

Remote Sensing & Imaging

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Human beings have a natural curiosity to explore and understand their environment. Through advances in technology, mankind has been able to extend the way we see the world to a perspective never before possible. Using airborne and spaceborne platforms, complex imaging systems that surpass the limitations of the human eye are used to observe the Earth. Through these systems, we can now see in spectral regions that were previously invisible to the unaided eye. Clearly one of the largest and most prominent applications is the study of the Earth's ecosystem through the use of remote sensing.

The synoptic view obtained from airborne and spaceborne imaging platforms provides an opportunity to understand weather systems, climate changes, geological phenomena, etc. from a global perspective. Not only are we able to view the Earth as a single ecosystem, but the amount and quality of information that we can gather is much greater than other methods of observation. Satellite imagery, and the information derived from it, is prone to a wide range of both civilian and military applications. It can be a "force multiplier" for the peacekeeper just as it can for the warfighter.

Perhaps one of the areas in which the greatest advances in imaging technology have occurred is in the field of intelligence data gathering for the support of military operations and national security. The need for accurate and timely data cannot be overemphasized. In addition, international treaties involving nuclear disarmament and biological/chemical warfare can be enforced without actually having to send in a team of inspectors. High-flying aircraft such as the SR-71 and U-2 and satellite platforms such as the recently de-classified CORONA provide this type of information. The resolution available from these systems is far greater than their civilian counterparts. The CORONA satellite, for example, could obtain images with resolutions of approximately 6 feet! This technology, although dating to the 1960's, is still better than most currently operating civilian/commercial spaceborne imaging systems such as the French SPOT

Before we can start analyzing and comparing remote sensing systems, we must first lay an approach for visualizing these imaging systems. A satellite, for example, could be equipped with the highest technology hardware available, but if the images generated by that system cannot be processed (or interpreted) then it is useless. The scene a system can capture is driven mainly by its Field Of View (FOV). In particular, we are interested in an imaging sensor's instantaneous FOV (IFOV), the ground IFOV (GIFOV), and the height of the imaging sensor platform. The relationship is given by

$$GIFOV = H \cdot IFOV \quad [1]$$

where H is the height of the platform, and IFOV is the size of the sensor at the imaging plane divided by the effective focal length of the optical system. The total ground

coverage is achieved depends on the dwell time on a particular scene. Depending on the sensor configuration, the total FOV may range from only 15° to 120°. Unfortunately, a larger FOV is not necessarily the best solution since it is more susceptible to geometric distortions and often results in poor spatial resolution. These parameters continue to improve as new electro-optics technologies develop.

The data transfer and storage capability of a system depends on the electronic configuration at the imaging platform. Because of weight limitations, satellite systems usually send the data in real-time or near real-time via telemetry to ground stations which then record the data in optical drives, CD's, or serial tape drives. This is another area where technology continues to improve and become more affordable allowing real-time delivery of large volumes of imagery data with minimal loss or distortion of data.

The quality of the imagery mainly depends on the atmospheric distortions, sensor performance, platform-induced distortions, and the effectiveness of image processing algorithms. Of all of these, the atmosphere is the most dynamic, and consequently, the most difficult source of image degradation to compensate for. Slight variations in the atmosphere change the effective index of refraction of the atmospheric medium for any given optical path between the scene and the sensor. The effect of the atmosphere is typically seen as a blurring and loss of contrast in an image. In the extreme case, heavy cloud cover may completely obscure a scene from a remote sensing system. The degradation process is difficult to characterize because of the large amounts of physical processes occurring in the atmosphere that affect the transmission of light through it. No sensor can provide high-quality imagery without proper calibration. A well-calibrated system increases the accuracy of the data.

As computer technology continues to improve dramatically, the use of image processing algorithms is becoming more viable. Through image processing, sensor data can be represented in a meaningful format that allows the extraction of vital information. Image processing can also help fill in the "gaps" caused by missing data through the use of application-dependent interpolation or extrapolation techniques.

Since no single system provides an end-all solution, the answer clearly lies in taking the information that can be obtained from every system and putting it all together in a single product. This is what remote sensing is headed towards. The real technological advance will occur when information technology catches up with all the sources of satellite and airborne imagery available and can fuse it all together in a way that it is available to the user in real-time mode. Advances in data transmission and computational speeds will definitely have to occur as well as display technologies that can accurately represent the fused imagery. The knowledge-power associated with having this capability is far reaching in all applications. The future of remote sensing is just beginning, and the reward for our efforts is a better understanding of our own home: The Earth.