Urban Spatial Pattern and Interaction based on Analysis of Nighttime Remote Sensing Data and Geo-social Media Information

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Abstract. *Urban development in Indonesia significantly incerasing in line with rapid development of infrastructure, utility, and transportation network. Recently, people live depend on lights at night and social media and these two aspects can depicted urban spatial pattern and interaction. This research used nighttime remote sensing data with the VIIRS (*Visible Infrared Imaging Radiometer Suite*) day-night band detects lights, gas flares, auroras, and wildfires. Geo-social media information derived from twitter data gave big picture on spatial interaction from the geospatial footprint. Combined both data produced comprehensive urban spatial pattern and interaction in general for Indonesian territory. The result is shown as a preliminary study of integrating nighttime remote sensing data and geospatial footprint from twitter data.*

Keywords: *remote sensing, geo-social media, spatial pattern, spatial interaction, urban*

1. Introduction

Urban development in Indonesia increasing significantly caused by development in infrastructure, utilities, and transport networks. Urbanity activity can be characterized by the activity of people in longer time. The higher of the level urban area had the longer community activities even until night. Community activities at night need an electric light at public space or settlement. The use of light at night indicated community activity at urban area.

Recently, there has been a renewed interest in using nighttime images of Earth that show visible light emissions, providing a picture of urbanization through the detection of city lights. The high contrast provided by this type of image between lighted and unlighted lands and the sensor's moderate spatial resolution (45 m) make it a potent choice for identifying areas where significant human activity is being carried out. Dependence of communities on the light at night can be identified through remote sensing image is the Visible Infrared Imaging Radiometer Suite (VIIRS). VIIRS image has two bands and one of it is night band. VIIRS image of night gives an overview of spatial community activities through the lights at night. Satellite imaging of stable anthropogenic lights provides an accurate, economical and

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straightforward way to map the global distribution of urban areas [4,5]. Urban areas account for a small fraction of Earth's surface area but exert a disproportionate influence on their surroundings in terms of mass, energy and resource fluxes.

Along with the development of technology, the use of social media was one of the needs of urban communities. With the increasing capabilities of social media, individuals leave behind footprints of their interaction with urban environments. In this context, cell phones have become one of the main sensors of human behavior, thanks, among others, to their growing penetration and wealth of social applications. The use of social media can be obtained geo-social media is social media data that has location attributes. Geo-social media twitter derived from these data that could give an idea of interaction of geospatial footprint. One of the widely used social media community is Twitter. Particularly georeferenced Twitter data is a promising opportunity to understand geographic processes inside online social networks. The enormous potential of interactive social media platforms like Twitter has been increasingly recognized by numerous research domains over the last years [2,6,7].

VIIRS imagery and geo-information provide an overview of social media and the pattern of urban spatial interaction in the area of Indonesia. In this paper, we propose to analyze the pattern and spatial interaction based on nighttime remote sensing data and geo-social media information The results of this study represent an early review the integration of nighttime remote sensing data and geo-social media information

2. Material and Methods

2.1 Study Area

The study area was the Java Island, Indonesia (Fig. 1). Until this year, the highest urban development happened on Java Island beside the others islands [10]. Its mean java has complexity spatial pattern and interaction. The urban development that used to appeal others islands is infrastructure, utility, and transportation network. Based on rapid development in java, people now live in the fast rhythm. Due to this habit people live to depend on lights at night and social media. These two factors can figure out the spatial pattern and interaction [1].

