Lowland Technology International 2020; 22 (1): 008-012
International Association of Lowland Technology (IALT): ISSN 1344-9656
Special Issue on: Engineering Geology and Geotechniques for Developing Countries

Research Paper

Virtual Geo-Hazard Monitoring and Asset Management System (ViGMAS)

R.C. Omar [1], H. Taha [2], R.Roslan [3], I.N.Z. Baharuddin [4], M.M. Fared [5] and W.S.W. Hashim [6]

ARTICLE INFORMATION

Article history:

Received: 21 October, 2019
Received in revised form: 25 February, 2020
Accepted: 06 March, 2020
Publish on: 06 June, 2020

Keywords:

Geo-hazard monitoring
Asset management
Satellite system
Virtual reality
Geographic Information System

ABSTRACT

This paper describes a virtual geo-hazard monitoring and asset management system (ViGMAS) which implements a near real-time satellite image processing system to extract relevant environmental and meteorological parameters. The system focuses on geo-hazard monitoring by accumulating information about the earth using remote sensing technologies which can be applied in disaster risk management. This system also includes asset management program for managing assets by inventory and assessment through integration with Geographic Information System (GIS). Mapping and inventory by GIS help to improve efficiencies and assist in decision making based on gathered data. The system was designed to manage preliminary construction and management planning, health performance, risk and costs of management asset through 4D visualization which integrates existing data and primary data obtained from a data set of mapping terrain and satellite that will fit in the system of virtual reality.

1. Introduction

Geohazard is defined as any natural hazards or damages caused by the geological and environmental conditions of the Earth or by human activities that can happen anywhere at any time without warning (Knight J. 2019). Geohazards can result in environmental impact, loss of life and property. Geo-hazard is difficult to predict and the best way to manage geo-hazard effectively is through hazard prevention using integrated approach to assess the data and calculate the risk by establishing geohazard modeling (Kundu.,2017). However, geo-hazards can be monitored and predicted through the introduction of new technology such as new satellite, laser scanning and remote sensing techniques (Abellan et al., 2016). Satellite remote sensing and Geographic Information System (GIS) applications have become essential tools in morphological mapping and simulating of earth environments including monitoring of disaster prone areas (Bala et al., 2017, Yu et al., 2018). This can be achieved by developing strategies and geohazard modeling to disseminate the data and information for an effective environmental management and decision making through the application of latest software

[1] Associate Professor and Corresponding Author, Institute of Energy Infrastructure, University Tenaga Nasional, 43000 Kajang, MALAYSIA, Rohayu@uniten.edu.my
[2] Post-doctoral, Institute of Energy Infrastructure, University Tenaga Nasional, 43000 Kajang, MALAYSIA, Hairin@uniten.edu.my
[3] Lecturer, Institute of Energy Infrastructure, University Tenaga Nasional, 43000 Kajang, MALAYSIA,Rasyikin@uniten.edu.my
[4] Lecturer, Institute of Energy Infrastructure, University Tenaga Nasional, 43000 Kajang, MALAYSIA, Intan@uniten.edu.my
[5] Engineer, TNB GRID Maintenance, 50050 Kuala Lumpur, MALAYSIA, muzadf@tnb.com.my
[6] Engineer, TNB GRID Maintenance, 50050 Kuala Lumpur, MALAYSIA, wan.nsyazwani@tnb.com.my
Note: Discussion on this paper is open until December 2020

(Hanifah MIM et al., 2016, Bouali et al., 2016). Historically, asset management activities have been implemented individually and it is found to be insufficient to support activities associated with data integration and data quality. Thus, geohazard management approach is very important for maintaining the safety of asset and infrastructure in disaster management (Mazzanti., 2017, Sigtryggsdóttir et al., 2016).

ViGMAS was designed to manage the preliminary construction and management planning, health performance, risk and costs of transmission asset owned by stakeholder Grid through 4D visualization. This integrated system was developed to enhance the asset maintenance process using Visual Reality (VR) which combines several fields such as asset maintenance, asset development, flood, satellite technology, Virtual Reality, information system and society engagement. ViGMAS allows stakeholders to try out situations and responses, especially in asset maintenance and geo-hazards management that cannot be rehearsed in the real world.

