**INNOVATIVE RESEARCH IN REMOTE SENSING APPLICATIONS FOR GEOSPATIAL SOLUTIONS AT *UNIVERSITI TEKNOLOGI MALAYSIA***

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**ABSTRACT**

This paper reports the innovative research in remote sensing and elated technologies at the Institute of Geospatial Science & Technology (INSTeG), Universiti Teknologi Malaysia (UTM). The Research within the post-graduate programmes and the Centre-of-Excellences (COE) such as in Institute of Geospatial Science & Technology (INSTeG) are now welcoming more synergism from related industries; fulfilling the triple helix innovation environment in providing geospatial solutions to the industry. We examplified in this article sharing some recent completed works at INSTeG, where innovative applied research remote sensing applications involving geospatial solutions in sustainablity, satellite oceanography for oil spills, tropical forest and biodiversity, exploration geology for mineral, aerosol and air pollution, and close-range subsurface utility sensing.

Keywords: Remote Sensing Application; Capacity Building/Education, innovation research,

**INTRODUCTION**

Universiti Teknologi Malaysia (UTM) is one of the few and earliest higher learning institutes in South East Asia region that offers Remote Sensing post-graduate programme leading to Master of Science and PhD degrees since 1987 (Mohd et al,2004a; Mohd et al,2004b). This graduate programme was initially hosted in Faculty of Surveying where the undergraduate programme leading to Bachelor of Surveying was offerred since 1970. With recent ranking of higher institutions in Malaysia in accordance to the Global University Rankings, UTM have alleviated to one of the four research universities in Malaysia, and have been accredited a 6-star for undergraduate progamme in Engineering & Technology category. Research within the post-graduate programmes and the Centre-of-Excellences (COE) such as in Institute of Geospatial Science & Technology (INSTeG) are now welcoming more synergism from related industries; fulfilling the triple helix innovation environment in providing geospatial solutions to the industry apart from meeting the requirements of research fulfillments within the graduate programme and producing related articles indexed in SCI documents. We examplified in this article sharing some recent completed works at INSTeG, where innovative applied research remote sensing applications involving geospatial solutions in sustainablity, satellite oceanography for oil spills, tropical forest and biodiversity, exploration geology for mineral, aerosol and air pollution, and close-range subsurface utility sensing.

**REMOTE SENSING RESEARCH AT UTM**

Remote sensing and related technology is one of main research element that had been conducted in Universiti Teknologi Malaysia. Remote sensing applications have been in fact one of the major space applications within space science form a significance revenues in the downstream indutries. However, the level of operationalization of downstream industries have somehow have been hampered in many developing countries, hence created a huge space gap with the space-abled countries. The despite the establishment of the United Nations Space Office to foster cooperation among member countries in space science related activities, but the space still persist and in most of these gaps are solely attributed due to unreadiness of the some government of member countries to fully accept the technology applications for various reasons, ranging to unreadiness of the goversnment agencies to change from the long conventional methods to that invloving certain security aspects. This, however does not the case in the private firm in the entire country where the applications of remote sensing are vibrrant, catering both the national and international projects. UTM has position the importance of remote sensing and related technology for its post-graduate research since 1987.

With the establishment of centre of excelence in UTM, this research thrust is extended in Institute of Geospatial Science and Technology (INSTeG). In INSTeG, we practices integrative and collaborative research which involves multi-disciplinary teams, knowledge and networking at national and international levels. Apart from research, we also offer consultancy for customization of remote sensing applications to one specific needs. In transfering such services, we involved the post graduate candidates in the project. Hence bridging the post-graduate research to industries need. The research area covers geospatial solutions for various application of atmosphere, oceanography, land and close range sensing as exemplified below.