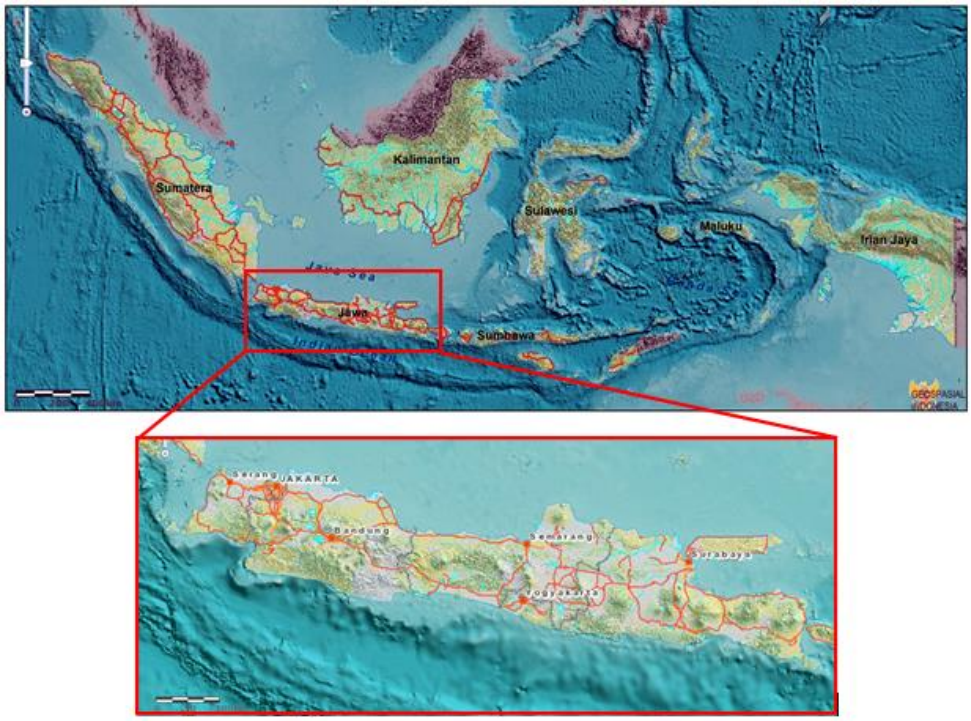


Figure 1. Java Island, Indonesia as study area
(source: http://tanahair.indonesia.go.id/)

2.2 Data Collection

a. Remote Sensing Night-time data

Remote Sensing Night-time data is a reliable source of information on light emissions only if the clear imagery is available. In addition, nightlight imagery is available at a low temporal resolution due to the uniqueness of the satellite collection and its orbit. Visible Infrared Imaging Radiometer Suite (VIIRS) data established from Earth observations Group (EOG) NOAA/NGDC with National Polar-orbiting Partnership (NPP) imagery that specific to detects lights, gas flares, auroras, and wildfires [9]. Remote sensing data that used to this research is VIIRS Day/Night Band (DNB) Cloud free composites data were acquired on July 2016. VIIRS DNB Cloud free composites are one of the provided data with scope cloud free and visible region based on average light on one month.

Human activity, especially in that night, depends on light. Remote sensing night-time data probably give some information for the area which has high activity in the night that shown by high reflectance of light. The other hands, Dark region in imagery indicate low activity of light. Figure 2 point out light reflectance in java island so it can absorb spatial distribution of light from the picture.

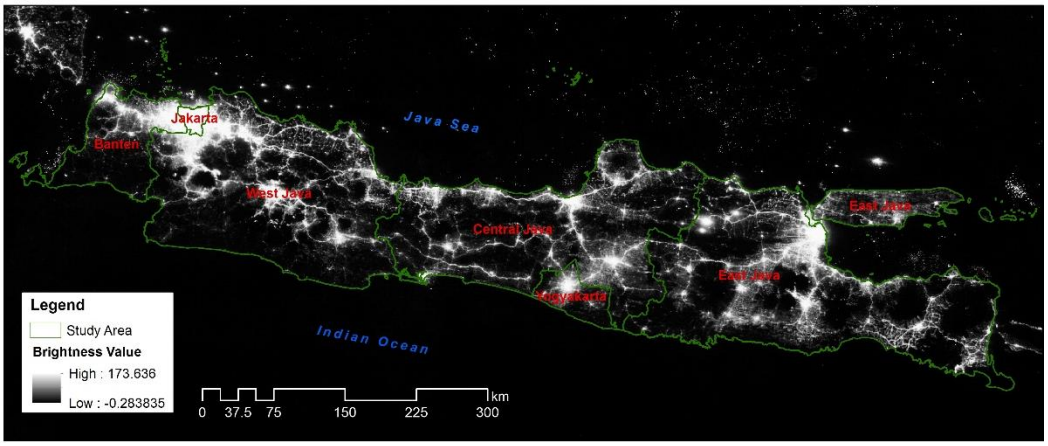


Figure 2. Java Island at night.
(*http://ngdc.noaa.gov/eog/viirs.html*)

b. Night Light Development Index (NLDI)

Development of night light information in the certain area be known by compare remote sensing night-time data with density inhabitant, it called Night Light Development Index (NLDI). The calculation of NLDI based on co-distribution light at night and inhabitant. NLDI data is development imagery data from NOAA/NGDC and the value based on state and province. Table 1 shows NLDI in each province of Java. NLDI is additional data to support how to know urban development in a certain area.

