Classification of natural scenes via multispectral Imaging

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Scene Recognition and Goal

- Two week project with the University of Houston
  - Submitted to ICIP
- Scene understanding and object recognition is important in many computer vision applications
  - Robot navigation, remote sensing, medical imaging, etc.
- Classification performance improves if hyperspectral images are used
  - At the expense of time, convenience, and money
- Goal: Achieve similar accuracy using far fewer measurements

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Hyperspectral Images of Natural Scenes

Hyperspectral data captured using Headwall Photonics hyperspectral imager

Image Resolution: $1004 \times 2500 \times 325$

Rendered in RGB using Flea3 sensor Response

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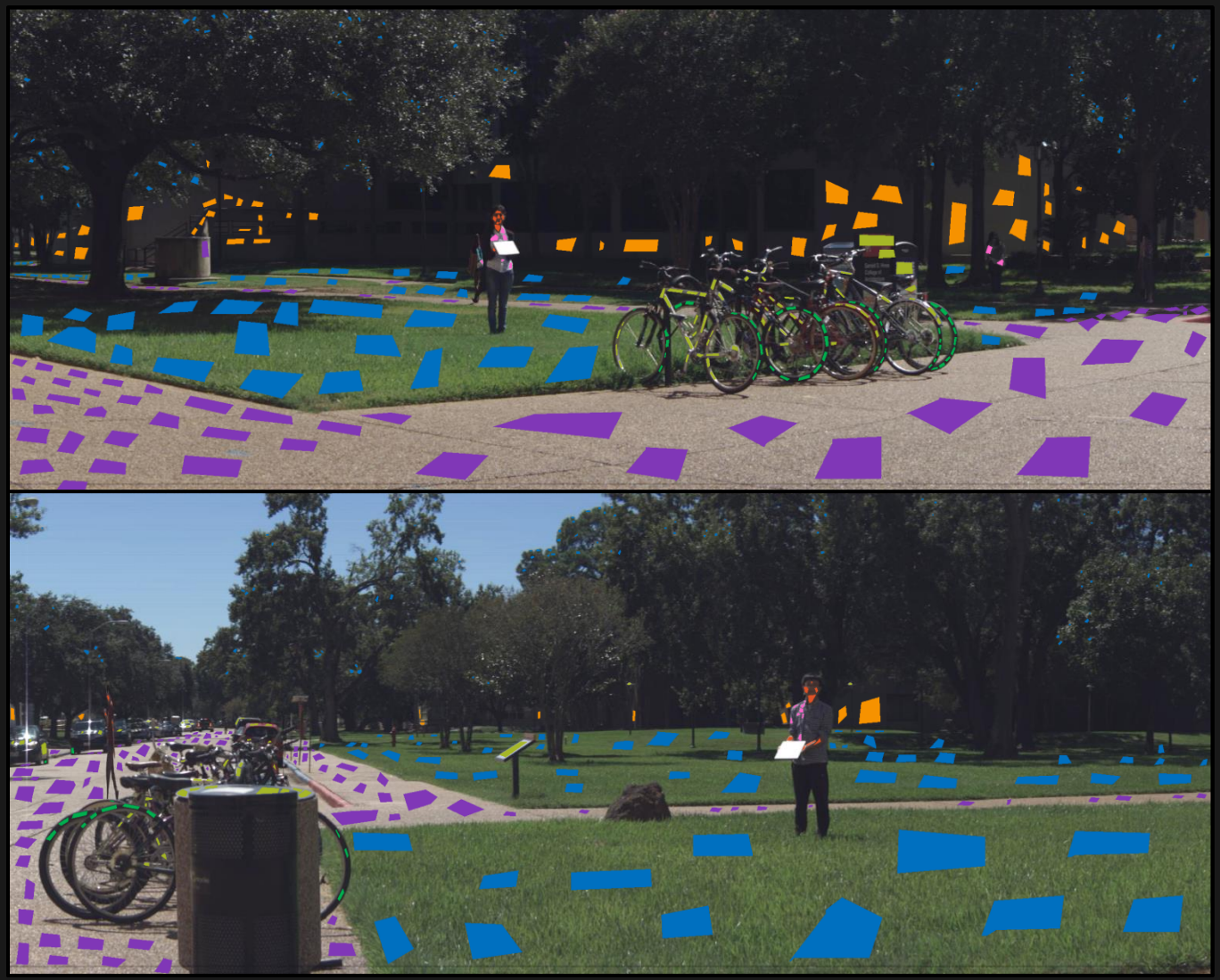
Object Labeling



