

VRE for regional Interdisciplinary communities in Southeast Europe and the Eastern Mediterranean

Analysis of Learned Features for Remote Sensing Image Classification

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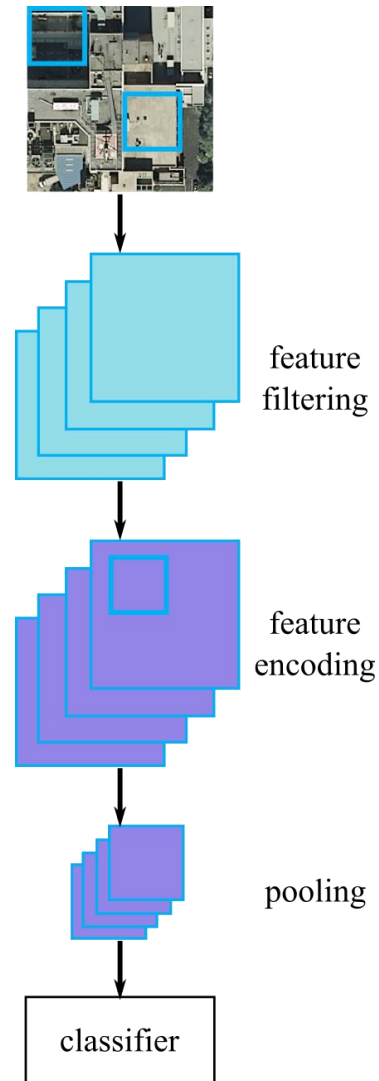
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Vi-SEEM

- ❑ Convolutional neural networks (convnets)
 - ❑ Excellent results in image classification tasks
 - ❑ Computational requirements
 - ❑ Large training datasets needed
 - ❑ Data labeling in remote sensing is expensive
- ❑ Good classification results with random weights
- ❑ Using pretrained convnets on different tasks
- ❑ Convnet = feature extractor + classifier
- ❑ Features are important in image classification
 - ❑ Classifiers working on pixels vs. Classifiers working on features
 - ❑ Hand-crafted features: Gabor, SIFT, HOG
 - ❑ Learning features
- ❑ Why are convnets good feature extractors?

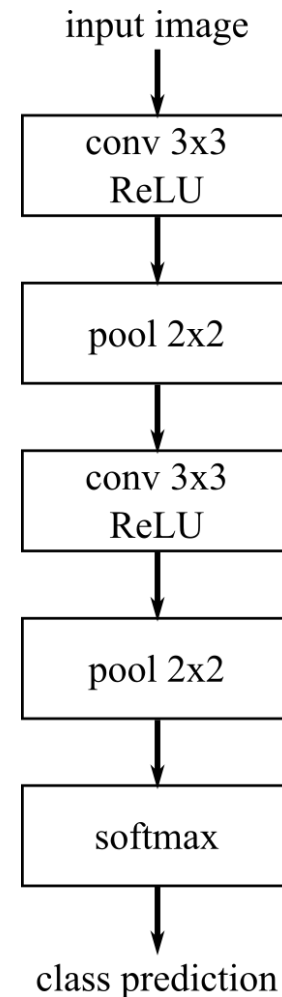
- ❑ Convolutional layer
 - ❑ Filter bank
- ❑ Nonlinear activation
 - ❑ Filter response encoding
- ❑ Pooling layer
 - ❑ Pooling of coded features
- ❑ Filters are learned
- ❑ Pretrained convnets
 - ❑ Classifier training
- ❑ How good are the obtained features?





- ❑ Images sampled from NAIP dataset,
- ❑ Ortophoto aerial images,
- ❑ Spatial resolution 1 m,
- ❑ RGB+NIR images,
- ❑ 28 x 28 pixels,
- ❑ **SAT-4 dataset**
 - ❑ 500,000 images
 - ❑ 4 land-cover classes
 - ❑ 400,000 images for training, 100,000 for testing
- ❑ **SAT-6 dataset**
 - ❑ 405,000 images
 - ❑ 6 land-cover classes
 - ❑ 324,000 images for training, 81,000 for testing

- ❑ Simple convnets
 - ❑ One/Two convolutional layers
 - ❑ Max-pooling layers
 - ❑ Softmax classifier
- ❑ Random filter weights
 - ❑ Softmax classifier is trained
- ❑ Learning filter weights and classifier
 - ❑ Same dataset
 - ❑ Different datasets