2. ViGMAS

ViGMAS is a new technology that incorporates virtual reality system with satellite and scanning technology that will enable user to carry out planning, operation and maintenance by stage designing and virtual construction (Figure 1). Figure 2 shows the seven subgroups or project components which are incorporated in the system. This system utilizes Geo Visionary software and Virtual Reality for landscape planning and vegetation control and management that can assist in managing land encroachment. By using the Geo Visionary software, numerous sets of data from different sources can be assimilated and integrated to create a 3D model of a landscape.

The Virtual Reality technology enables the process of decision making in asset management by using the VR models. Multiple sets of data from different sources can be assimilated and combined together in ViGMAS to create a 3D model of a landscape in which "what if" scenarios can be played out. ViGMAS allows stakeholders to try out situations and responses, especially in asset maintenance and geo-hazards management that cannot be rehearsed in the real world. The system architecture is illustrated in Figure 3. The development of ViGMAS is considered to be one of the first examples of the replication of near real-time conditions in real world sites virtually. ViGMAS will be used as a platform to integrate previous projects with existing data from the stakeholder Grid and government agencies such as cadastral map, land use map, geological map and topographical map including new data from satellite technology and laser scanning in 4D visualization which are similar to their natural environment and near to real time.

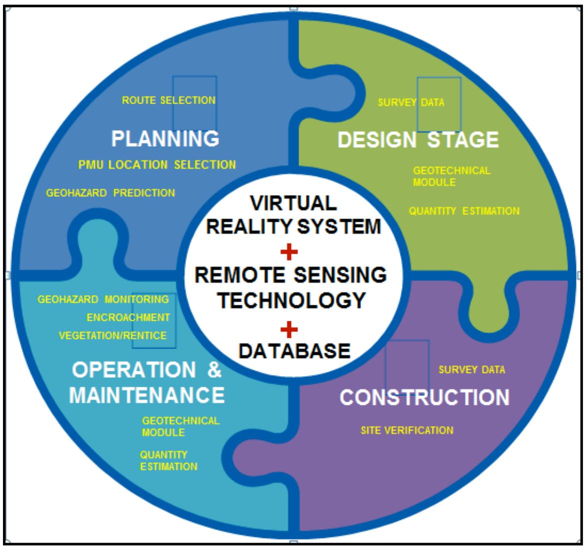

Fig. 1 ViGMAS system

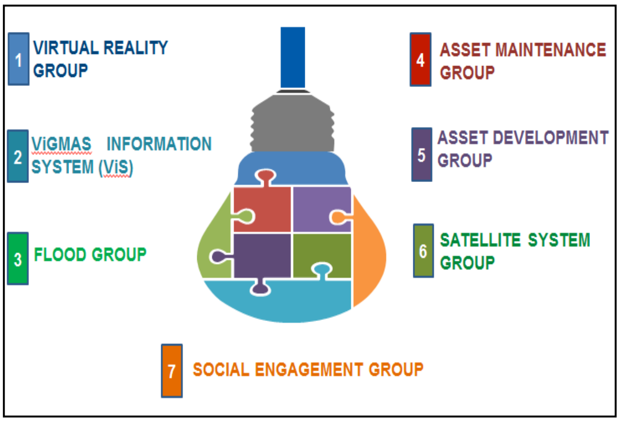

Fig. 2 The project components in ViGMAS

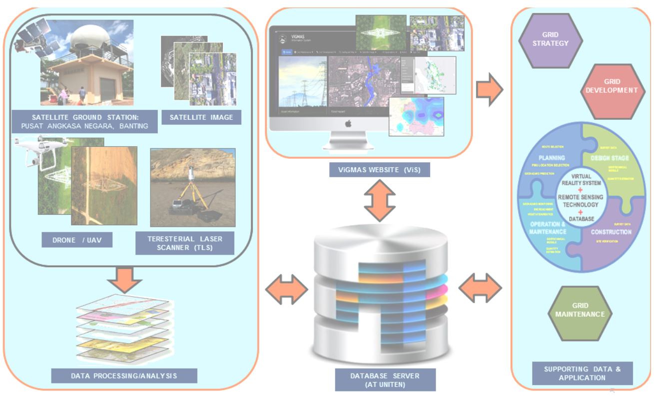

Fig. 3 System architecture of ViGMAS

3. Methodology

The data accumulation in the ViGMAS system consists of data acquisition, data processing and analysis, data integration and data visualization as shown in Figure 4.

