NEAR INFRARED IMAGING

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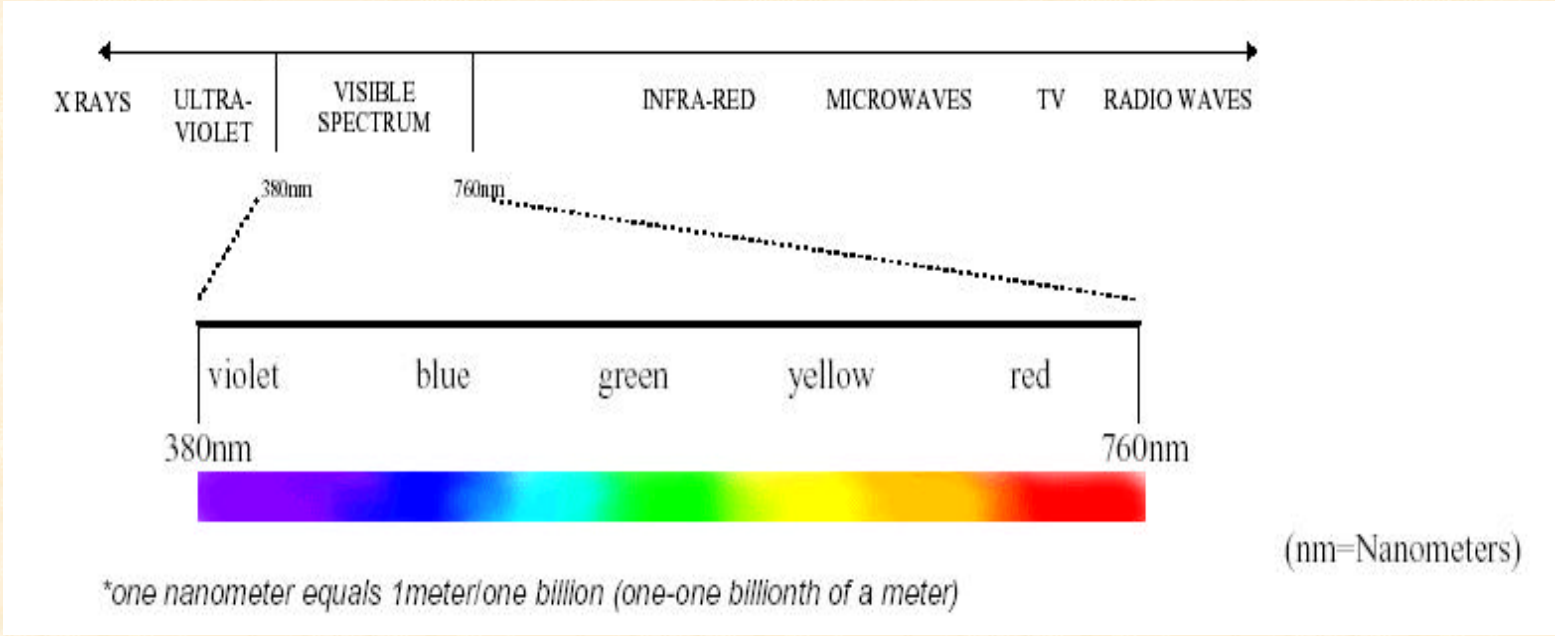
- EE 362/Psych 221

What's in Store for You

- **Introduction**
  - What is near infrared photography?
- **Methodology**
  - The setup of our experiment
- **Models**
  - Transfer Functions in Matlab
- **Results**
  - Qualitative Analysis of Images
- **Applications**
  - Forestry & Biomedical
- **Conclusion**
  - The opportunity for future projects