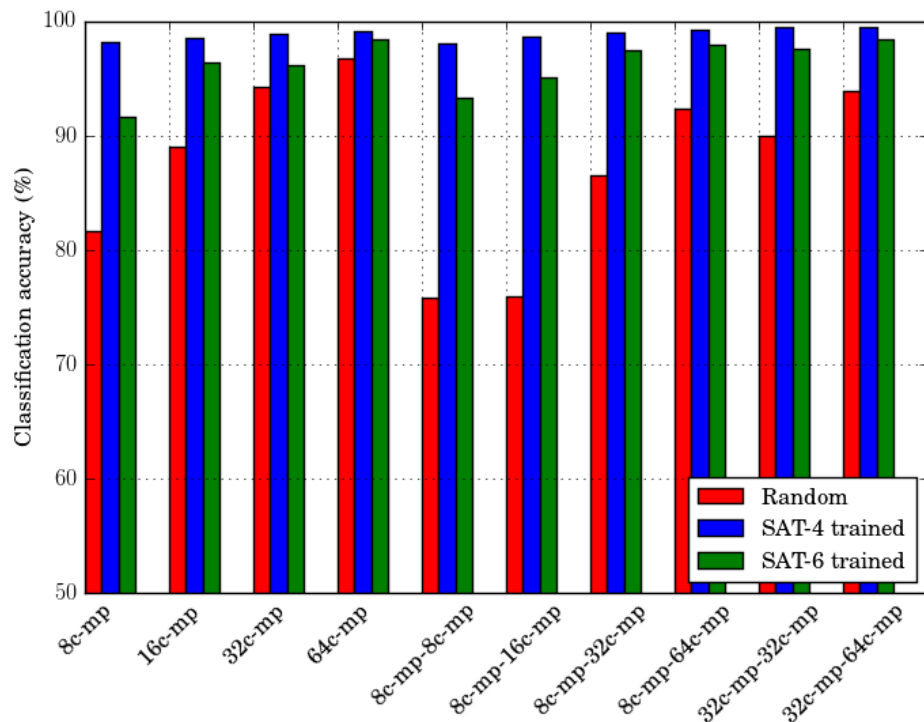




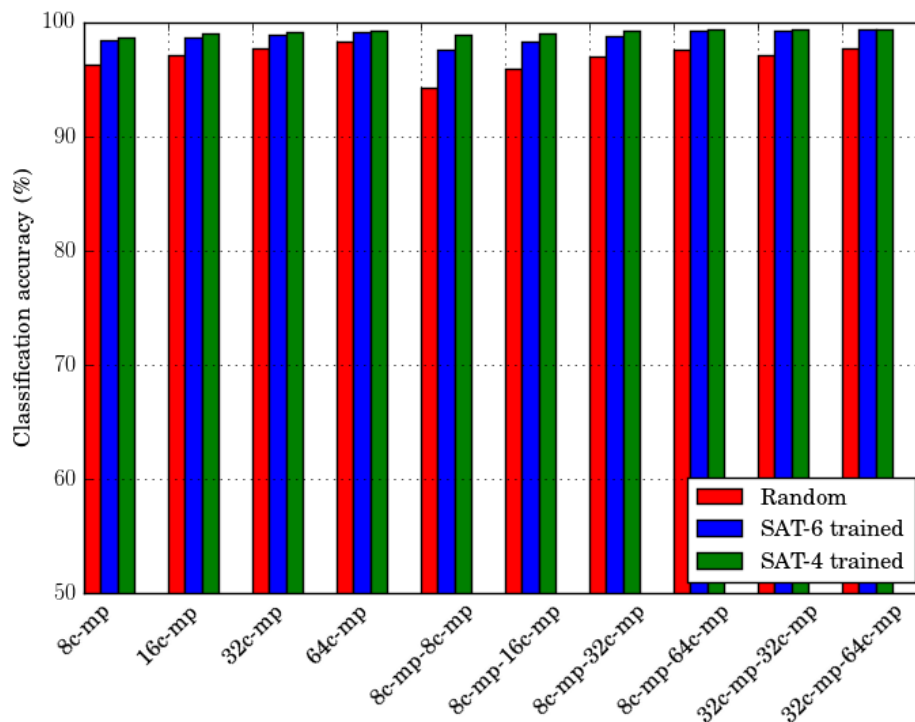
- ❑ Discrimination between classes
 - ❑ Distance
 - ❑ Compactness
- ❑ Fisher discriminant analysis
- ❑ Linear transform of data
 - ❑ Increase between-class scatter
 - ❑ Decrease within-class scatter
- ❑ Fisher criterion
 - ❑ Optimal for Gaussian distributed data
 - ❑ Approximation of class separability