Objects of Interest

- Vegetation
- Metal
- Concrete
- Pathway
- Skin
- Fabric
- Rubber

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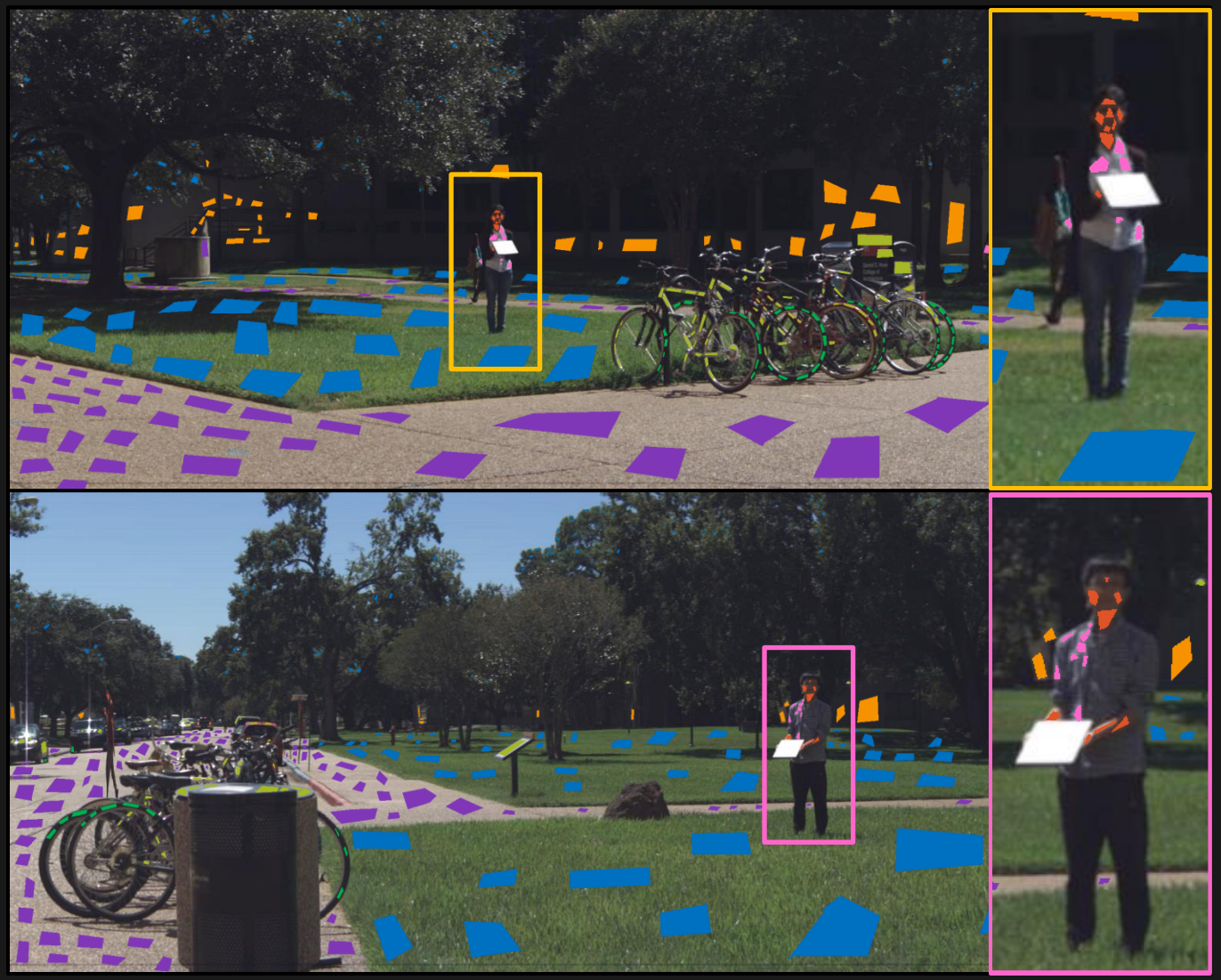

