Machine Learning in Remote Sensing
–Practice material–

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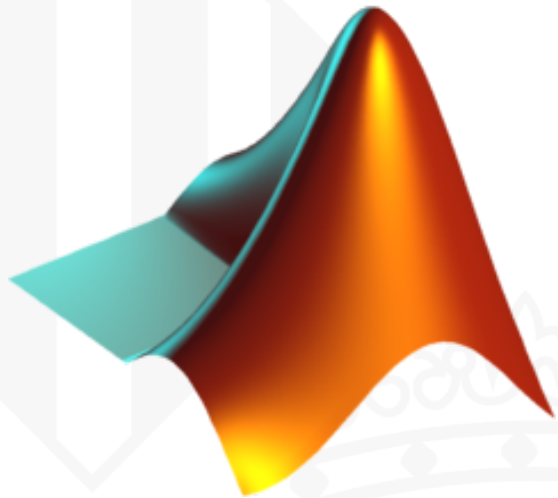
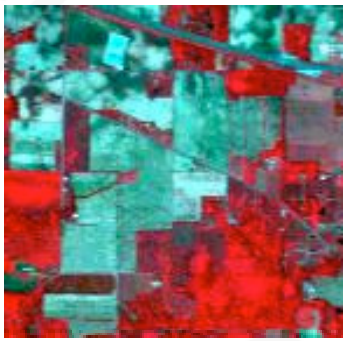
1. **Supervised classification of hyperspectral images**
2. **Feature extraction from hyperspectral images**
3. **Spectral unmixing and abundance estimation**
4. **Hyperspectral and LiDAR data fusion**
5. **Biophysical parameter retrieval with kernel regression**



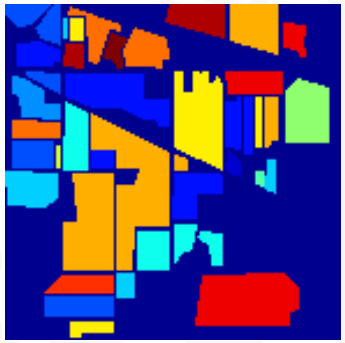
Practice 1: Supervised classification of hyperspectral images: LDA, k-NN, and SVMs w/wo spatial information `>> demo1.m`

- **Data:**
  - Standard image: 16 crop classes, Indiana (USA), 1999.
  - AVIRIS sensor: 220 bands, 145×145 pixels.

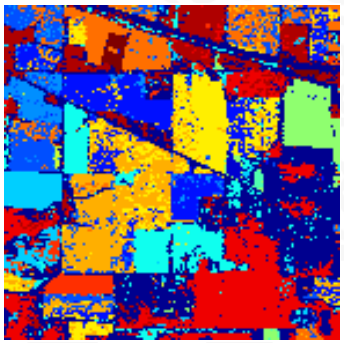
RGB



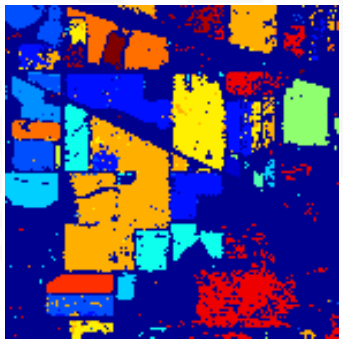
Ground truth



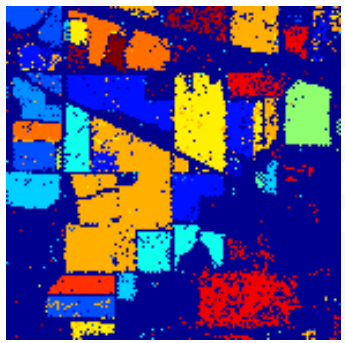
LDA (59.72%)



kNN (86.11%)



SVM (88.27%)