Table 1. NLDI of Java Island [9]

No.	Country	County	NLDI
1	Indonesia	East Java	0.629397
2	Indonesia	Jakarta	0.407950
3	Indonesia	West Java	0.652290
4	Indonesia	Central Java	0.656312
5	Indonesia	Yogyakarta	0.521561

c. Social Media Data (Twitter)

Real-time collection of social media is the most reliable method for gaining a sufficient quantity of streaming tweets during an event. Geo-social media information on this research is twitter data that has

a large amount of data in the word. It collected by using Twitter API utility. Then API data visualized spatially using Mapbox application or website developed by Eric Fischer. Historical twitter data that had been collected able to visualize in dot map suit at a certain scale.

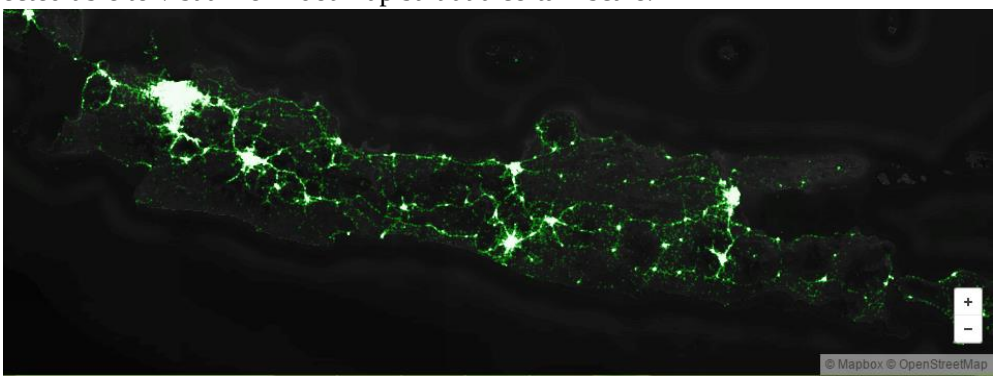


Figure 3. Twitter Spatial Data
(https://api.tiles.mapbox.com/)

2.3Analysing Data

Spatial analysis is a horde of methods to determine and depicted the pattern of the spatial phenomenon, so it can understand easily. There are various types approach to analyse spatial pattern and interaction, ranging from visual interpretation till applied statistic/mathematic [3]. This research is preliminary work, experiment design to catch information for spatial pattern and interaction from data above use visual interpretation both of the data (VIIRS data and Twitter data). Visual interpretation very useful to find and make clear pattern and interaction a few object and spatial phenomenon in the surface of the earth. If doing visual correctly, the complicated spatial pattern can detect quickly. Visual analyse of urban development divide into distributed of point object and spatial tessellation. The important things that're have to concern to detect spatial pattern are distance, interaction, and movement.

Spatial pattern and interaction urban development in java island determine based on [8]. According to Yunus [8] spatial pattern divides into nine elements, that is:

