Robotic Vision:

Applications of image processing in the electromagnetic spectrum

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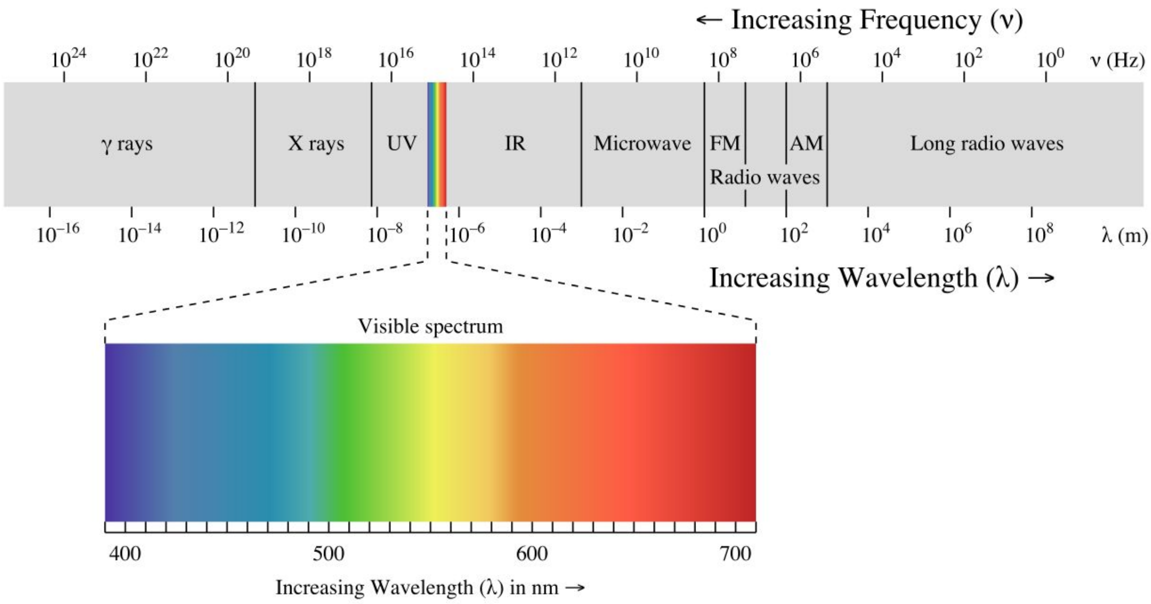
24th January 2019

Introduction



The Electromagnetic Spectrum

Definition of electromagnetic spectrum:

The entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light (Merriam-Webster dictionary).

Applications of Image Processing are not only found within the visible spectrum using RGB cameras. Several other applications of image processing are found out of the region of the visible spectrum.

These are 5 application of image processing outside the visible spectrum:

Motion Capture

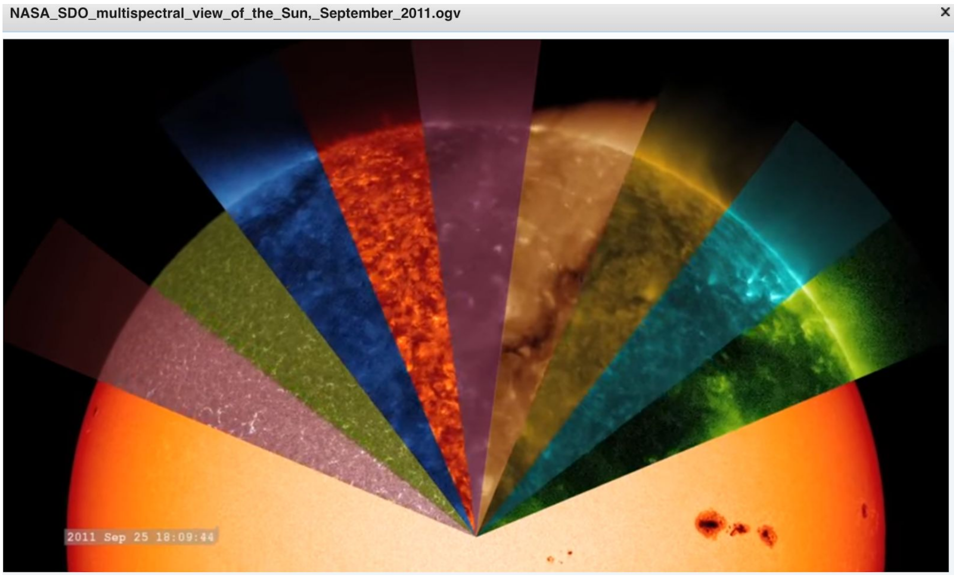
Motion capture (MoCap) is the process of recording the movement of objects or people. It is used in military, entertainment, sports, medical applications, and computer vision and robotics. The most of the applications are developed by using optical markers and cameras to perceive the light emitted or received by them. But on the other hand (outside of the visible spectrum), we have markers that are capable of sending data about its inertial sensors to a computer, where the motion is recorded or viewed. Most inertial systems use inertial measurement units (IMUs) containing a combination of gyroscope, magnetometer, and accelerometer, to measure rotational rates.