Electromagnetic Spectrum

- Normal film images visible light
- Near infrared film goes up to about 900nm



Sample Digital Images

A Simple Model of Photography

- The Image intensity depends on the source, camera, and reflectance of object

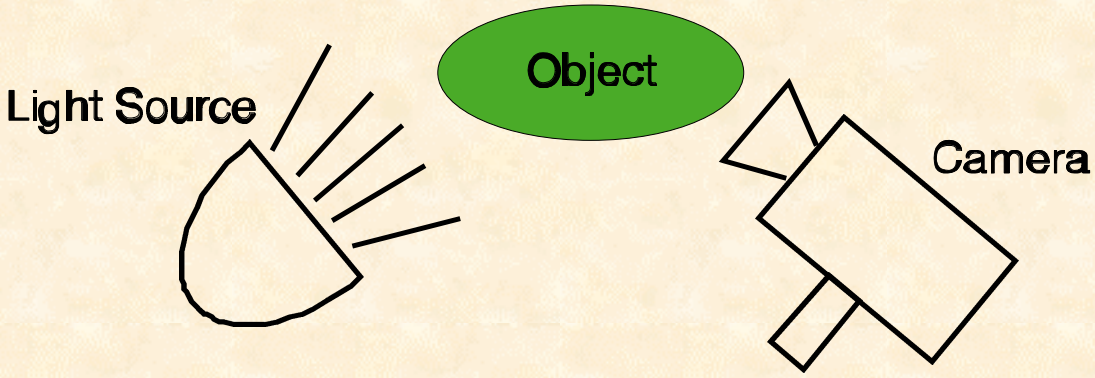
$$I = \int S(l)C_{filter}(l)C_{film}(l)R(l)dl$$

- Developed a transfer function for each combination
- Can estimate reflectance from intensity

$$I = \int H(l)R(l)dl$$

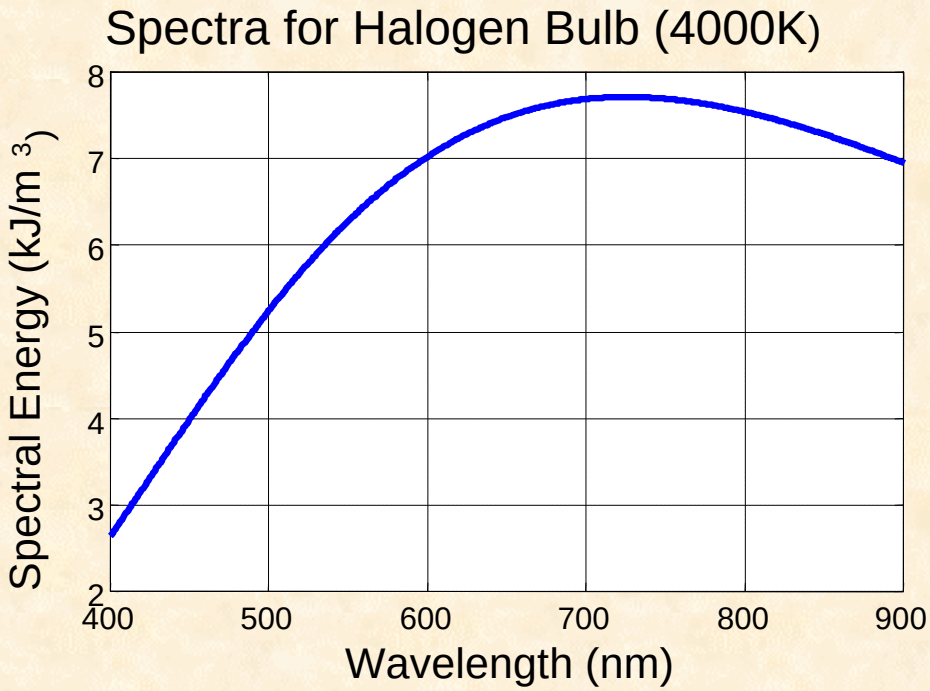
Experimental Setup

- Controlled:
  - Lighting Conditions (Darkroom)
  - Orientation of Source, Object, Camera
  - Film (Kodak HIE 135-36 Infrared Film)
  - Camera (Nikon AF N6006)
- Varied:
  - Light Sources (Halogen, GE Reveal, Strobe)
  - Filtered/Unfiltered (Promaster R2 Red Filter)



Models of Sources

- Modeled as blackbody radiators
  - Strobe: 2700 Kelvin
  - Reveal: 2700 Kelvin with Filtering
  - Halogen: 4000 Kelvin
  - Daylight: 6000 Kelvin