**ATMOSPHERE, AEROSOL AND SMOKE APPLICATIONS**

Remote sensing offers versatile technique to monitor and track the air quality using suitable data. With the persistence of transboundary smoke, haze in the regions, and this is evident with serious studies addressing the issue for operational issues since early late 90’s (Ahmad and Hashim, 2000; Hashim et al ,2004). The application is then revised with availability of MODIS satellite data (Yap and Hashim, 2011); to retrieve air pollution (PM10) in Peninsular Malaysia. They establish a relationship between satellite-retrieved AOD and surface measured PM10 in a country under maritime climate that is Peninsular Malaysia and to investigate its reliability in monitoring PM10 concentration. Monthly average shows higher correlation of 0.6 with +/-12.90 μg/m3 RMSE for six years. These suggest that, MODIS estimated PM10 has the potential to be utilized in air quality monitoring over Peninsular Malaysia. Robust approach for PM10 retrieval using MODIS aerosol optical depth within the region is then reinforced in Yap and Hashim (2013) for best addressing contimated pixels, hence forming best tool for operational applications.

**COASTAL ENVIRONMENTS AND MARINE APPLICATIONS**

Rapid coastal development is in tandem with rapid urbanisation as new economic growth is much a factors of existence of ports and martime as well as the national oil and gas industries. The coastal / marine applications research have evolved from field observation, visual interpretation from aerial photography, mapping from remote sensing satellite data along with field survey and hydrograhic chart; focussed on: Mapping shallow coastal substrates and mangrove for input into eclogical studies (Hashim et al 2001a, Yahya et al. 2014); Coastal / marine oil spills (Marghany and Hashim, 2007; Marghany et al 2009a, 2009b; Marghany and Hashim, 2011a, 2011b); Ocean colour and chlorophyll a (Hashim et al 2000; Marghany and Hashim, 2010a; Siswanto and Hashim,2012); Coastal morphology, bathymetry and wave spectra including simulation on sea surface current for specific coastal area (Maged and Hashim, 2006; Maged and Hashim, 2008; Maged and Hashim, 2009a, 2009b; Marghany and Hashim, 2010).

**AGRICULTURAL / FOREST / VEGETATION APPLICATIONS**

Agriculture has been the mainstay of the nation economy, and as such remote-sensing applications to agriculture has been one of the important application in Malaysia. At the operational level, only the tangible information retrieved from satellite remote sensing data has been used. In the context of vegetation science the focus of UTM research have been on the complimenting the extraction of intangible information for precision agriculture (Hashim et al, 2001b); forest ecosystem and phonological changes (Hashim et al 2001c, Hashim et al 2002, Okuda et al 2004, Numata et al 2013); and landscape development and implications to ecosystems (Hashim et al 2002, Hashim et al 2010).

Most all of these studies have form the basis for innovation in the commercialisation.

GEOLOGY AND MINERAL EXPLORATION APPLICATIONS

Most of the applications of remote sensing to geology and related applications are motsly depending on the tangible information. This in fact is only a small portion of untapped intagible information. Apart of the intangible geologic and anomalies related to mineralogy (Pour and Hashim, 2012), we have empahsized also the automatic approach (Marghany and Hashim, 2010b; Hashim et al., 2012). Both these approach have found relevancy in the related industries local and at regional levels. In tropic region, the fully vegetated terrain have been a great challenge to operationalise (Pour and Hashim, 2014), hence comparative of retrieval of information with semi-arid and arid zones have been also performed succesfully (Pour and Hashim, 2012; Pournamdari et al 2014) . Copper and gold have been two minerals sucessfully studied especially in identifying anomalies of the new prospects for the selective area of interest.

CLOSE RANGE SENSING APPLICATIONS

Rapid urbanisation in Malaysia and the region have contributed significantly to fully utilise the urban spaces optimally. Sub-surface urban spaces have been one of the main thrust of operational research in UTM where radar basckscatters are reconstructed for sub-surface mapping (Jaw and Hashim, 2013). Not only the works done the locational and depth accuracy to ensure meeting the sub-surface mapping standard, but we have remphasised the work to cover recognition of buried materials (El-Mahallawy and Hashim, 2013) and its condition (Hashim et al 2011; Hashim and Jaw 2012).

**CLOSING REMARKS**

This paper has summarised group of remote sensing applications in UTM that have been carried out as input into specific geospatial solutions. All these innovation studies have employed both the passive, active and cloase range sensing systems. We are also venturing to benefit most from the under-exploited remote sensing applications such as the retrieval of intagible information. Close range sensing using ground penetrating radar is also prominently important in our sensing innovative for geospatial solutions.

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