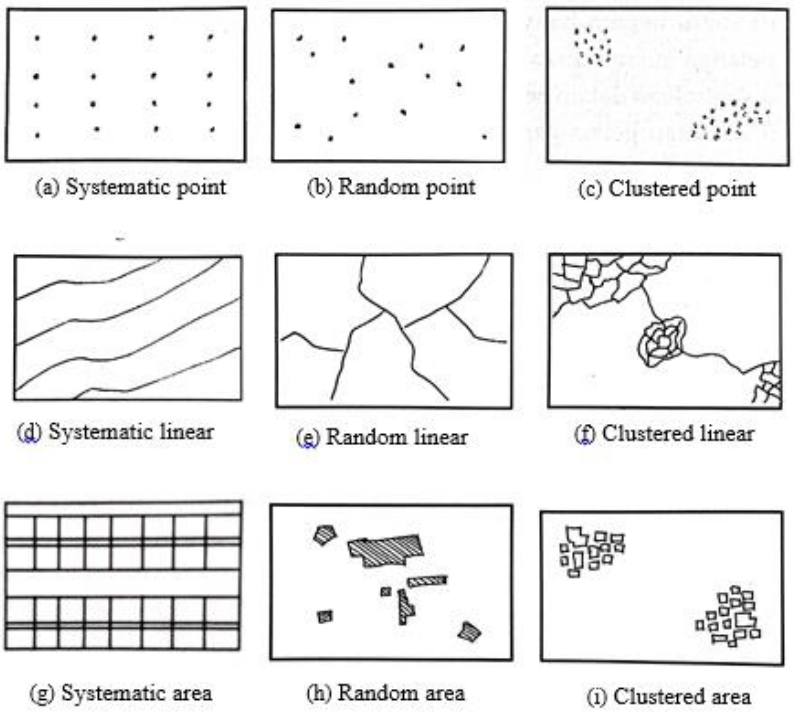


Figure 4. Types of spatial [8]

Each of the data either VIIRS data and twitter data should be analysed with the same way, which is used spatial pattern method using visual interpretation. Similarities and differences of the result are the points of view discussion. Additional data (NLDI) is support and prove how urban or rural area grown up and help to detect the spatial pattern and interaction information.

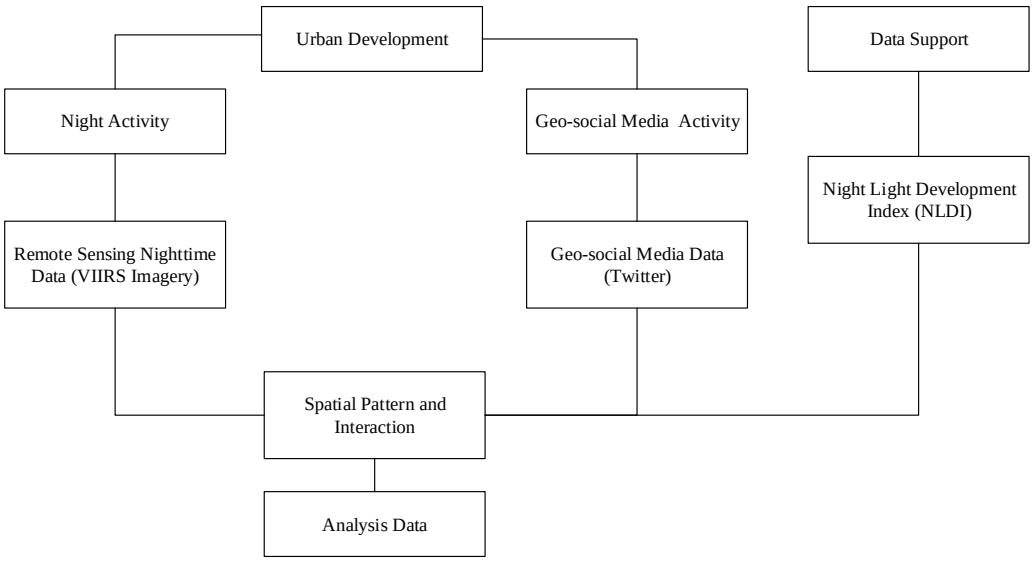


Figure 5. Workflow Design

Spatial interaction is a process influencing another object at the certain space [8]. There are two types of spatial interaction Yunus [8] that are stimuli-responses i.e. urban-rural interaction and push-pull i.e. one-way interaction and two ways interaction. This research used the spatial interaction above to identify in case study area.

3. Result

The result is shown as a preliminary study of integrating nighttime remote sensing data and geospatial footprint from twitter data. The integration can depict urban spatial pattern and interaction in Java Island. Based on the visual analysis we can see three types of spatial pattern: systematic, random, and clustered. Clustered area in Java Island can be seen from VIIRS image and twitter data visually, especially located in big cities such as Jakarta, Bandung, Semarang, Yogyakarta, Solo, and Surabaya. Geospatial footprint from twitter for the big cities has the same pattern with the image as can be seen in Figure 5. Clustered area has the most dominant light resulting in the geospatial footprint as the brighter area formed originally from points (Figure 6). Urban activities are higher than rural area perform the higher needs of light and more concentrated. The availability of facilities and infrastructures in urban areas gives more active the people live in urban with social media such as twitter.

