

Development of Low-Cost Multispectral Imager

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Introduction

Multispectral imagers are cameras that take images in multiple areas of the electromagnetic spectrum and then uses them to construct a composite image with data that cannot be seen by the human eye.

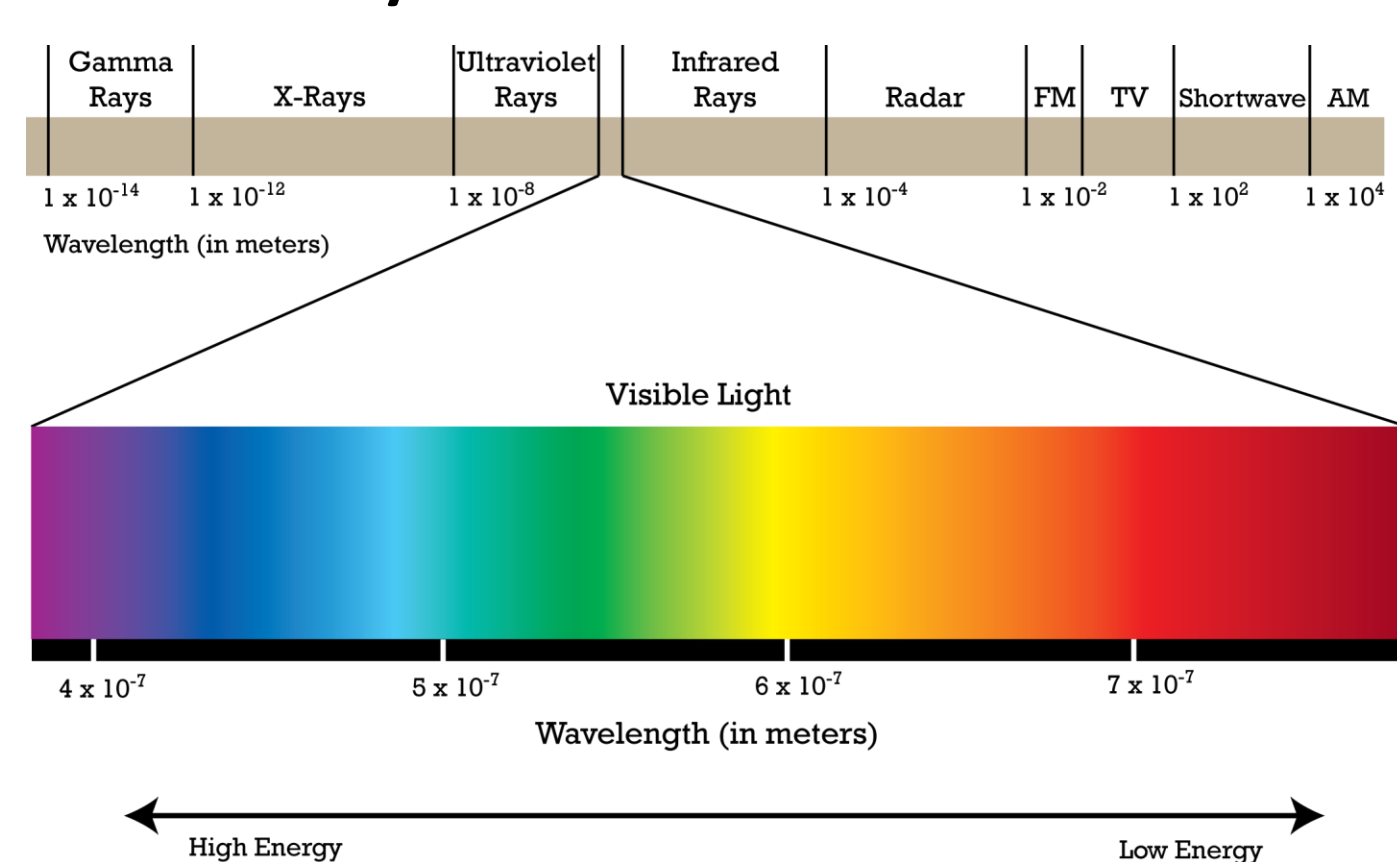


Fig. 1. Electromagnetic Spectrum

These systems typically cost tens of thousands of dollars; however, a recent release of a cost effective long wave infrared camera has made the construction of a cheaper multi-spectral imager for less than a thousand dollars possible. The body of the camera system was 3D printed for optimal functionality. The software was written in Java and Python to make it user accessible and multi-functional.

Objectives

- Low cost
- Expandable
- Multi-purposed
- Portable
- User friendly
- Well-Documented