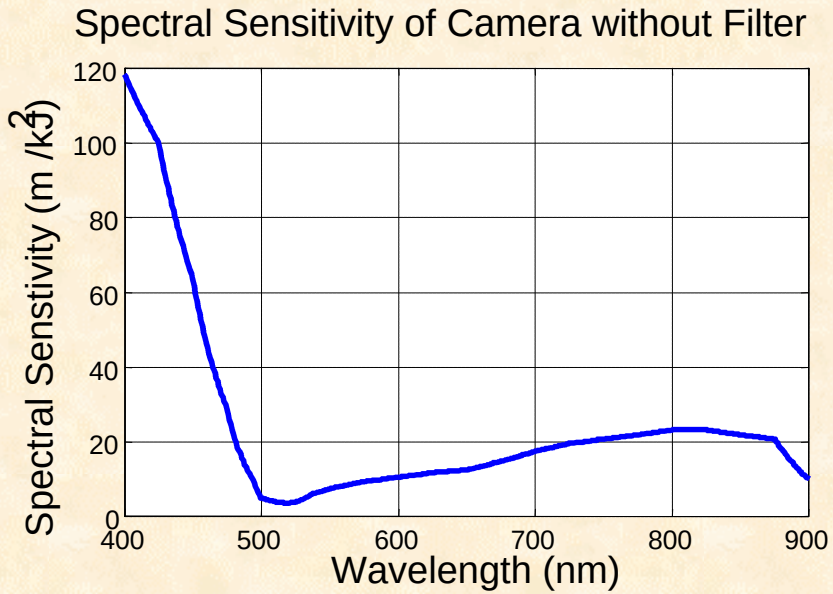


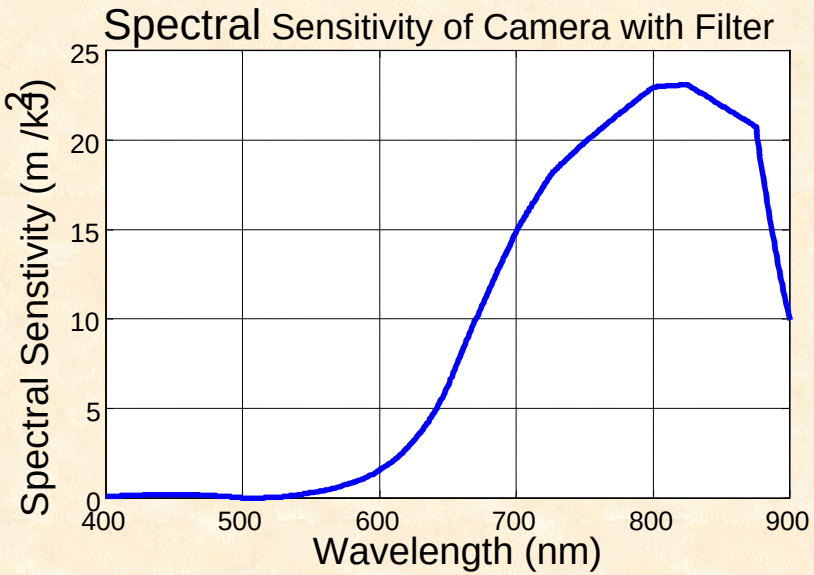
Energy per unit volume per unit wavelength

$$S_l = \frac{8phc}{l^5} \frac{1}{e^{hc/lkT} - 1}$$

Model of Camera

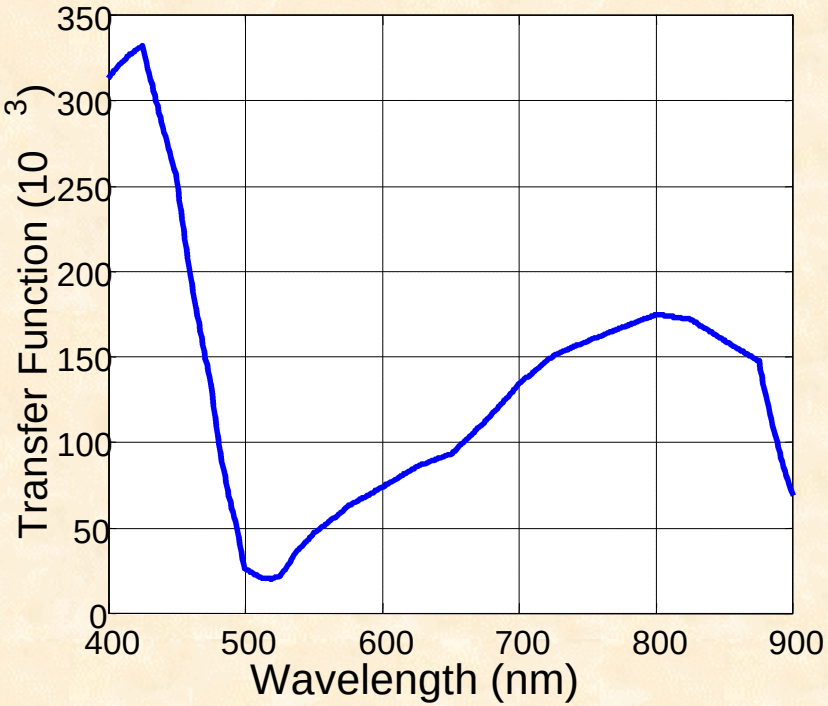
- Assumed Optics Equivalent for all Wavelengths
- Kodak Infrared Film Sensitivity Acquired from Kodak Website
- Promaster Red R2 Filter modeled based on other similar filters