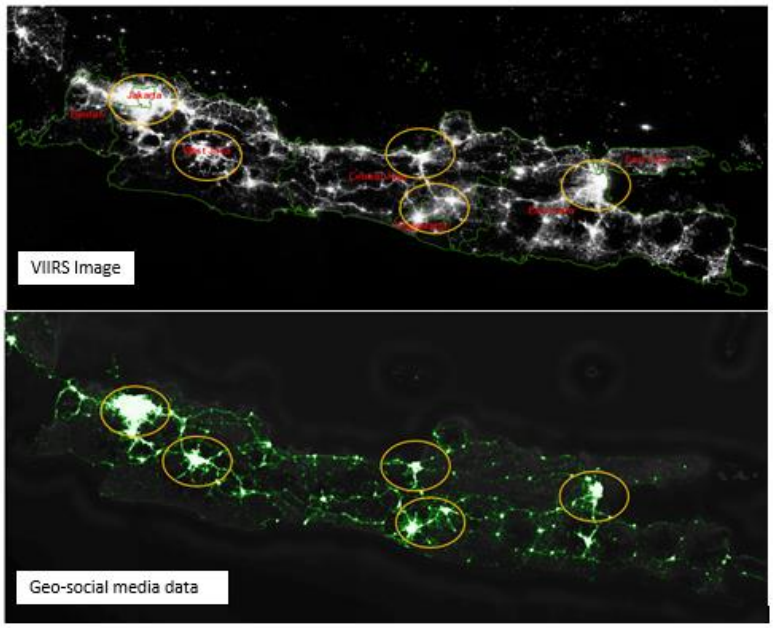


Figure 5. Clustered spatial of pattern from VIIRS image and Geo-social media data

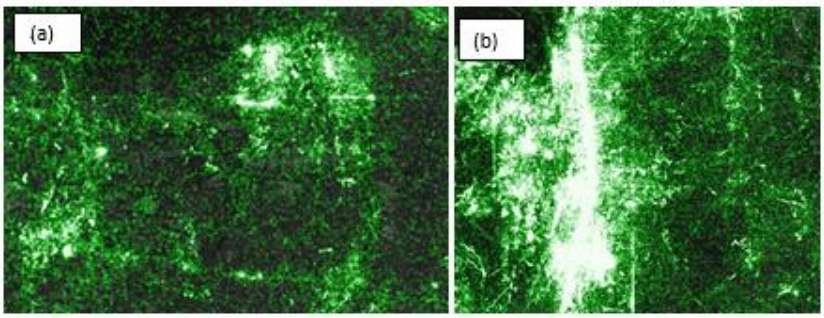


Figure 6. (a) Clustered Point of Spatial pattern in Gresik, (b) Clustered Area Pattern in Jakarta and big city

The spatial pattern may reflect the interaction between objects. As described by Yunus [8], spatial interaction as a process of mutual influence between the two terms has different types. Interactions that occur in urban areas included in the category of interaction balance. Balance interaction occurs because of the area adjacent or neighbouring affect each other, but each is independent of one another. The area adjacent to Jakarta indirectly be affected economically, socially, culturally and administration, such as

Tangerang, Bogor, Bekasi, and Serang. Land use of these areas mostly built-up areas which depend on the light becomes high.

