Shortcomings Common to Real Remote Sensing Systems

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Abstract

Remote sensing technology and systems have grown more rapidly in the last two and half decades. Advances in remote sensing systems have gained much attention from the academia, researchers, disasters management specialists, business community and public administration to the say the least. As such, there has been a great focus on the benefits that accrue from investing and using remote sensing systems with less attention paid to the shortcomings in real remote sensing environment. This short essay highlights the shortcomings associated with real remote sensing systems. In summary, the shortcomings range from remote sensing system design and launch, data acquisition process, processing and to data utilisation. I encourage for continued move towards open access repositories to leverage some of the shortcomings especially for the developing world.

Key words: *Acquisition, data, shortcoming, remote sensing systems*

Introduction

Remote sensing is as old as mankind, because a simple observation of a tree ahead of you is remote sensing. More technically though, remote sensing is used in reference (e.g. Smith, 2012; Aggarwal, 1998; Levin, 1999; Idowu and Ukoje, 2009) to the science and process of obtaining and interpreting information from a distance, using sensors anchored either space borne orbiting around the earth or airborne platforms flying over the sky and/or ground based stations without being in contact with the object whose attributes are being obtained. Remote sensing in principal operates by making use of electromagnetic radiation from the sun as the major source of illumination for passive remote sensing. Active remote such as RADAR technology illuminates the target objects and acquires the necessary data.

Remote sensing in the last three decades has gained importance in various fields due to its ability to offer data and information at a relatively faster rate, its ability to offer access to most remote locations and dangerous locations as well the ease with which remotely sensed data can be shared across the global divide. This has seen great investments undertaken to develop the technologies utilised. Various software and satellite systems for specific and multidimensional purposes orbit the earth. Some of which include; LANDSAT, IKONOS, SPOT, ASTER, METEOSAT, NOAA, GMS, INSAT, GOES and GOES W. Software such as ILWIS, ArcGIS, Idrisi, Erdas-Imagine, ArcInfo, TNTMips are some of the commonly used in the developing world for image processing; these altogether constitute remote sensing systems. Remote sensing has moved from airborne remote sensing in the Second World War, rudimentary space borne remote sensing technology in the Sputnik 1 era, spy remote sensing in the 1980s, and meteorological remote sensing to the earth observation systems era (Melesse et al., 2007).

Currently, there are over two dozen space-based satellite systems scanning the earth's surface and beaming back satellite imagery with data about the earth's bio-physical environment (Okoye and Koeln, 2009). These satellite systems in addition numerous drones in the in the lower and middle atmosphere produce various panchromatic, multispectral, hyperspectral and/or ultraspectral images. Whereas most organisations and individuals clamor to use remote sensing in data acquisition, they often focus on the benefits that accrue from usage. As such, less attention is paid to the challenges and/or shortcomings associated with remote sensing systems. It is the purpose of this write-up to highlight such shortcomings.

Shortcomings common to all real remote sensing systems

Remote sensing systems lie on two strands; the ideal remote sensing and the real remote sensing systems. Ideal remote sensing systems operate on idealized perfect conditions (e.g. a uniform energy source, a non-interfering atmosphere, a series of unique energy and/or matter interactions at the earth's surface, existence of a super sensor, a real time data handling systems, multiple users with in-depth knowledge) conversely, real remote sensing systems acknowledge the existence of interruptions thus a non perfect system that has to be adapted. The interruptions associated with real remote sensing systems in-effect communicate their shortcomings; these are highlighted in the sub-sequent paragraphs. In the mean time, I would prefer to broadly group these shortcomings into two i.e. technical shortcomings and organizational shortcomings.