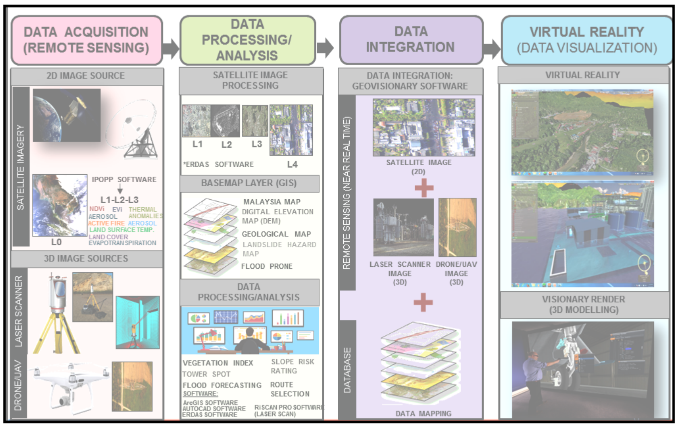

Fig. 4 Data accumulation

3. 1 Data acquisition

Data acquisition was acquired from two sources which were 2-Dimensional image (2D) and 3-Dimensional image (3D) data. Data from 2-Dimensional imagery were gathered from numerous satellite types accessible during that moment including Joint Polar Satellite System (JPSS), Suomi National Polar-orbiting Partnership (S-NPP), Aqua and Terra missions (Guan K et al., 2018). However, the 3-Dimensional images were gathered from different sources which were Terrestrial Laser Scanning (VZ400i) and Unmanned Aerial Vehicle (UAV). TLS and airborne technologies provide high precision and spatial resolution in 3D topography, suitable for morphological mapping of landscape and terrain structure (De cuyper M et al., 2018, Disney M., 2019). Together, the combination of 2D and 3D data were created into 4-Dimensional which were used in virtual reality (VR) environment.

3.2 Data image processing

Data processing system consists of two PCs, which were installed with International Polar Orbiter Processing Package (IPOPP) software. IPOPP processes science data and derivative products from the Joint Polar Satellite System (JPSS), Suomi National Polar-orbiting Partnership (S-NPP), Aqua and Terra missions. IPOPP has the capability to process real-time data (direct broadcast downlink) and non-real time data (downloaded from global archives). Whilst, FES is a set of equipment that receives raw sensor data from a direct broadcast downlink. Figure 5 shows how the raw data was processed.

For 3-Dimensional data, the data were processed using different software depend on the types of the data. The TLS data were processed with RiSCAN Pro software, which will create a point cloud data for virtual reality (VR) software. However, the UAV data was processed with Geographical Information System (GIS) only and the output from this process were topology data and imagery data for specific area. Finally, the outputs data from 2D and 3D were analyzed using GIS software to get the basemap and data analysis. The basemap were analyzed with spatial data which consist of digital elevation map (DEM), boundary, geology, river, landslide hazard map, flood prone area and etc. For data analysis, the information from satellite were analyzed using specialized software such as Quantum GIS (QGIS), Erdas Imagine in order to generate vegetation index, hot spots area, flood forecasting, slope failure and route selection.

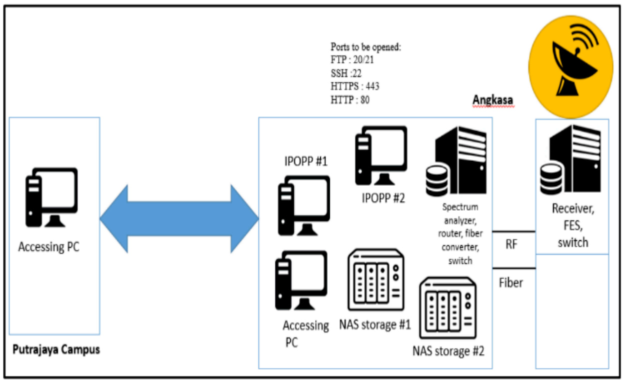

Fig. 5 The flow of raw data to processed data

3. 3 Data Integration in Virtual Reality (VR)

Data integration was performed after completion of the analysis phase. The integration of data was done using Virtual Reality software, which is geovisionary software. Terrain data were overlay with satellite imagery data to create 4-dimensional environment for topology in Peninsular Malaysia. The 3-dimensional data were directly imported to this software to create a virtual reality environment for Peninsular Malaysia. From this output, all the asset and hazards can be monitored directly which is near to real time imagery from satellite. User can feel the same environment with real site because in virtual reality, the scale that was based on 1 to 1 scale and the image depends on the quality of the data that were used. Using this Virtual Reality (VR) platform, user can do planning and monitoring assets and hazards from the office. Thus, reducing any work safety issues with less labor and time costs. It was mentioned that remote sensing satellite can play an important role in ecosystem risk management (Murray NJ et al., 2018).