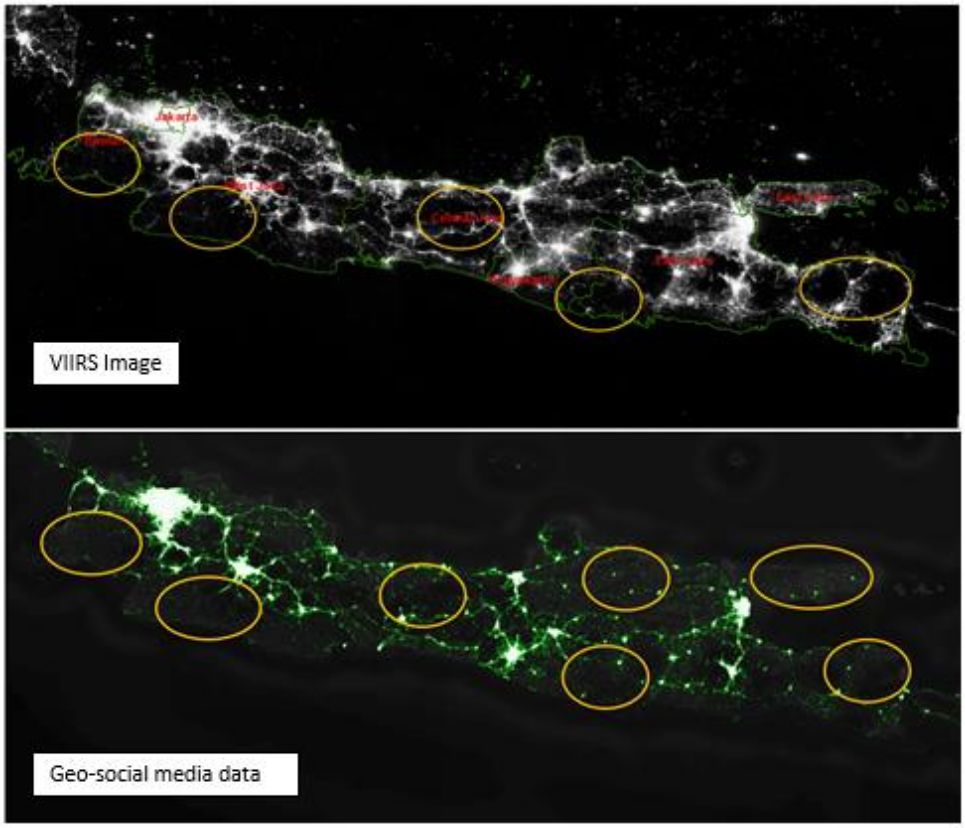


Figure 6. Random Spatial Pattern

The different can be seen in rural areas with a random spatial pattern as shown in Figure 6. The dependence of local people to light is not too high and likely to spread to adjust from the settlement, as well as social media activity is not dominant because of the limited facilities and infrastructure. Random pattern illustrates the distribution of data as point features. Areas with random pattern can be seen as spot areas in the southern regions of the province of Banten, West Java, and other districts in Java which has rural characteristics (Figure 7).

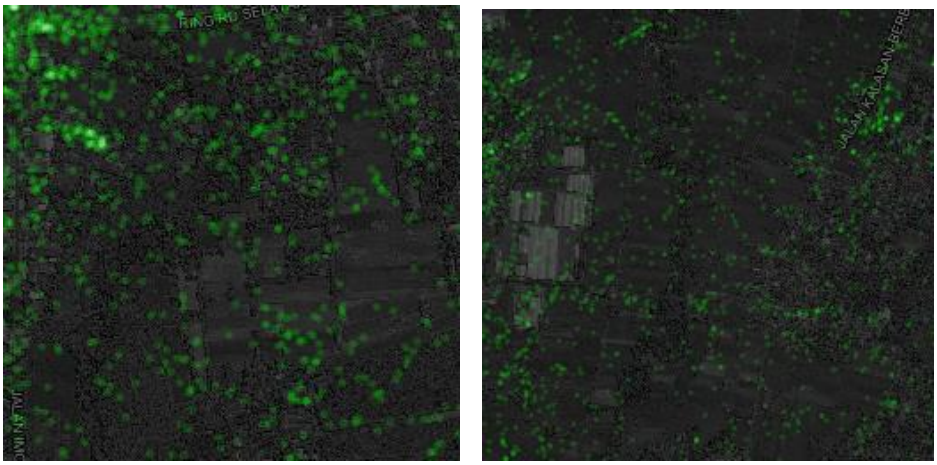


Figure 7. Random point spatial pattern in Bantul and another county

Rural areas also categorized as balance interaction as well, where the region immediately surrounding rural areas will also be affected, for example, land conversion. Land use in these areas still

dominated by agriculture, social and cultural situation are still identic with rural activities. Built-up areas are still inclined slightly so that the light intensity is not dominant.