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Object Classification using SVM

- Image classification is a well-studied research topic [1]
- We adapt a commonly used classifier
  - Not interested in designing a new classifier
  - Trying to show the value of the acquisition method, not classifier
- We use a simple SVM classifier with a radial basis function kernel
  - Non-linear mapping improves results for low-dimensional data
  - Only two degrees of freedom (C, γ)

[1] Lu, D., & Weng, Q. (2007). A survey of image classification methods and techniques for improving classification performance. *International journal of Remote sensing*, *28*(5), 823-870.

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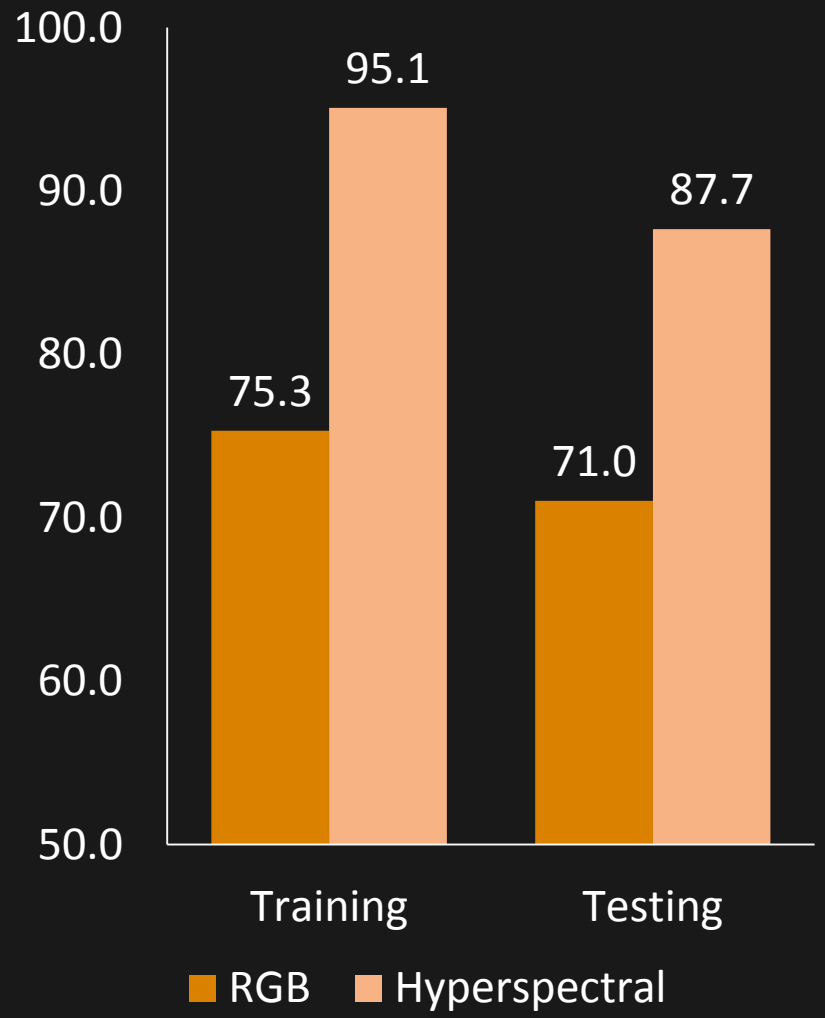
RGB & Hyperspectral Classification

Training Scene

Testing Scene



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Reducing Spectral Measurements

- Adding spectral measurements improves classification performance
  - RGB (3 channels): 71%
  - Hyperspectral (325 channels): 87.7%

- How much benefit is one additional channel over RGB? Three additional channels?