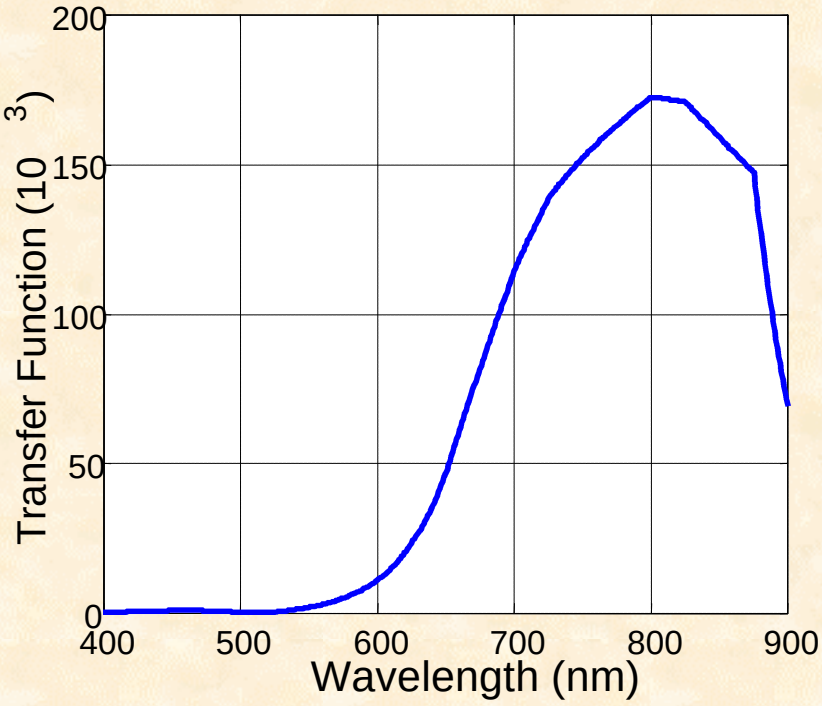


Transfer Functions

Transfer Function of Halogen Source and Camera without Filter

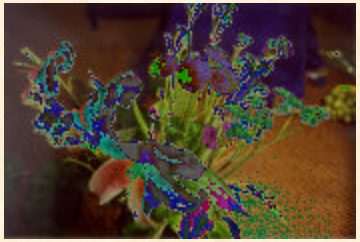


Transfer Function of Halogen Source and Camera with Filter



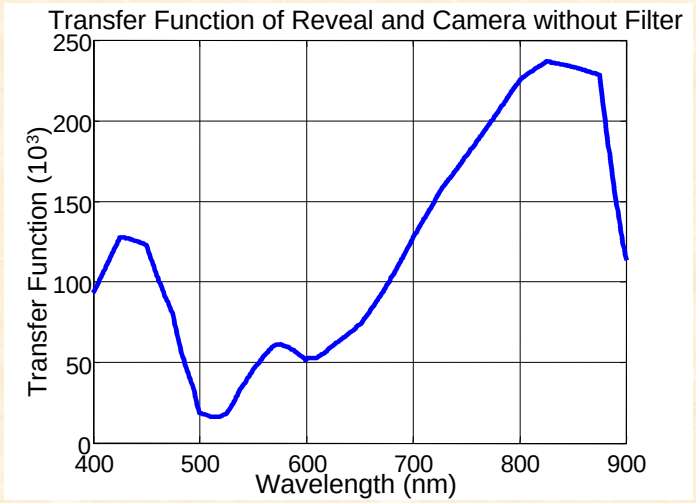
- Filter reduces components below 600nm
- Leaves near infrared and visible red components