Computed tomography scan

A CT scan, also known as computed tomography scan, makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional images (virtual "slices") of specific areas of a scanned object, allowing the user to see inside the object without cutting.
The narrow X-ray beam circles around one part of your body. This provides a series of images from many different angles. A computer uses this information to create a cross-sectional picture. Like one piece in a loaf of bread, this two-dimensional (2D) scan shows a “slice” of the inside of your body.
This process is repeated to produce a number of slices. The computer stacks these scans one on top of the other to create a detailed image of your organs, bones, or blood vessels.

Multispectral images

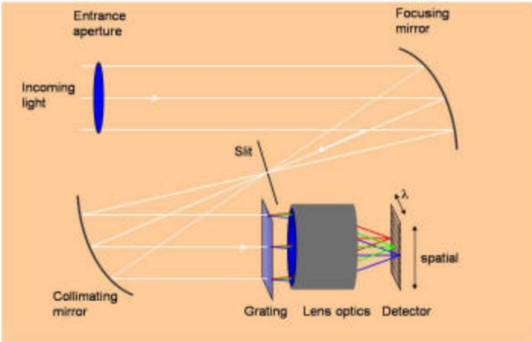
A multispectral image is one that captures image data within specific wavelength ranges across the electromagnetic spectrum. The wavelengths may be separated by **filters** or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range.
Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue.
It was originally developed for space-based imaging but its applications have been extended to military purposes and investigation.



Hyper spectral Analysis

Hyperspectral Imaging, or imaging spectroscopy, combines the power of digital imaging and spectroscopy. For each pixel in an image, a hyperspectral camera acquires the light intensity (radiance) for a large number (typically a few tens to several hundred) of contiguous spectral bands. Every pixel in the image thus contains a continuous spectrum (in radiance or reflectance) and can be used to characterize the objects in the scene with great precision and detail. Hence, hyperspectral imaging leads to a vastly improved ability to classify the objects in the scene based on their spectral properties.

Recent advances in sensor design and processing speed has cleared the path for a wide range of applications employing hyperspectral imaging, ranging from satellite based/airborne remote sensing and military target detection to industrial quality control and lab applications in medicine and biophysics. Due to the rich information content in hyperspectral images, they are uniquely well suited for automated image processing, whether it is for online industrial monitoring or for remote sensing.