- Acquisition schemes
  - RGB + Near-infrared
  - RGB + 3 narrowband channels
  - 6 narrowband channels
  - 6 common optical filters

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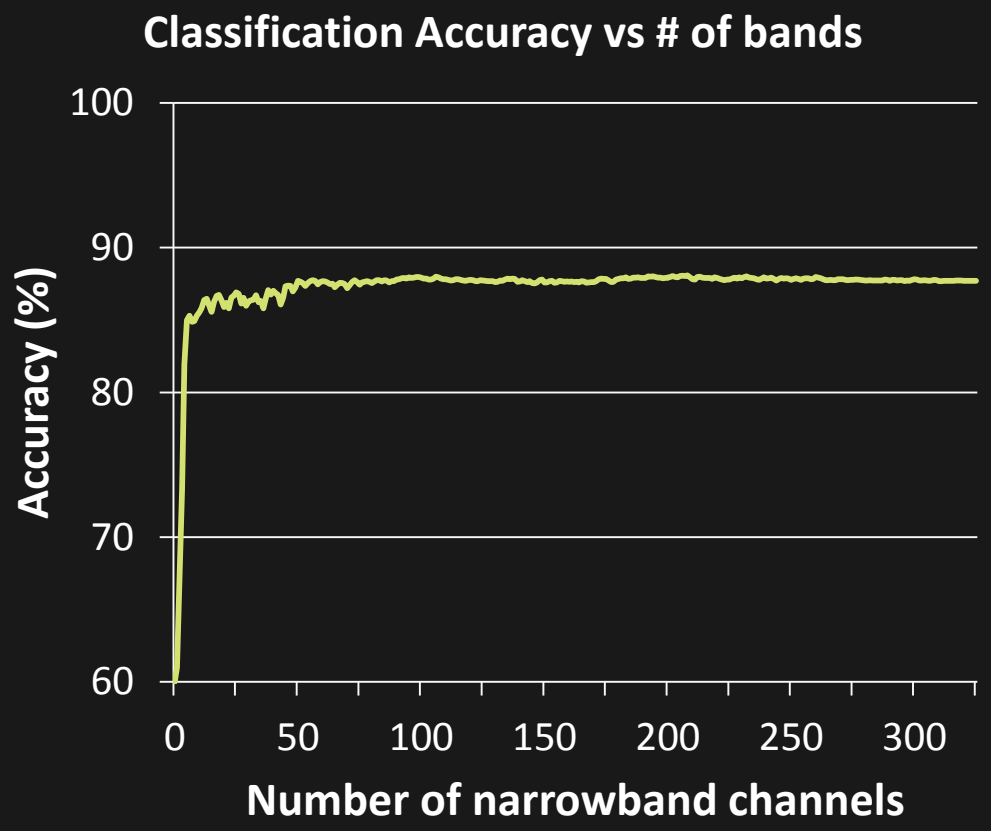
Channel Selection

- Accuracy of 325 bands: 87.7%
- Accuracy of 6 uniformly distributed bands: 84.9%
  - 97% as accurate
  - 50x fewer bands



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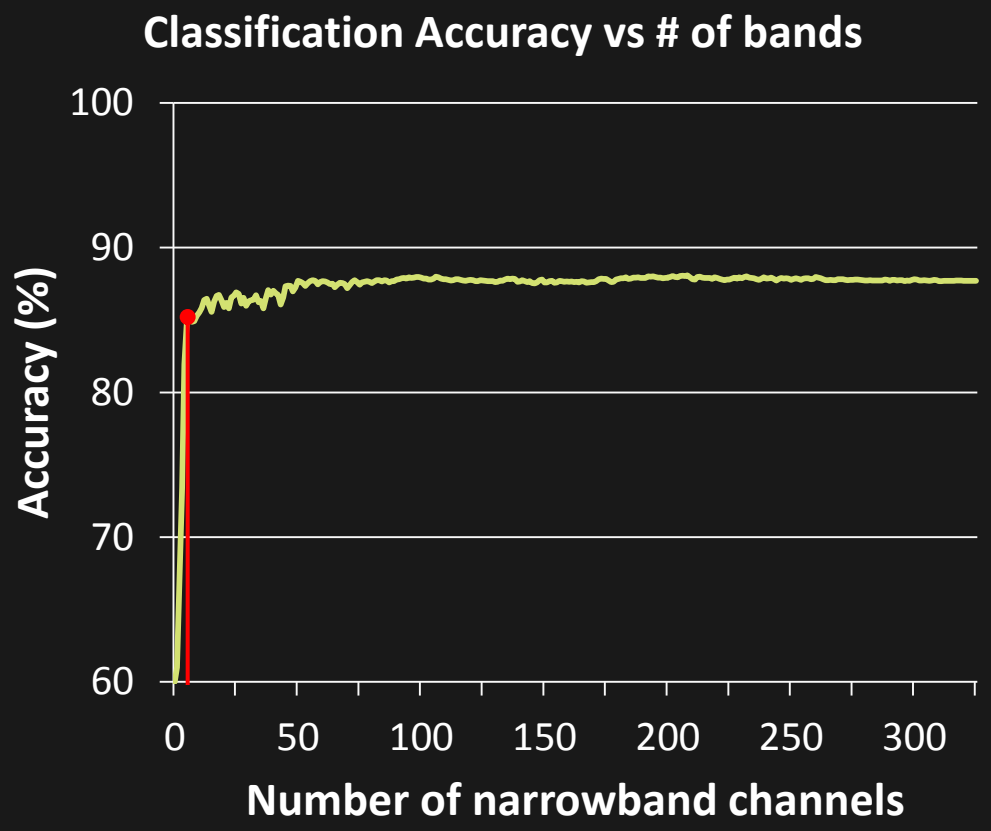