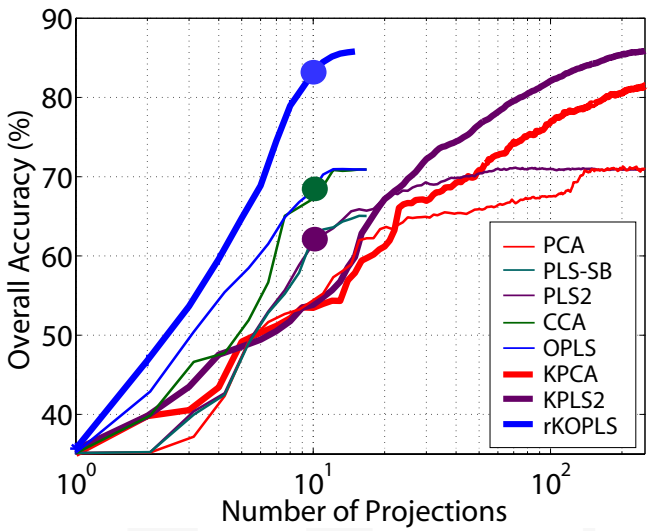


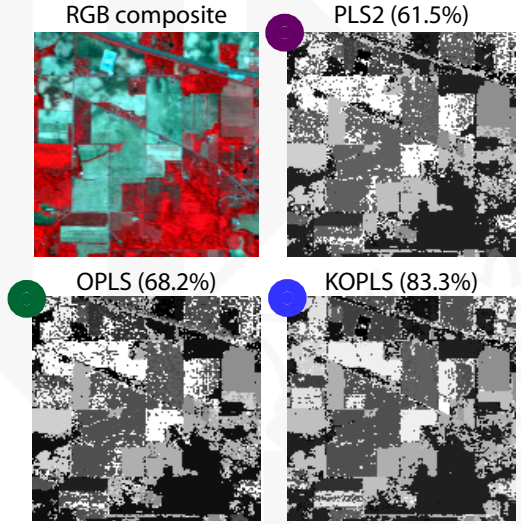
Practice 2: Feature extraction from hyperspectral images

P2a Extract standard spatial features `>> demo2a.m`

P2b Extract advanced spectral feature extraction `>> demo2a.m`

- **Data:**
  - AVIRIS image taken over NW Indiana's Indian Pine test site in June 1992
  - 145×145 image size, 220 features (bands), 16 land cover classes
  - 80% for training and 20% for testing
  - Classifier: linear classifier on top of different number of features





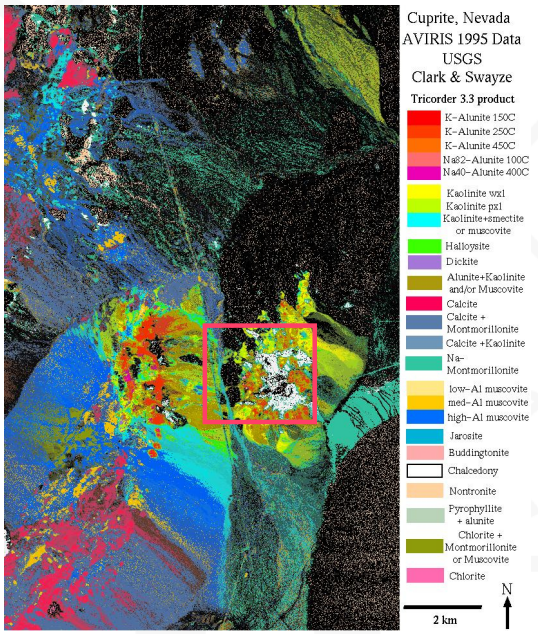
Practice 3: Evaluate several algorithms for signal unmixing

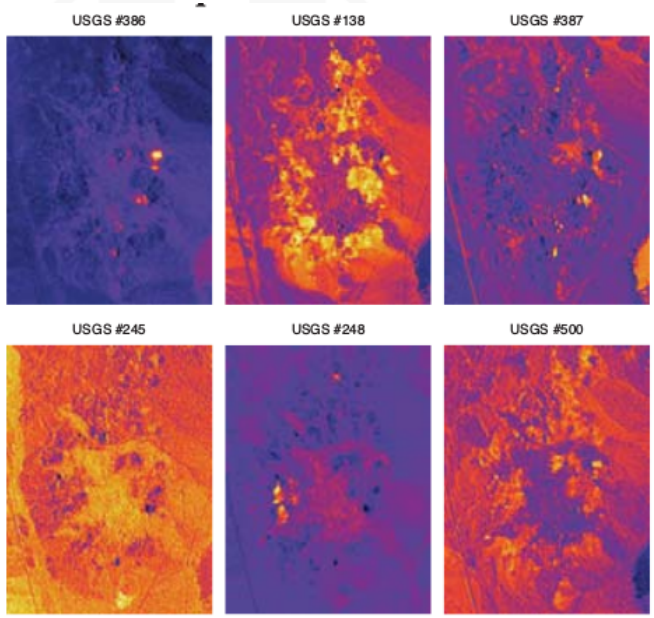
P3a Signal subspace determination `>> demo3a.m`