3.4 Data archiving

The satellite data was then transferred from Front End Server (FES) at National Space Agency (ANGKASA) to data archiving processing and data archiving system that is located at UNITEN. Figure 6 shows the flow of data from FES to archiving system and to end users and Automated Data Archive (ADA) Server respectively.

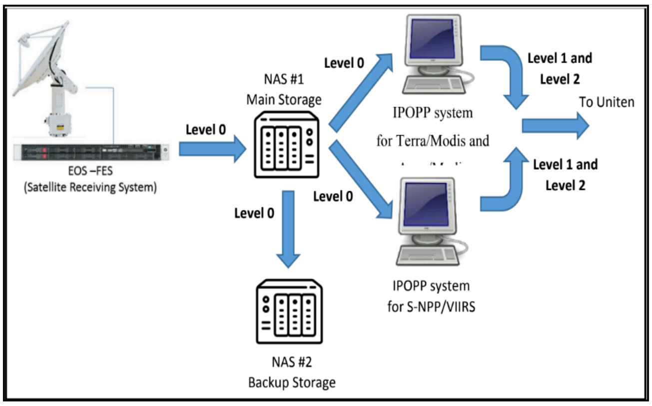

Fig. 6 Data from FES to archiving system and end users

3.5 Data Server / Network Set-Up

The data communication system from satellite FES to data processing and data archiving system was developed in several stages. Figure 7 shows the network set-up.

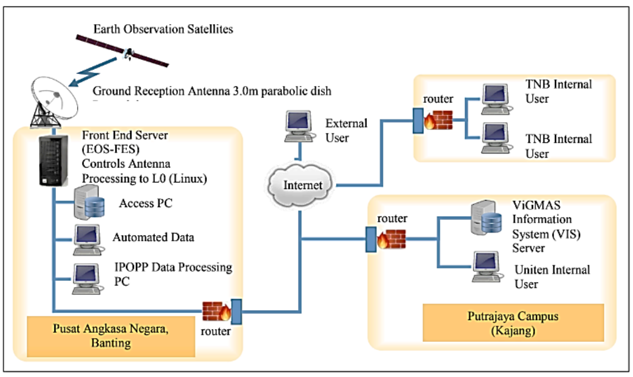

Fig. 7 ViGMAS Satellite Network set-up

3.6 Data Cataloging

Non-real data of Peninsular Malaysia ingested by Landsat8 was also collected from United States Geological Survey (USGS) global archive. More specifically, several months of Landsat8 raw data of Peninsular Malaysia had been acquired from September to December 2016, and January to April 2018. This data collection was done manually and catalogue onto the server. Figure 7 shows the data catalogue of Landsat8. Full cataloguing of the satellite data from the ground station was made through the ViGMAS Information Interface System (VIS).

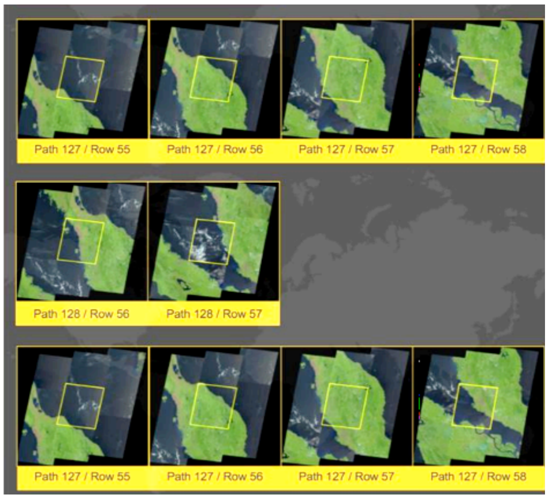

Fig. 7 Data catalogue of Landsat8

3.5 Development of website

The overall user interface structure of ViGMAS Information System website is illustrated in Figure 8. The website enables users to access it using registered username and password. Within the ViGMAS Information System, the main menu consist of Home, Grid Maintenance, Grid Development, Geohazard Map, Satellite Image, VR Applications, About and Sign Out. ViGMAS Information System is accessible to both stakeholder and UNITEN's researchers only.

