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Automatic lineament extraction in a heavily vegetated region using Landsat Enhanced Thematic Mapper (ETM+) imagery

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Abstract

Lineament extraction from satellite remotely sensed data has been one of the widely used applications of remote sensing in geology. In fact, recent advances in digital image processing allow such lineament extraction to be accomplished in semi-automatic to fully automatic approaches. However, satellite remotely sensed data acquired in heavily vegetated regions such as tropical rainforest, are vulnerable to higher inherent noise levels attributed to the resultant effects of scattering by clouds and adjacency effects of highly inhomogeneous vegetation cover within the pixel dimension. In this study, we examined the effects of noise levels to lineament extraction using a fully automatic approach, consisting of a combination of edge-line detection algorithms. Ancillary information from a digitized topographic map and image classification was used to discriminate between cultural and natural lineaments from the extracted lineaments. Adapting the combination of edge detection and a line-linking algorithm, we have found the optimal parameters for automatic lineament extraction of such complex areas using Enhanced Thematic Mapper (ETM+) data. A noise level of 30% is the maximum threshold before artifacts are generated. It is therefore concluded that the combination of edge-based and line-linking digital image processing operations with the priori local optimal parameters is crucial in lineament feature extraction in heavily vegetated regions.

Keywords: Lineaments; Automatic extraction; Edge detection; Line detection; Tropical rainforest

1. Introduction

Satellite remotely sensed data has been widely used as source of information for geologists to map lineaments at district and regional scales. Geological lineaments such as linear (fault) or curvilinear (anticlinal or synclinal fault) structures are amongst the parameters that can be used in assisting mineral prospecting, hydrogeology studies (Corgne et al., 2010; Masoud and Koike, 2006; Pour and Hashim, 2012a; Qari et al., 2008; Rajesh, 2008; Ramadan and Abdel Fattah, 2010; Ranganai and Ebinger, 2008; Roy et al., 2006), and tectonic studies for the delineation of major structural units, analysis of structural deformation patterns and the identification of geological boundaries (Abete et al., 1995; Ekneligoda and Henkel, 2010; Kageyama et al., 2000; Lim et al., 2001; Loizzo et al., 1994; Marghany and Hashim, 2010; Mountrakis and Luo, 2011; Noltimier et al., 1998; Paganelli et al., 2002; Qari, 1990; Ramli et al., 2010; Saadi et al., 2011; Salati et al., 2011). Systematic mapping of linear structures can be used to assist geologists in interpreting crustal structure and other subsurface phenomenon in tropical vegetated areas with unexposed lithology (Juhari and Ibrahim, 1997; Leary et al., 1976; Raj, 1989; Ramli et al., 2010; Tjia, 1989).

Lineaments can be detected due to their physiographic features that caused the tonal change in contrast to the relief, pattern and textures in the satellite images. Two types of lineaments are mostly recognizable from remote sensing data, namely: (i) the positive lineaments that consist of strike ridges and dykes; and (ii) negative lineaments, which are made up of joints and faults (Raj, 1989; Leech