P3b Endmember determination `>> demo3b.m`

P3c Abundance estimation with unconstrained LS linear regression `>> demo3c.m`

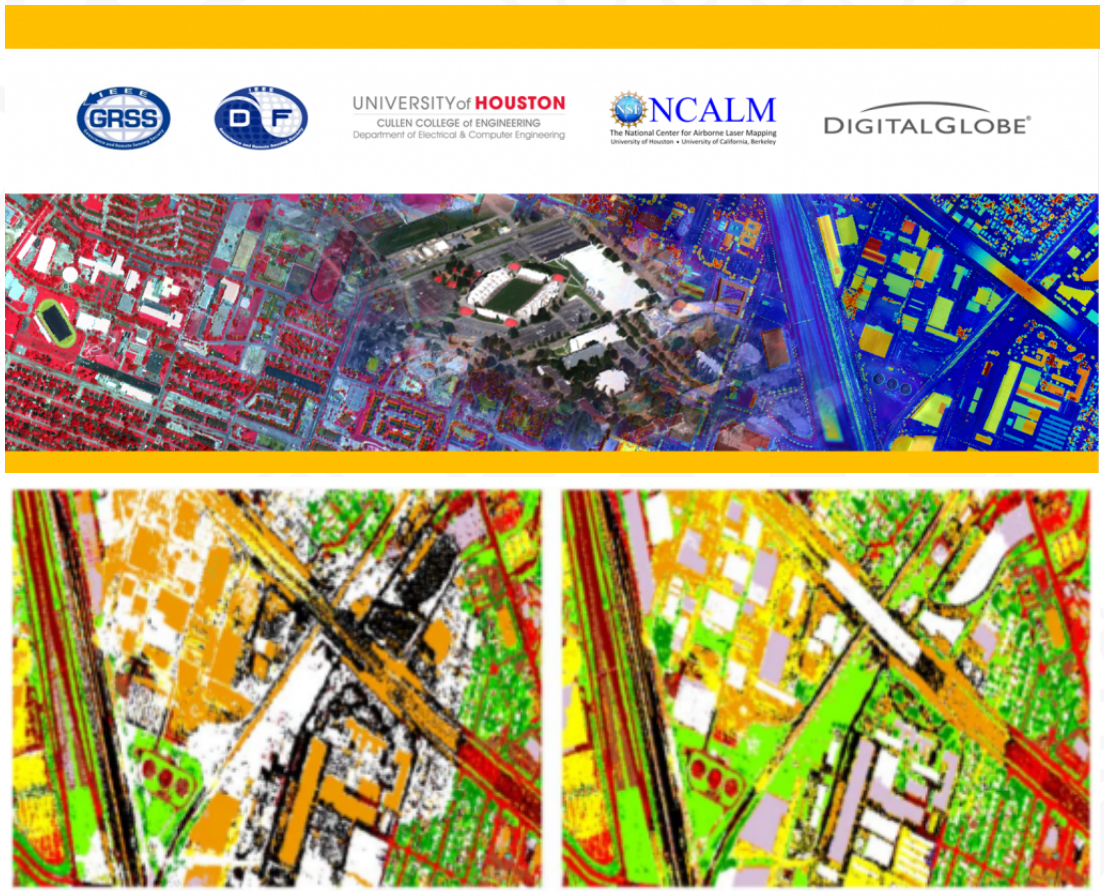
- **Data: AVIRIS Cuprite site over Nevada (1995)**





Practice 4: Evaluate feature extraction and standard supervised classifiers with and without hyperspectral+LiDAR fusion `>> demo4.m`

- **Data:** Hyperspectral CASI1500 (144 bands in the 380-1050 nm) + LiDAR derived Digital Surface Model (DSM)



Practice 5: Evaluate the kernel ridge regression to predict Chla, LAI and fCover from hyperspectral images `>> demo5.m`

- **Data:** SPARC data set (2003, 2004; Barrax, Spain)
  - Field data: Chl measured with CCM-200
  - 30 additional bare soil samples
  - CHRIS mode 1 (62 bands; 34m) nadir spectra

Table 6.1: Correlation coefficient R results of narrowband and broadband indices proposed in relevant literature tested in the present study along with recent non-parametric models. See Verrelst et al., 2011 and references therein.