Validation accuracies



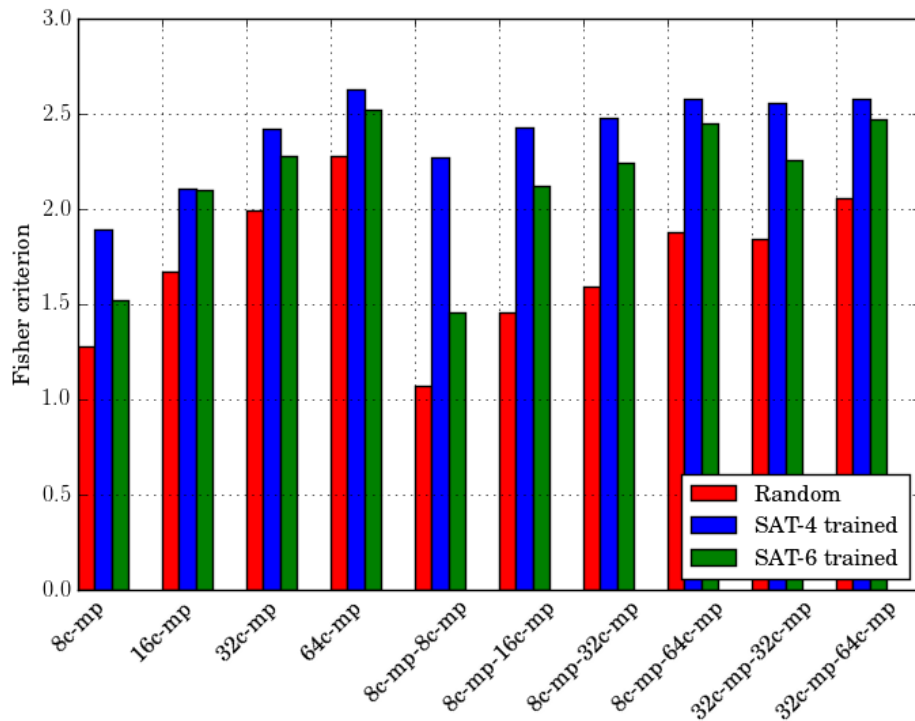
SAT-4



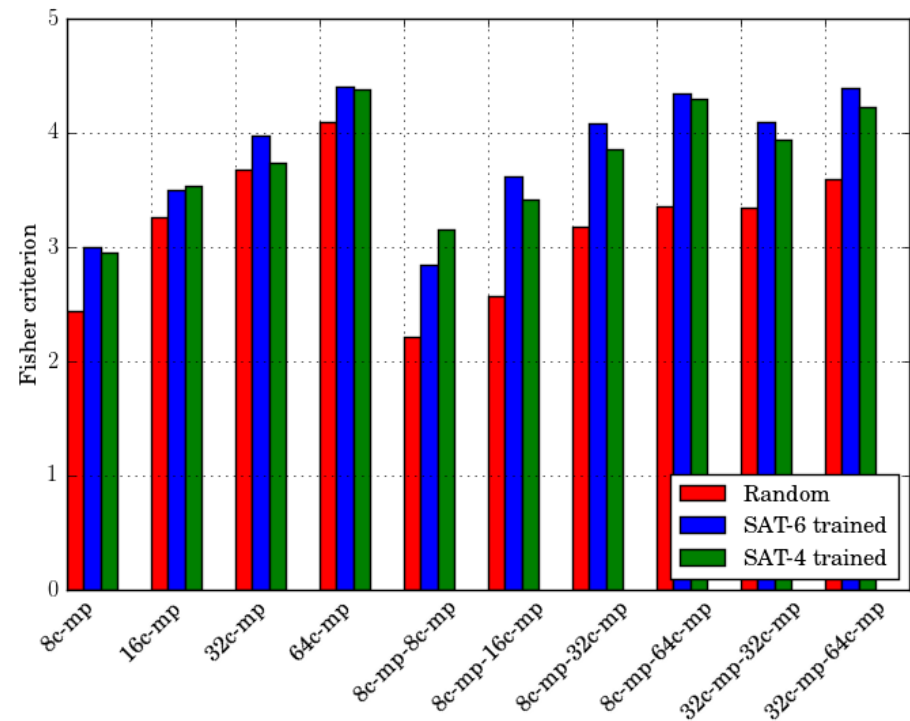
SAT-6



Fisher criterion



SAT-4



SAT-6



Comparison with the state-of-the-art



Model	SAT-4 (%)	SAT-6 (%)
DeepSat	97.95	93.92
VGG	99.98	99.98
64c-mp (random)	96.87	98.00
32c-mp-32c-mp (trained)	99.52	99.40
32c-mp-64c-mp (trained)	99.54	99.44



- ❑ Random weights
 - ❑ Reasonable results with one convolutional layer
 - ❑ Adding filters helps
 - ❑ Adding convolutional layers does not help
 - ❑ Importance of convolution
- ❑ Learned filters
 - ❑ Improve results
 - ❑ Better discriminability of features
 - ❑ Adding filters help
 - ❑ Adding convolutional layers help
- ❑ Explore universality of features
- ❑ Fisher discriminant with non-Gaussian data