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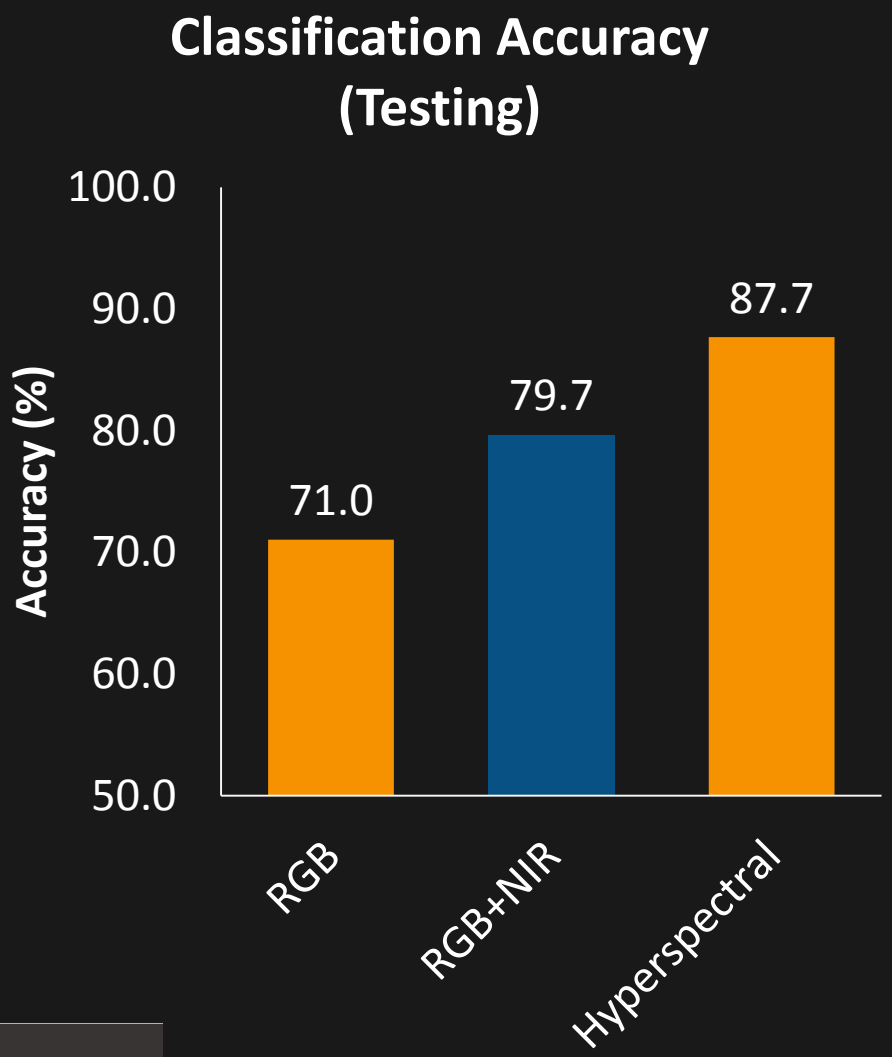
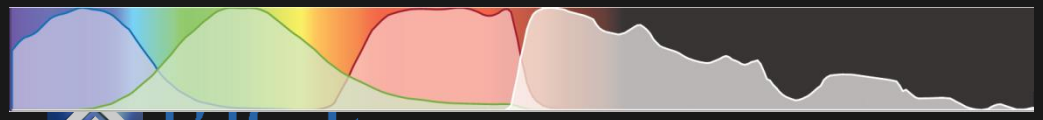
RGB+NIR