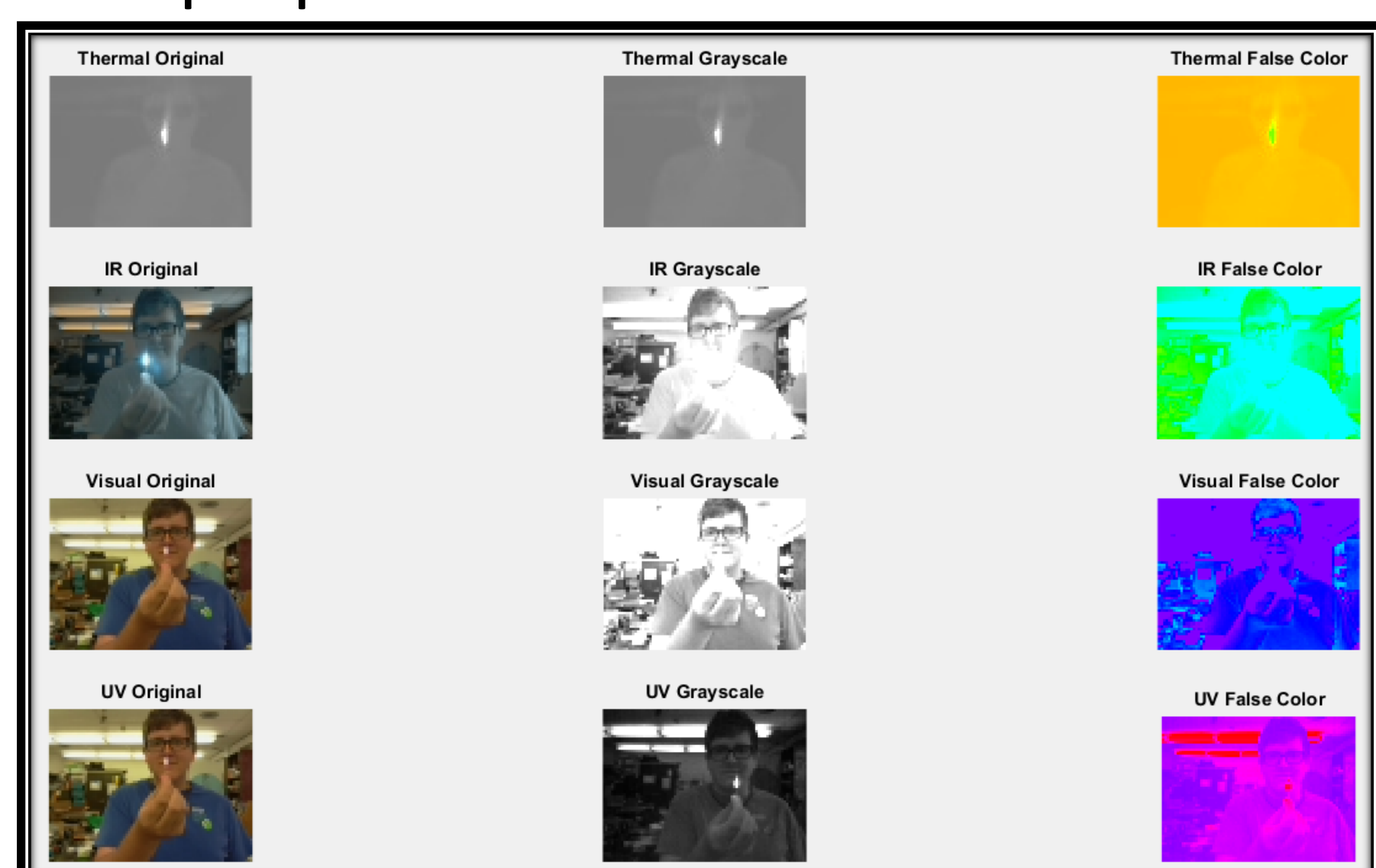


Fig. 2. Separated and False Color Images

Imager Design Requirements

Major Components:

- Long wave IR camera (Flir®)
- Three filter-less CMOS cameras
- Raspberry Pi microcomputers
- Touch screen
- ABS Plastic

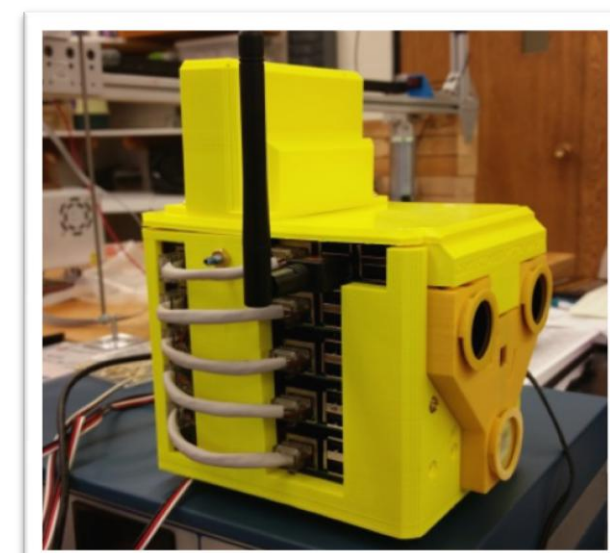


Fig. 3. Camera Rev 1



Fig. 4. Camera Rev 2

Major Considerations:

- Cluster communication
- Image capture synchronization
- Camera symmetry
- Minimal mathematical artifacts
- Portable power source
- Modular
- Filter selection
- 3D Printability
- Automated battery management

Software

- UI written in Java
- Easy to use interface
- Descriptive and powerful
- Expandable functionality
- Controls reboot and restart operations in hardware