HySpex operating principle

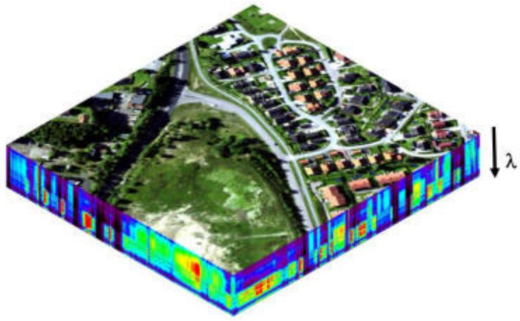


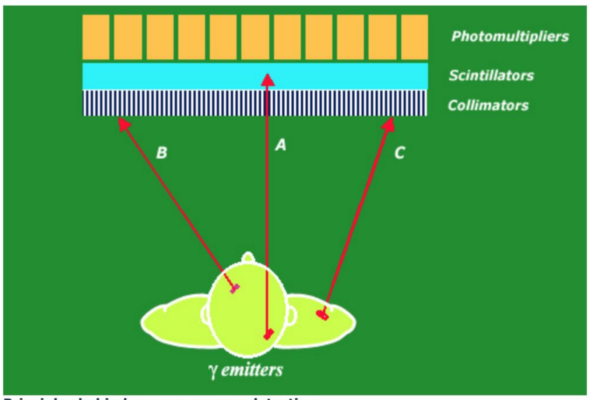
Illustration of hyperspectral data cube.

By scanning over the scene, the HySpex camera collects slices from adjacent lines, forming a hyperspectral image or "cube", with two spatial dimensions and one spectral dimension

(γ-camera)

Scintillation camera or Anger camera, is a device used to image gamma radiation emitting radioisotopes, a technique known as scintigraphy. The applications of scintigraphy include early drug development and nuclear medical imaging to view and analyse images of the human body or the distribution of medically injected, inhaled, or ingested radionuclides emitting gamma rays.

SPECT (single photon emission computed tomography) imaging, as used in nuclear cardiac stress testing, is performed using gamma cameras. Usually one, two or three detectors or heads, are slowly rotated around the patient's torso, generating a 3d image.



Principles behind gamma-camera detection
In a gamma-camera, every decaying technetium radionuclei emits a gamma photon. After measuring the position of the gamma impact on the detector, one needs to know its direction to go back to its origin. A collimation is necessary. This collimation is obtained by lead channels selecting the photons travelling through. In the figure above, only the photon A which reaches the scintillator will be detected by the photomultipliers, the photons B and C being absorbed by the lead.
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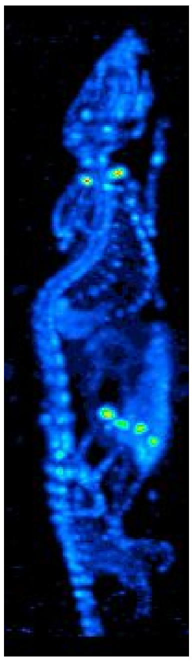

As its name suggests, a 'gamma camera' detects scintillations produced by gamma rays emitted by a radioactive marker. The impact of these gamma rays on a sodium iodide crystal generates scintillations that are detected by photomultipliers. Once a large number of these scintillations have been observed, the radioactive emitters of these gamma rays can be located.

References

[1]"Applications and Usage", *www.tutorialspoint.com*, 2019. [Online]. Available: https://www.tutorialspoint.com/dip/applications_and_usage.htm. [Accessed: 24- Jan- 2019].
[2]"What Is a CT Scan?", *WebMD*, 2019. [Online]. Available: https://www.webmd.com/cancer/what-is-a-ct-scan#1. [Accessed: 24- Jan- 2019].
[3]"Image Processing and Related Fields", *Fourier.eng.hmc.edu*, 2019. [Online]. Available: http://fourier.eng.hmc.edu/e161/lectures/e161ch1.pdf. [Accessed: 24- Jan- 2019].
[4]"Hyperspectral Imaging", *Hyspex.no*, 2019. [Online]. Available: https://www.hyspex.no/hyperspectral_imaging/. [Accessed: 24- Jan- 2019].
[5]"Radioactivity : Gamma Cameras", *Radioactivity.eu.com*, 2019. [Online]. Available: http://www.radioactivity.eu.com/site/pages/Gamma_Camera.htm. [Accessed: 24- Jan- 2019].
[6]"Full 6DOF Human Motion Tracking Using Miniature Inertial Sensors"(PDF).
[7]"Wikipedia", *Wikipedia.org*, 2019. [Online]. Available: https://www.wikipedia.org. [Accessed: 24- Jan- 2019].