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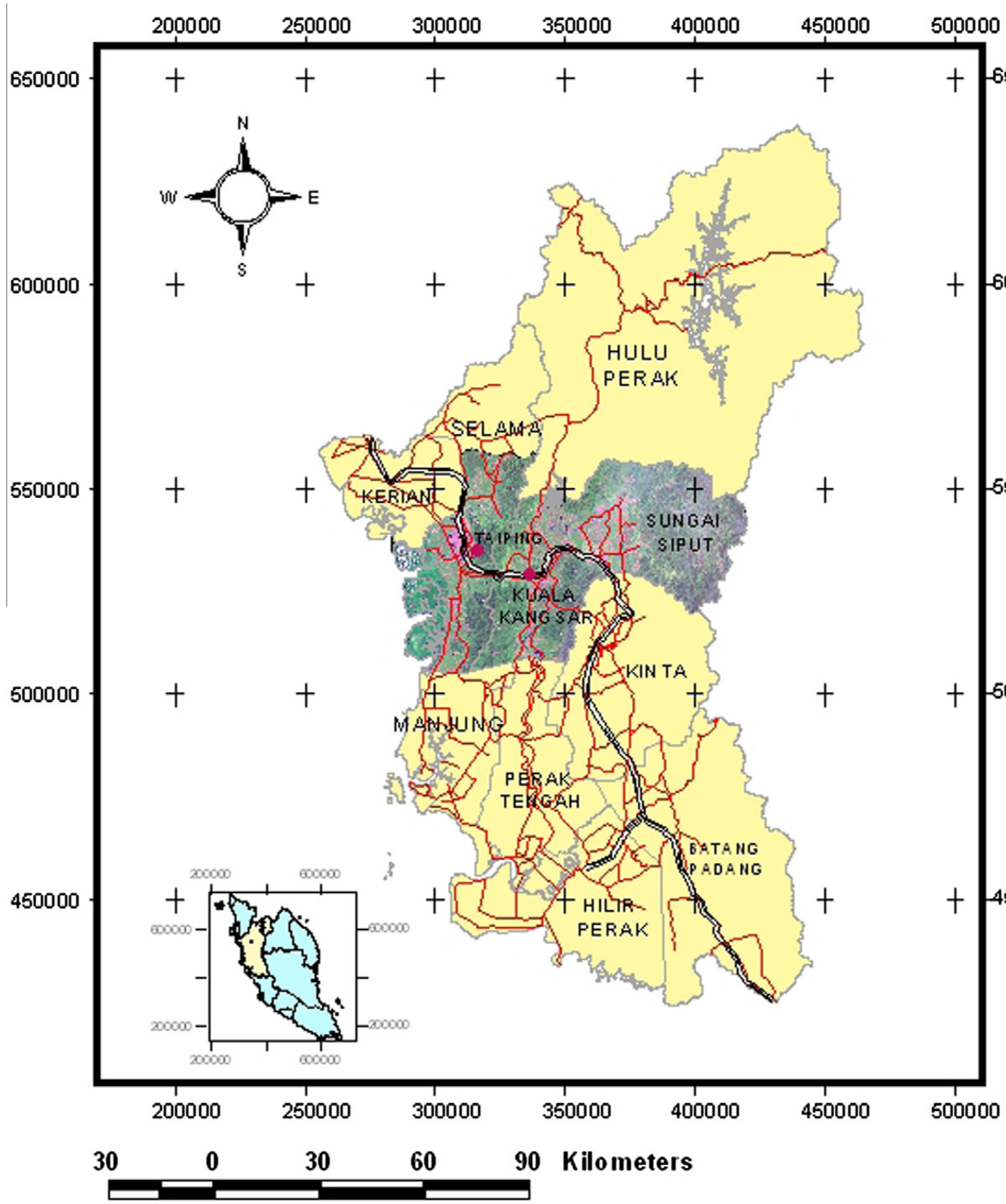

Fig. 1. (a) Location of the study area in Malaysia; (b) Geology map of the study area (modified from Malaysian Geosciences and Mineral Maps, 2002).

et al., 2003). Lineaments consist of both natural and artificial features, with the natural ones occurring due to geological formations and the others being mainly man-made features such as highways, area boundaries (such as urban and farm boundaries), relief dark tonal lines and linear drainage channels. Thus, extracting the natural lineaments from optical imagery requires experienced interpreters or post processing tasks to be applied for differentiating these natural lineaments from artificial ones.

As is shown by the literature, the extraction of geological lineaments from remotely sensed data can be grouped into at least three main approaches, namely: (i) manual extraction (Ehmann, 1985; Jordan and Schott, 2005; Leary et al., 1976; Raj, 1989), (ii) semi-automatic extraction (Jordan et al., 2005; Juhari and Ibrahim, 1997; Lim et al., 2001), and (iii) automatic extraction (Jinfei and Howarth, 1990; Joshi, 1989; Kageyama et al., 2000; Masoud and Koike, 2011; Mostafa and Bishta, 2005; Saadi et al., 2011). The extraction of the information from manual and semi-automatic approaches has been greatly influenced by the experience of the analyst, while automatic extraction, so far, depends on the algorithms efficiency as well