- Three color filters
- One broadband NIR channel

- Classification accuracy
  - 79.7%

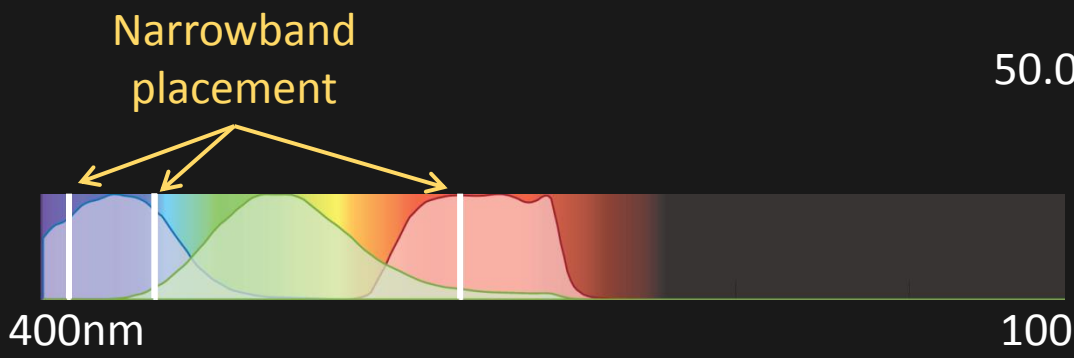


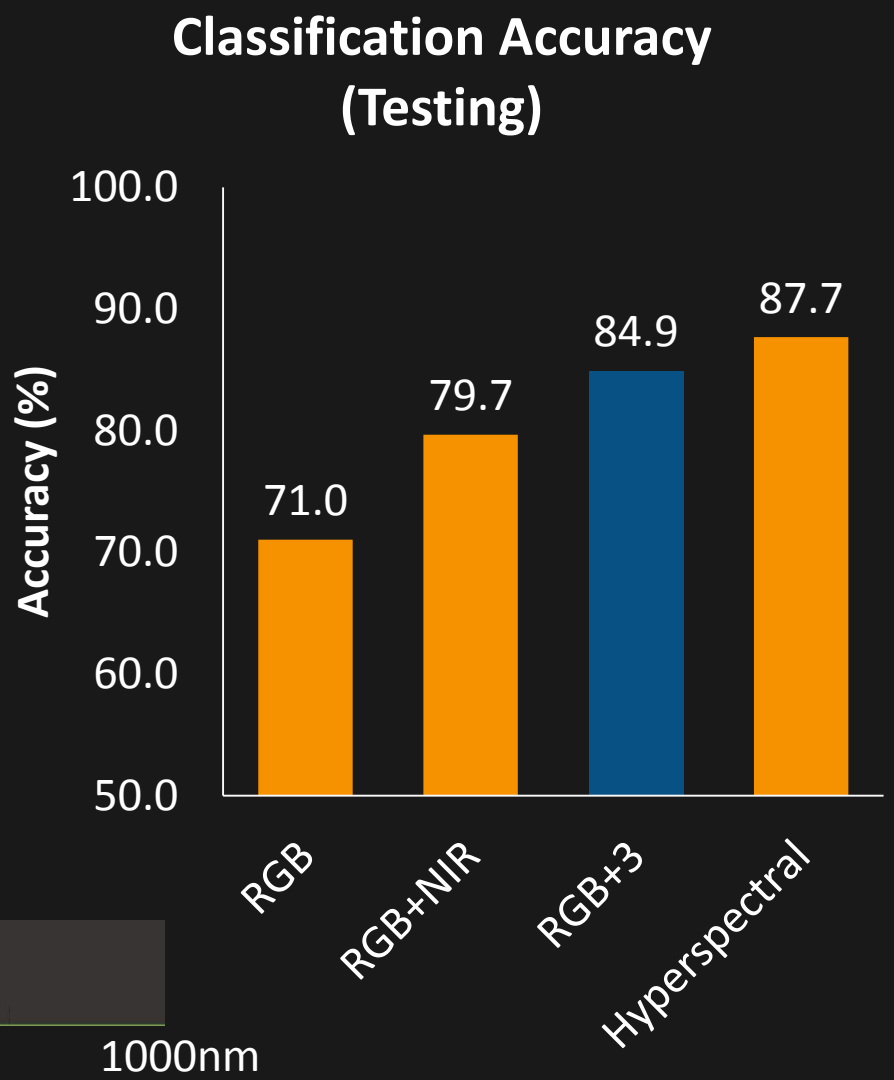


400nm 1000nm

RGB+3 Narrowband Channels