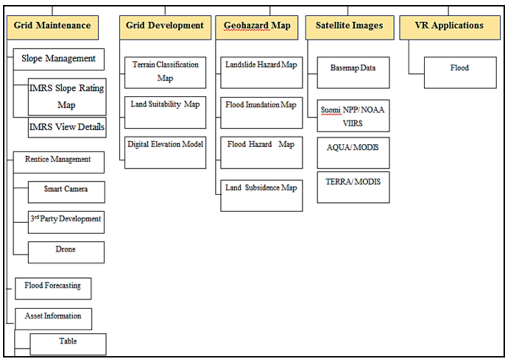

Fig. 8 Structure of ViGMAS Information System

4. Conclusion

ViGMAS was developed to monitor stakeholder assets in virtual reality (VR) environment integrated with remote sensing system. The system was designed and installed at the UNITEN proved to be successful in grid asset management and geo-hazard monitoring. The established system can be used to monitor any disaster situations; before, during and after. Decision making and data monitoring can be carried out based on integrated data from various resources in real time. Disaster areas such as flood prone areas can be identified as hot spot zone, thus identifying high risk areas that require attention and assistance for emergency decision making.

ACKNOWLEDGEMENTS

This project was funded by TNB SEEDFUND grant (U-TE-CR-17-01). The authors would like to thank the FEG members for their valuable assistance in this project.

References

Abellan, A., Derron, M.H. and Jaboyedoff, M., 2016. “Use of 3D Point Clouds in Geohazards” Special Issue: Current Challenges and Future Trends.

Bala, P., Tom, S. and Shinde, R., 2017. GIS and Remote Sensing In Disaster Management. Imperial Journal of Interdisciplinary Research (IJIR), 3(5).

Bouali, E.H., Oommen, T. and Escobar-Wolf, R., 2016. Interferometric stacking toward geohazard identification and geotechnical asset monitoring. Journal of Infrastructure Systems, 22(2) : 05016001.

Decuyper, M., Mulatu, K.A., Brede, B., Calders, K., Armston, J., Rozendaal, D.M., Mora, B., Clevers, J.G., Kooistra, L., Herold, M. and Bongers, F., 2018. Assessing the structural differences between tropical forest types using Terrestrial Laser Scanning. Forest ecology and management, 429, pp.327-335.

Disney, M., Burt, A., Calders, K., Schaaf, C. and Stovall, A., 2019. Innovations in ground and airborne technologies as reference and for training and validation: terrestrial laser scanning (TLS). Surveys in Geophysics, pp.1-22.

Guan, K., Li, Z., Rao, L.N., Gao, F., Xie, D., Hien, N.T. and Zeng, Z., 2018. Mapping Paddy Rice Area and Yields Over Thai Binh Province in Viet Nam From MODIS, Landsat, and ALOS-2/PALSAR-2. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 11(7), pp.2238-2252.

Hanifah, M.I.M., Omar, R.C., Khalid, N.H.N., Ismail, A., Mustapha, I.S., Baharuddin, I.N.Z., Roslan, R. and Zalam, W.M.Z., 2016, November. Integrated geo hazard management system in cloud computing technology. In IOP Conference Series: Materials Science and Engineering (Vol. 160, No. 1, p. 012081). IOP Publishing Ltd..

Kundu, S.N., 2017. Geohazard Modeling Using Remote Sensing and GIS. In Modelling Trends in Solid and Hazardous Waste Management (pp. 127-139). Springer, Singapore.

Knight, J., 2019. Geological and Environmental Hazards in South Africa. In The Geography of South Africa (pp. 285-294). Springer, Cham.

Mazzanti, P., 2017. Toward transportation asset management: what is the role of geotechnical monitoring?. Journal of Civil Structural Health Monitoring, 7(5) : 645-656.

Murray, N.J., Keith, D.A., Bland, L.M., Ferrari, R., Lyons, M.B., Lucas, R., Pettorelli, N. and Nicholson, E., 2018. The role of satellite remote sensing in structured ecosystem risk assessments. Science of the Total Environment, 619, pp.249-257.

Sigtryggsdóttir, F.G., Snæbjörnsson, J.T., Grande, L. and Sigbjörnsson, R., 2016. Interrelations in multi-source geohazard monitoring for safety management of infrastructure systems. Structure and Infrastructure Engineering, 12(3), pp.327-355.

Yu, M., Yang, C. and Li, Y., 2018. Big data in natural disaster management: a review. Geosciences, 8(5), p.165.