Method	Formulation	R
GI	R_{672}/R_{550}	0.52 (0.09)
GVI	$(R_{682}-R_{553})/(R_{682}+R_{553})$	0.66 (0.07)
Macc	$(R_{780}-R_{710})/(R_{780}+R_{680})$	0.20 (0.29)
MCARI	$[(R_{700}-R_{670})-0.2(R_{700}-R_{550})]/(R_{700}/R_{670})$	0.35 (0.14)
MCARI2	$1.2[2.5(R_{800}-R_{670})-1.3(R_{800}-R_{550})]$	0.71 (0.12)
mNDVI	$(R_{800}-R_{680})/(R_{800}+R_{680}-2R_{445})$	0.77 (0.12)
$mNDVI_{705}$	$(R_{750}-R_{705})/(R_{750}+R_{705}-2R_{445})$	0.80 (0.07)
mSR_{705}	$(R_{750}-R_{445})/(R_{705}+R_{445})$	0.72 (0.07)
MTCI	$(R_{754}-R_{709})/(R_{709}+R_{681})$	0.19 (0.26)
mTVI	$1.2[1.2(R_{800}-R_{550})-2.5(R_{670}-R_{550})]$	0.73 (0.07)
NDVI	$(R_{800}-R_{670})/(R_{800}+R_{670})$	0.77 (0.08)
NDVI2	$(R_{750}-R_{705})/(R_{750}+R_{705})$	0.81 (0.06)
NPCI	$(R_{680}-R_{430})/(R_{680}+R_{430})$	0.72 (0.08)
NPQI	$(R_{415}-R_{435})/(R_{415}+R_{435})$	0.61 (0.15)
OSAVI	$1.16(R_{800}-R_{670})/(R_{800}+R_{670}+0.16)$	0.79 (0.09)
PRI	$(R_{531}-R_{570})/(R_{531}+R_{570})$	0.77 (0.07)
PRI2	$(R_{570}-R_{539})/(R_{570}+R_{539})$	0.76 (0.07)
PSRI	$(R_{680}-R_{500})/R_{750}$	0.79 (0.08)
RDVI	$(R_{800}-R_{670})/\sqrt{(R_{800}+R_{670})}$	0.76 (0.08)
SIPI	$(R_{800}-R_{445})/(R_{800}-R_{680})$	0.78 (0.08)
SPVI	$0.4[3.7(R_{800}-R_{670})-1.2(R_{530}-R_{670})]$	0.70 (0.08)
SR	R_{800}/R_{680}	0.63 (0.12)
SR1	R_{750}/R_{700}	0.74 (0.07)
SR2	R_{752}/R_{690}	0.68 (0.09)
SR3	R_{750}/R_{550}	0.75 (0.07)
SR4	R_{672}/R_{550}	0.76 (0.10)
SRPI	R_{430}/R_{680}	0.76 (0.09)
TCARI	$3[R_{700}-R_{670})-0.2(R_{700}-R_{550})(R_{700}/R_{670})]$	0.53 (0.13)
TVI	$0.5[120R_{750}-R_{550})-200(R_{670}-R_{550})]$	0.70 (0.10)
VOG	$R_{740}/(R_{720}$	0.76 (0.06)
VOG2	$(R_{734}-R_{747})/(R_{715}+R_{726})$	0.72 (0.09)
NAOC	Area in $[643, 795]$	0.79 (0.09)
LR	Least squares	0.88 (0.06)
SVR Smola and Schölkopf, 2004	RBF kernel	0.98 (0.03)
MSVR Tuia et al., 2011b	RBF kernel	0.98 (0.03)
GP Verrelst et al., 2011	Anisotropic RBF kernel	0.99 (0.02)