- Narrowband channels picked using greedy algorithm
- Classification accuracy
  - 84.9%





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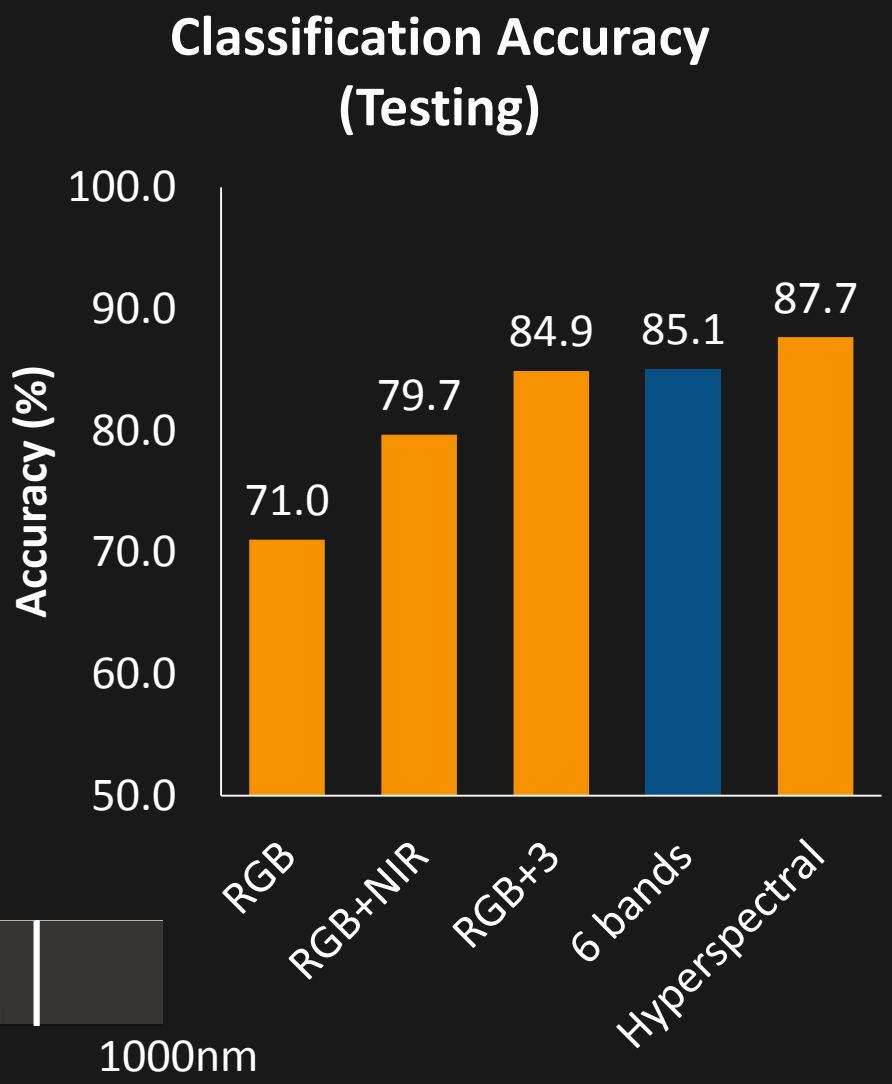
6 Narrowband Channels