Given the diversity of remote sensing systems in place at present, there are various technologies in operation in each system. The remote sensing systems in place include the satellite, air borne and ground based. Some of the satellite based systems have been identified in the introduction section above. Each of these systems has its own requirements and shortcomings. Satellite remote sensing for example is dependent on energy radiance from the sun; this electromagnetic energy travels through the atmosphere where it is subject to a number of interruptions (e.g. absorption and scattering). Scattering is of particular importance to satellite remote sensing due to its effect in creating distortions in the images acquired. Rayleigh scatter and Mie scatter all have negative effects in real remote sensing systems. Mie scatter for example decreases the spatial details recorded by the sensors by affecting energy in the lower atmosphere. The shortcoming arises because; the sensors are pre-determined in-terms of spectral resolution, orbital characteristics (e.g. speed, residence time, swath/path and row, and return period) while the scattering is dependent on atmospheric conditions. Depending on the intensity of atmospheric scattering, imagery become distorted and blurred. For example, sections that were supposed to be dark appear lighter while the sections that were to be lighter appear darker.

Further, when electromagnetic energy reaches the earth's surface, it undergoes reflection, adsorption, and refraction. Reflected energy is what is important to remote sensing because, it gives spectral signatures of various earth surface objects and conditions to the sensor. As this energy travels back to space as long wave radiation, temperature, water vapour and high clouds cause interruptions. Therefore, calibration is required on a mission-by-mission basis otherwise users have to deal with relative energy sensed at any given time and location. However, RADAR remote sensing systems that are active remote sensing systems beam their own source of energy during data acquisition. The shortcoming with this technology is associated with high investment costs and very high skill and technical competence requirements. More technical shortcomings relate to the spreading of energy with range thus targets closer to the radar reflect proportionally higher energy than targets farther away (Haykin et al., 1994). Further, it is also associated with layovers and shadows especially when operating in hilly and steep areas.

All remote sensing systems require relatively high investment costs. These costs include: initialization costs for systems research and development, administrative costs for systems management and staff capacity development and for the users; systems establishment and data acquisition costs. Initialization costs are particularly huge because most remote sensing systems (satellites) from design to launch of a new, large and complex satellite are way to a decade. A part from Landsat that offers some series of imagery at no cost, most of the earth observation satellite remote sensing systems avail data on purchase basis (table 1) Landsat inclusive. The costs of establishing a remote sensing system are particularly a greater shortcoming to developing countries such as Kenya, Uganda, Tanzania, Burundi and the greater sub-Saharan Africa. Because of this, institutions such as universities, hospitals and government agencies that need to use remotely sensed information barely have established any and do lag behind.

Table 1: Summary of image cost and various resolutions

Platform	Ground resolution	Image type	Image Extent	Approx. price/image	Approx. min price for 30x30km AOI[1]
Landsat MSS	80m	Multi-spectural	185km x 170km	$210	$210
Landsat TM	30m	Thematic Mapper	170km x 183km	$446	$446
Landsat ETM	15-60m	Enhanced TM	170km x 183km	$632	$632
SPOT 5	10m	Multi-spectural	1/4 scene - 30x30km:	$1,675	$1,675
	5m	Pano-chromatic	30 min frame - 54 x 54km:	$4,275	$4,275
IKONOS	5m	Multi-spectural	49 km^2	$18/km^2	$16,200
	1m	Pano-chromatic			
Digital Globe - QuickBird	0.65m	Pano-chromatic	1/4 scene = 64 km^2	$22.50/km^2	$20,250

Courtesy of Max Lock Center (2003)

Most remote sensing systems generate great amounts of data that constrain existing handling capabilities. This calls for great investments in instrumentation, time, experience and logistical operations. Where most remote sensing data is obtained due to snap short projects, sustainability of these systems thus becomes a daunting task to users, resource persons and organisations. The SEASAT spacecraft for example that in 1978 operated for only three (3) months generated massive amounts of data that took eight (8) years to analyze. Further, with the deployment of EOS system of polar orbiters, large volumes of data to the tune 1-2 trillion bits each day are expected acquired (U.S. Congress, Office of Technology Assessment, 1993). Because of enormous data generated, information overload gets physical i.e. requiring for increased storage devices this puts a cost implication on the users.