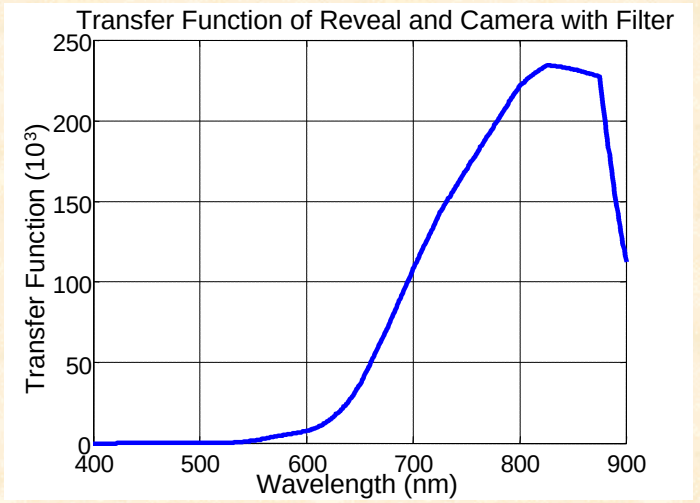
Results from Flower Images



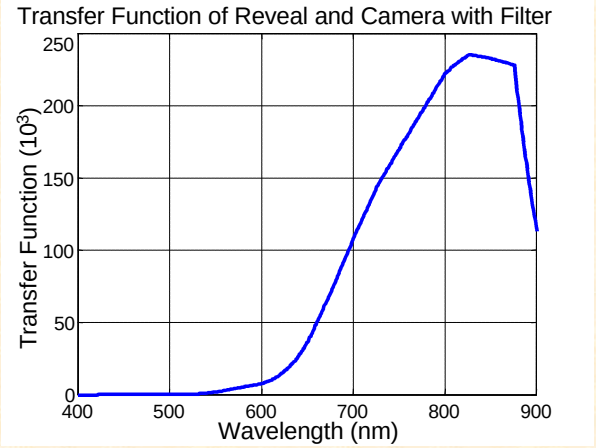
- Photographs of flower bouquet taken in dark room, lit by Reveal 100 light

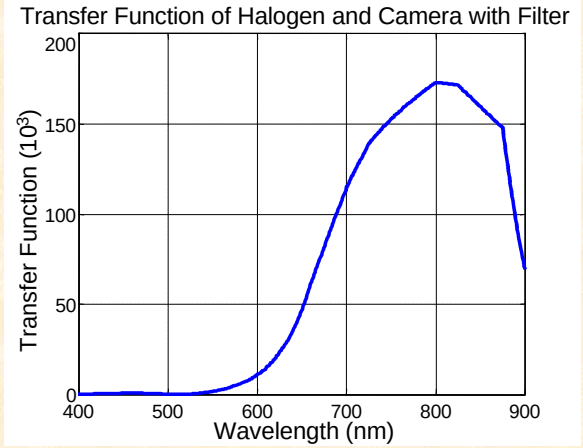
- Salient Points
  - Appearance of leaves at far left
  - Equalization of flower colors

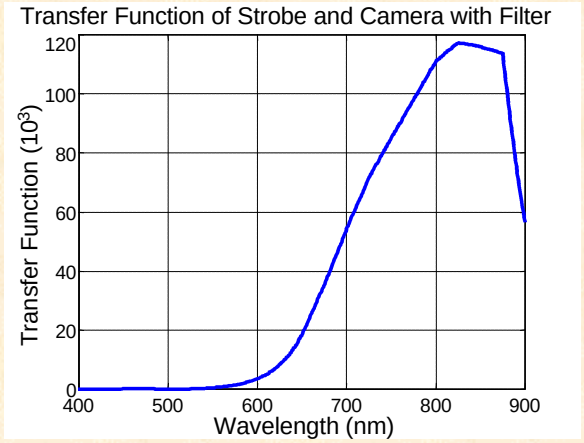




Light Source Comparison







Reveal lightbulb with filter

Halogen lightbulb with filter

Strobe incandescent with filter

Other Subjects

Fruits under Reveal bulb unfiltered (top) and filtered (bottom)

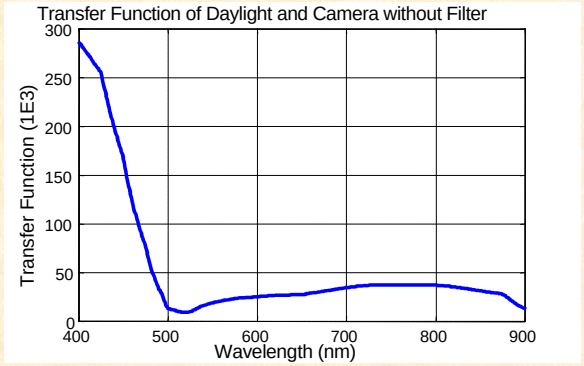
Circuitboards under strobe light unfiltered (top) and filtered (bottom)