- Channels picked using greedy algorithm as before
- Classification accuracy
  - 85.1%



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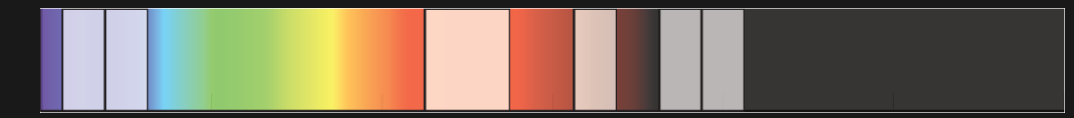
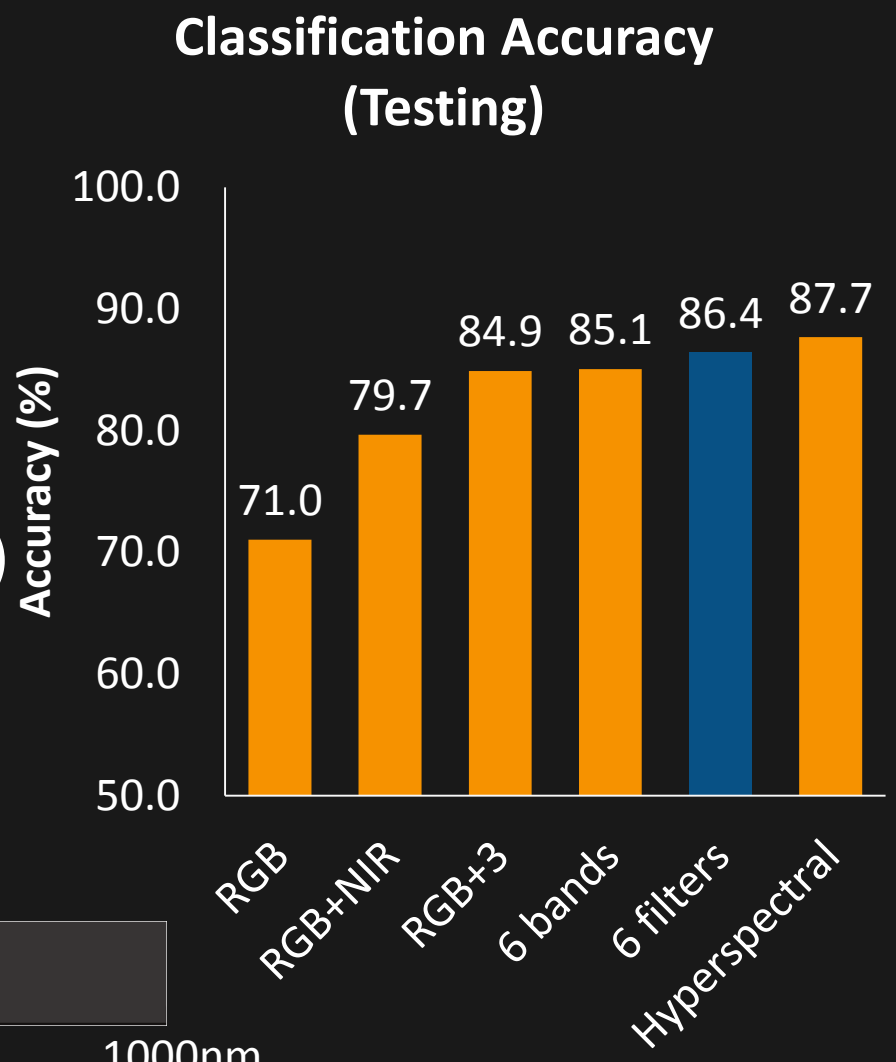
6 Optical Filters

- Inspired by available shortpass, longpass, bandpass, band reject filters
  - Placed every 25nm, bandwidths of 25, 50, 75nm (where applicable)
- Classification accuracy
  - 86.4%





Future Work

- These preliminary results merit further investigation using a diverse dataset of natural scenes (captured with a hyperspectral imager)

- If the results hold for the full dataset:
  - Investigate optimal filter selection
  - Quantify the tradeoff between accuracy and number of channels

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