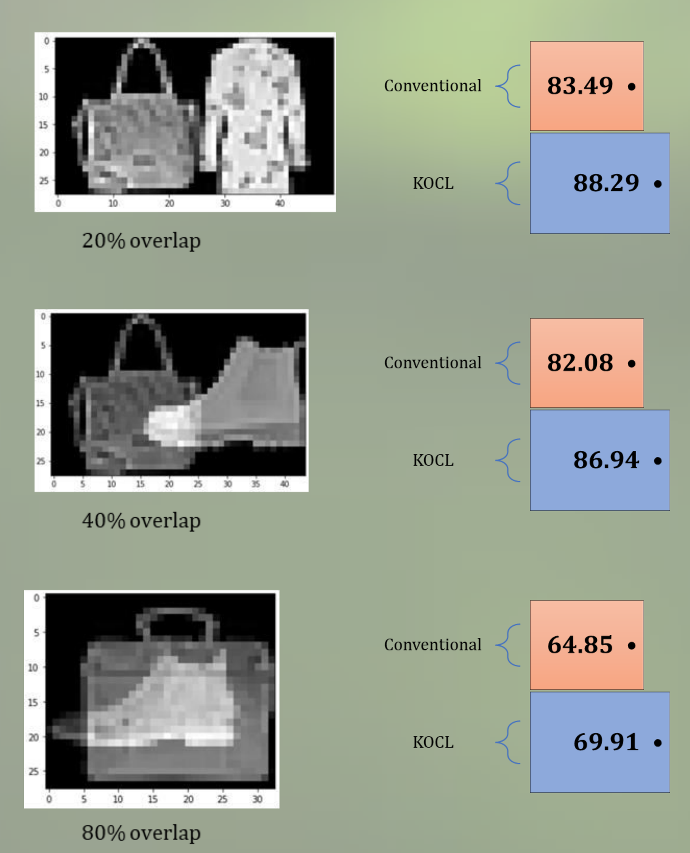
MNIST



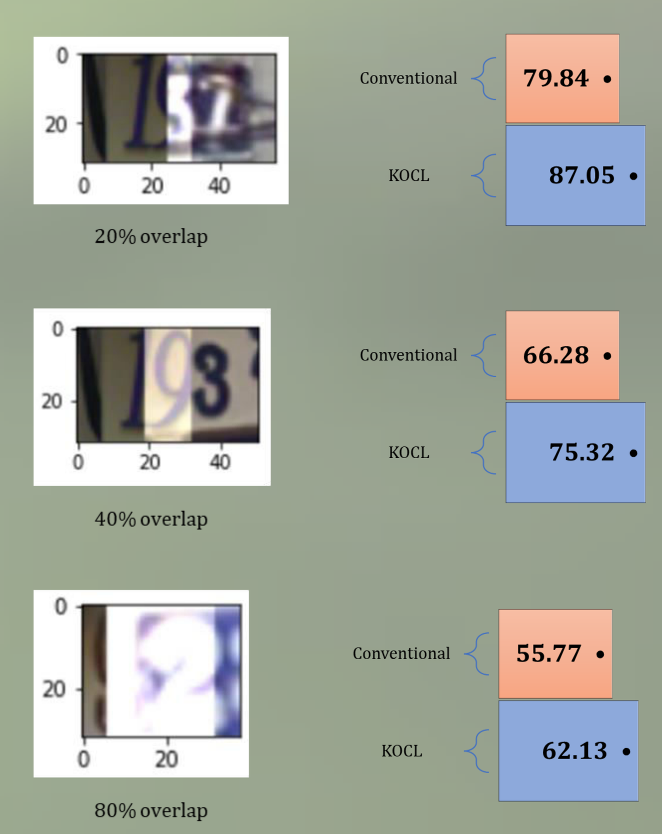
CIFAR10



Fashion MNIST



SVHN



Conclusion:

Neural networks trained on single label data showed very good potential to generalize for multilabel test data without requiring any additional multi-label training. KOCL showed significant performance advantage compared to conventional classification layer where it consistently provided higher testing accuracy of multi-label data in all the experiments conducted in this study. KOCL ability to encourage the network to produce Kasami codes as latent representation for different data classes provide it with a competitive advantage when the network is tested against multi-label images due to the orthogonality properties of Kasami codes

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