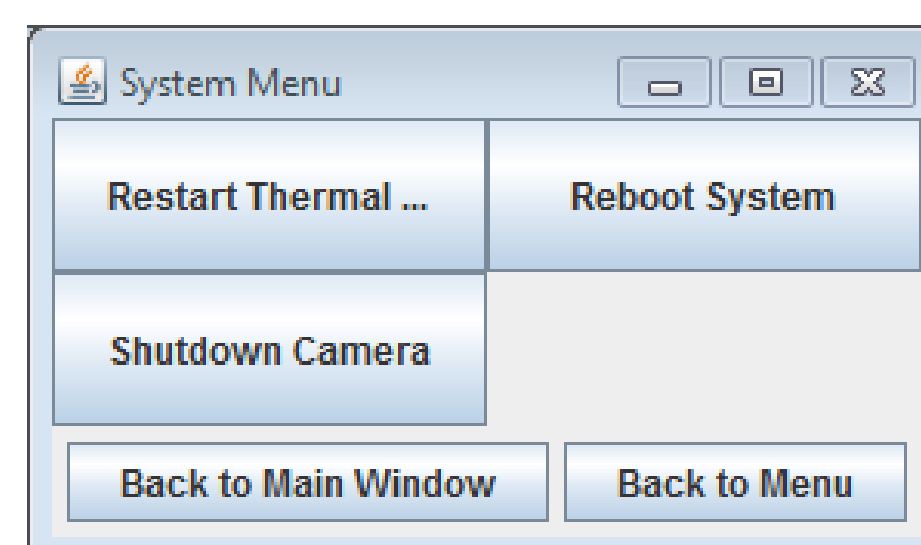


Fig. 5. Maintenance Menu

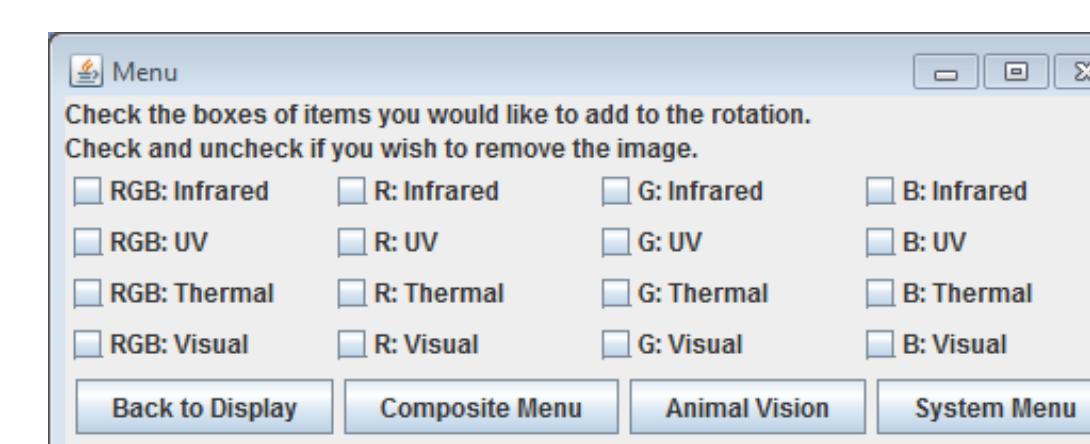
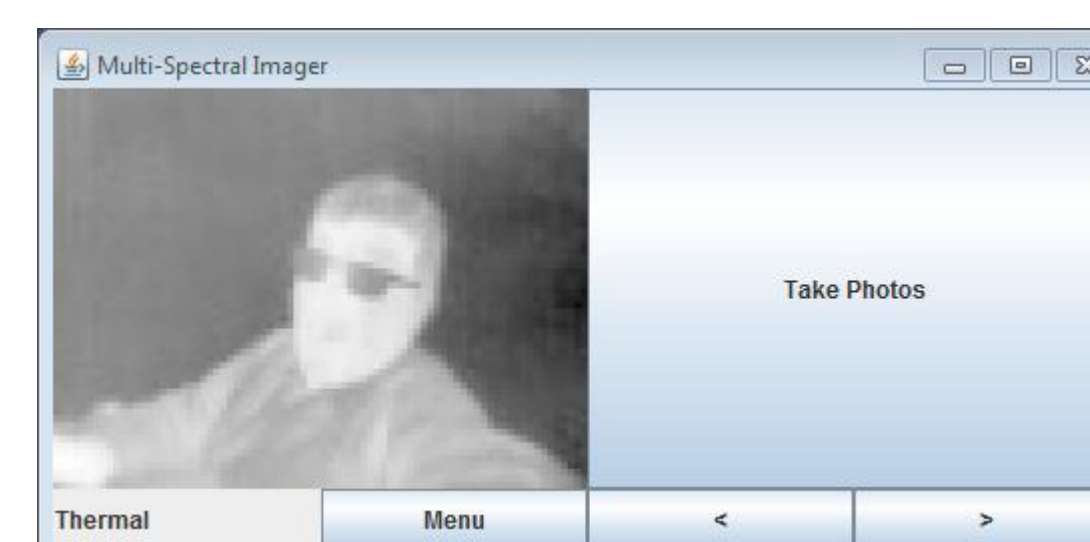