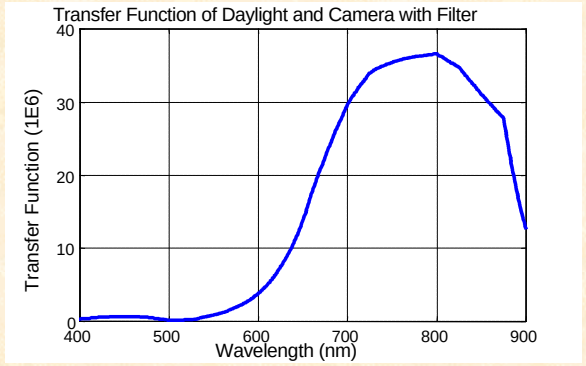
Human face under Reveal bulb filtered (top) and Halogen bulb filtered (bottom)

Results from Forest Images

- Photographs of the redwoods near Fort Bragg, CA, taken in strong sunlight about noon.

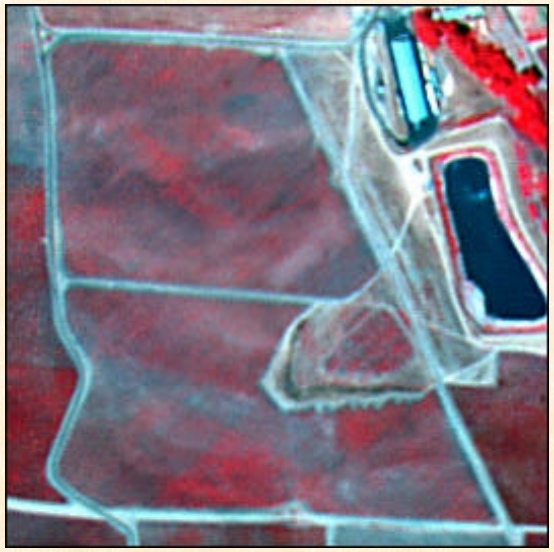
- Salient Points
  - Darkened sky
  - Brightened leaves (Woods effect)

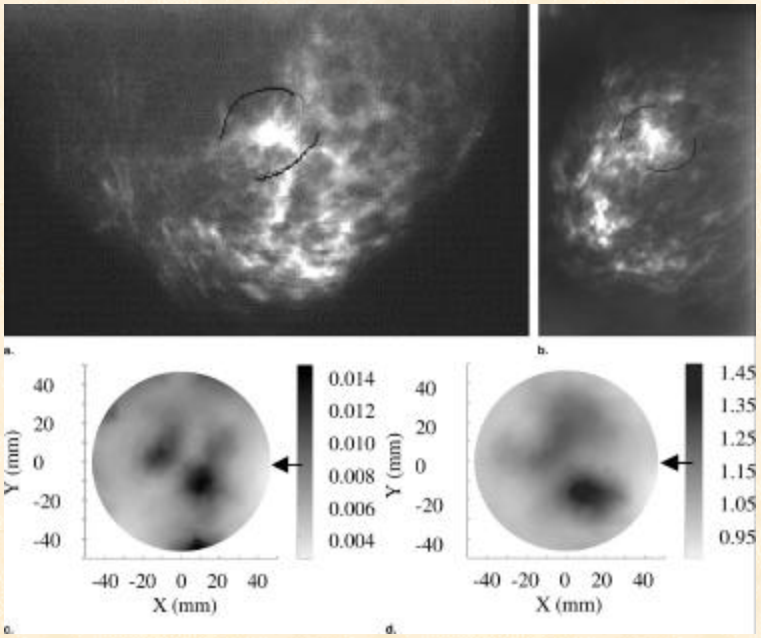




Applications

- Absorption peaks are in near infrared regime for many organic functional groups
  - Explains foliage brightness
    - Used in forestry studies to assess metrics such as canopy coverage, leaf moisture content, leaf area
    - False color image of vineyard
      - “red” = near infrared (healthy)
      - “blue” = green (unhealthy)
  - Many such compounds related to oxygenation/metabolism
    - Useful for spectroscopy
    - Functional brain studies
    - B&W breast cancer diagnostic
      - Increased vascularization results in bright sections





Acknowledgements

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  - Parker Pruett for letting us borrow his analog camera, and for his invaluable advice about taking photographs with it.
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- We hope you enjoyed our presentation!