Still within the data arena lie data errors in remote sensing systems. Where remote sensing technology such as GPS is used, data errors usually tend to arise associated with the process of encoding and input of spatial and non-spatial data. The common errors made include; incomplete spatial and non-spatial data, distorted spatial data due to incomplete acquisition of the constellating earth-orbiting satellites, storing spatial data at wrong locations and scale. Errors may arise due to several factors which may operate single handily and/or a combination of many such as: digitizing processor error, registration accuracy ties, machine precision which may be a function of coordinate rounding by a computer during storage and transformation, and analog to digital conversion among other conditions. These at times lead to disorganization in the system. If not well managed, the output from such a system will ideally not be credible.

Closely linked to data quantities is the diversity of users each category with a diversity of needs to be satisfied in terms of application requirements. Because, remote sensing provides data for multiple uses, remote sensing systems are susceptible to abuse from different users. Trivial though is the privacy abuse associated with military based remote sensing systems, which acquire data at great detail. These have been utilised by governments especially intelligence agencies at the expense civil liberties. Turning back to common shortcomings associated abuse due to multiple users; this arises from the various interpretations that particular data is accorded. As such, a similar image can receive multiple interpretations to varying classification schemes that could be adopted. For example, if different users classified the same remote sensing image using different classification algorithms such as parallelepiped classifier, minimum distance technique, maximum likelihood, spectral angle mapper, artificial neural network classifier and/or Mahalanobis distance; it is most likely that he/she will have varying results. This kind of scenario therefore increases with increased number of users using one or more classification schemes in either supervised and/or unsupervised classification process.

Remote sensing systems associated with satellite technology tend to experience delayed propagation (transmission of signals inputs of a logic gate to output) depending on the satellite orbit. A geosynchronous (GEO) remote sensing satellite systems for example experiences delayed propagation however, there are few satellites that can provide connectivity across the globe. As such users have to deal with delays in real time and non-real time applications (Goyal et al., ???). This is particular critical in remote sensing technology for navigation such as Global Navigation Satellite Systems (GNSS) where propagation effects may impact user accuracy, integrity, availability or continuity of service (Rastburg, 2011).

Ground based remote sensing systems such as those applied in meteorological observation (e.g. SODAR, RASS, Radar wind profilers, LIDAR among others) have a range of shortcomings. SODAR for example tends to be limited by temperature inversion that limits altitude coverage, its performance usually degrades during low humidity and cold and also experiences negative effects of externally generated acoustic noise. RASS is particularly limited by ground clutter while LIDAR is limited by fog clouds, high aerosol concentrations and high costs of acquisition and maintenance (Kadygrov, 2006). Further, ground based remote sensing is highly susceptible to inefficiencies especially in the developing world where the skills and technical competences in handling the procedures permeate. Taking an example of GPS technology for example, quite often inaccurate readings occur due to limited experience in using the technology, poor signal acquisition and poor handling of recorded coordinates.

Conclusion

From this brief presentation of shortcomings common in real remote sensing, it is apparent that there are no uniform weaknesses. The weaknesses arise out of a diversity of expectations, utilisation and expertise of remote sensing systems. Despite this observation, there are some commonalities especially those associated with costs, expertise requirements and management challenges. As remote sensing technology and systems continue to grow, scientists are moving towards finding amicable ways in reducing the costs of anchoring and operating remote sensing systems. Such efforts have seen the establishment of the global commons digital laboratories (open source data and software) such as those supported by USDA, Center for Natural Information Technology, and Landsat/Tropical Rain Forest Information Center in association with NASA's Federation of Earth Science Information Partners (ESIP). These are just some of the few institutions that are striving to provide free access to remote sensing data. Some other software developers have open source software available such as GRASS, ILWIS, Q-GIS, Awhere, among others. There is still a lot that needs to be done in this direction as well as building capacity in the developing world to be able to access these data and software repositories.

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