Fig 6. Main User Display (top), Main submenu (bottom)

Future Work

- Implement stitching algorithm
- Higher resolution imager
- Optimize code (Transition from Python to C)
- Revise mechanical design
- Better power management unit
- External lighting
- Thermal management
- Three-Dimensional imaging
- Occlusion filtering (Synthetic Aperture)
- Thermal object tracking through occlusions
- Add onboard fractal algorithms
- Cluster-based image processing algorithms
- Generation of arbitrary pseudo color images
- System calibration

$$\begin{bmatrix} R \\ Y \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Fig. 12. Transform matrix from RGB standard to RYB standard for pseudo color images. For example, simulating how animals see.

Conclusion

- Prototype meets project objectives

LWIR	8,000 nm	14,000 nm
IR	750 nm	1,000 nm
UV	290 nm	370 nm
Visual	400 nm	750 nm

- Coordinated imaging achieved
- A user friendly GUI was created
- Unit open to software/hardware upgrades
- Images stored for future analysis

Applications

Crop Monitoring:

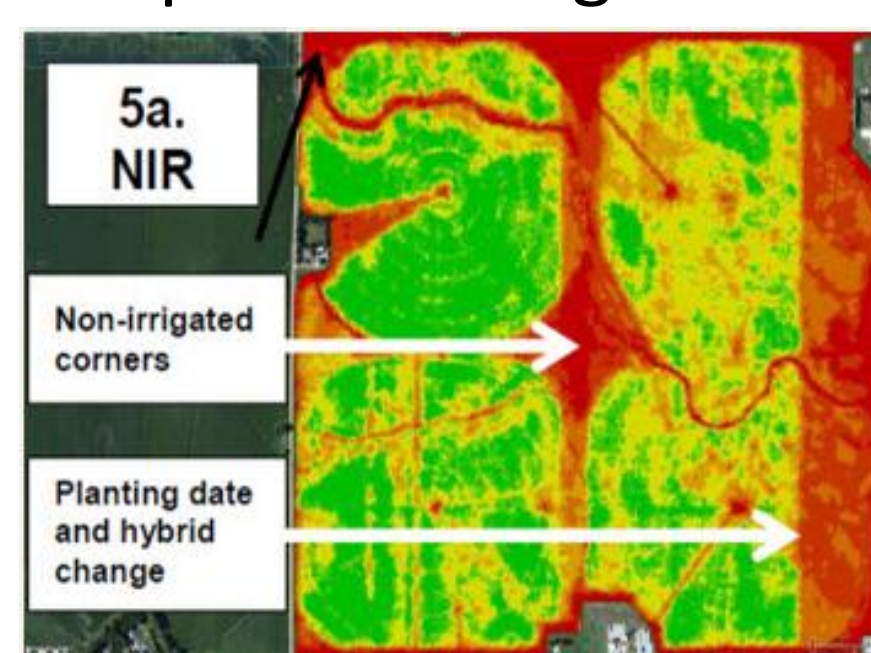


Fig. 7. NIR Analysis of Crops

Medical Imaging:

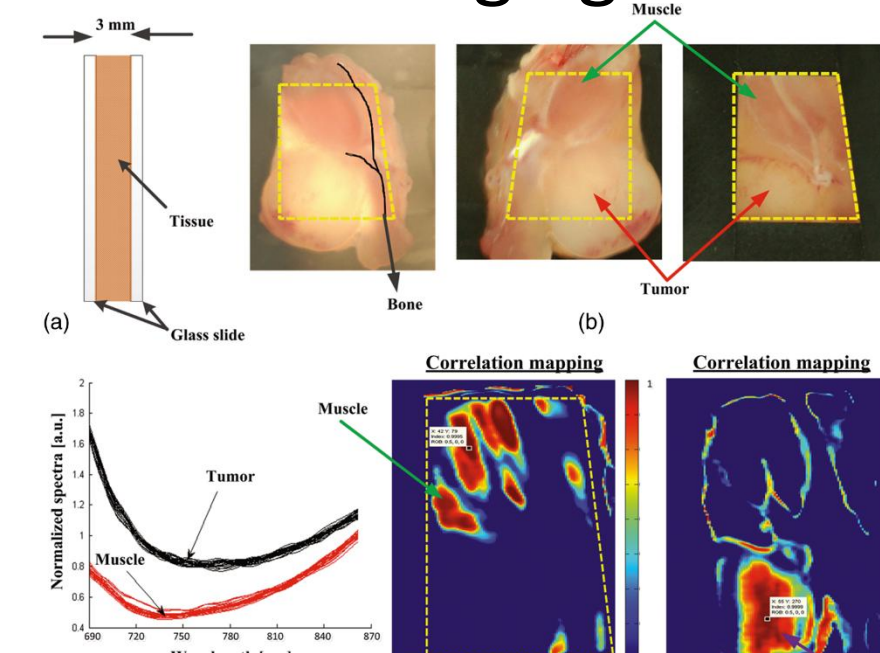


Fig. 8. Tumor detection in the NIR band

Wildlife Monitoring:



Fig. 9. Thermal Finding of Wildlife

Target Tracking:



Fig. 10. Seeing around occlusions

Biofilm Fractal Analysis:

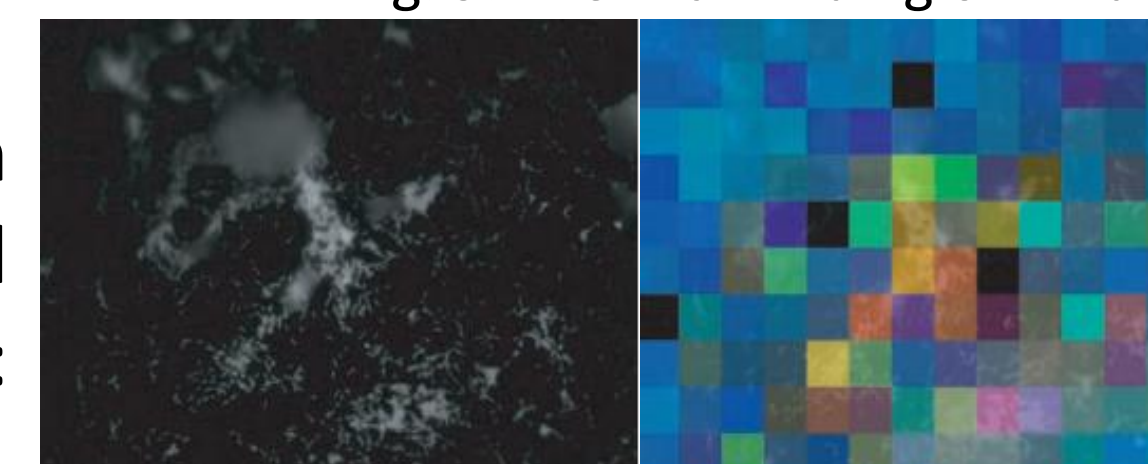


Fig. 11. Multispectral Biofilm Fractal Analysis

Image References

- Fig. 1: <http://www.pion.cz/en/article/electromagnetic-spectrum>
- Fig. 7: <http://www.pioneer.com/home/site/us/agronomy/library/remote-sensing-imagery/>
- Fig. 8: <http://biomedicaloptics.spiedigitallibrary.org/mobile/article.aspx?articleid=1816617>
- Fig. 9: http://www.resourcemappinggis.com/app_aerial.html
- Fig. 10: https://www.youtube.com/watch?v=QNFARyO_c4w
- Fig. 11: http://www.hpcnet.org/upload/attachments/428059_20090225074625.pdf

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