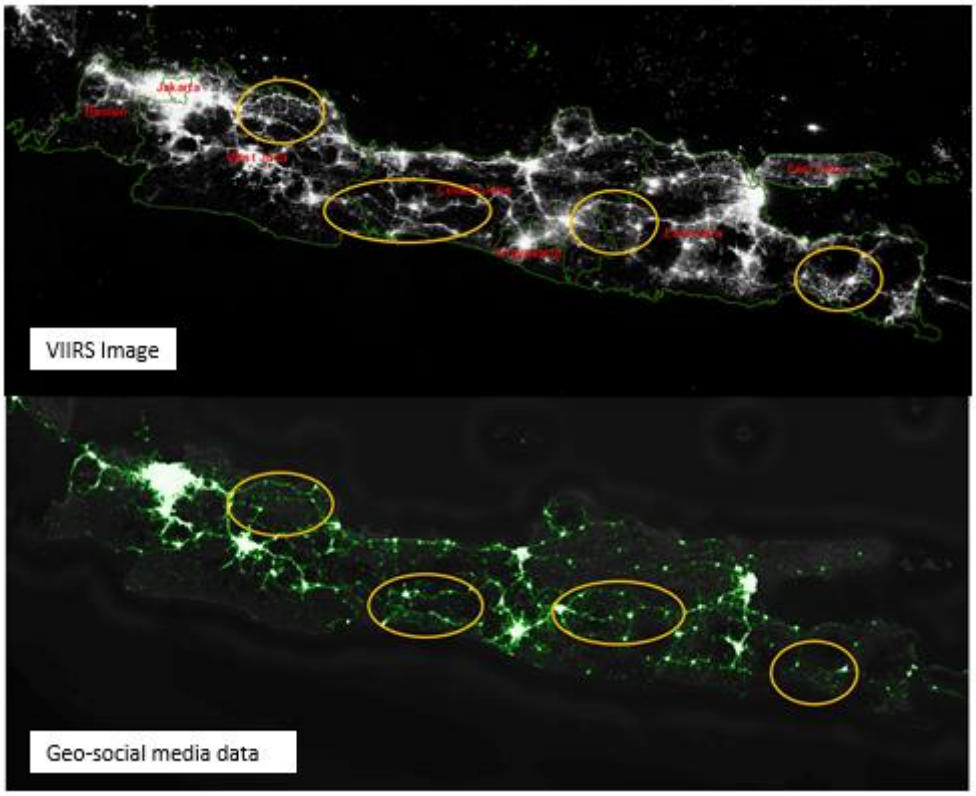


Figure 8. Regular spatial pattern

Regular spatial pattern has a tendency to follow a particular object in this example, the road pattern as can be shown in Figure 8. There is a spatial pattern of scattered points regularly follow the road so it can be seen forming into line feature, such as roads in northern of Java and the road connecting the town with other areas (figure 9). The pattern following the network of the roads. Figure 9 shows the distribution pattern of random lines formed in the city of Yogyakarta and Surabaya. Interactions that occur can be included in the category of interaction balance and solid interaction. Solid interaction which is defined as the interaction between the two regions are interdependent.

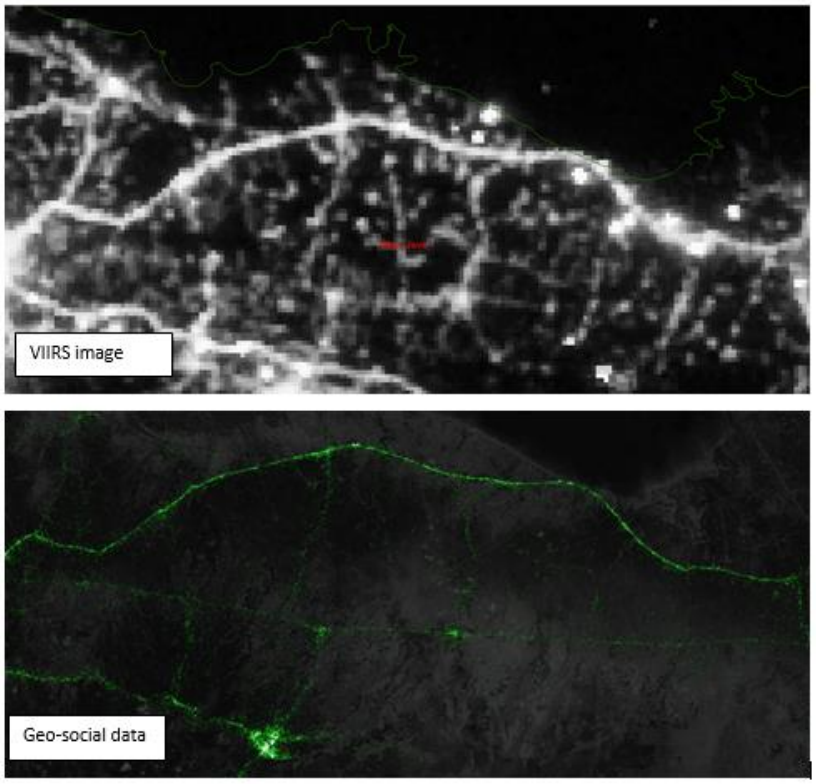


Figure 9. Systematic point of spatial pattern

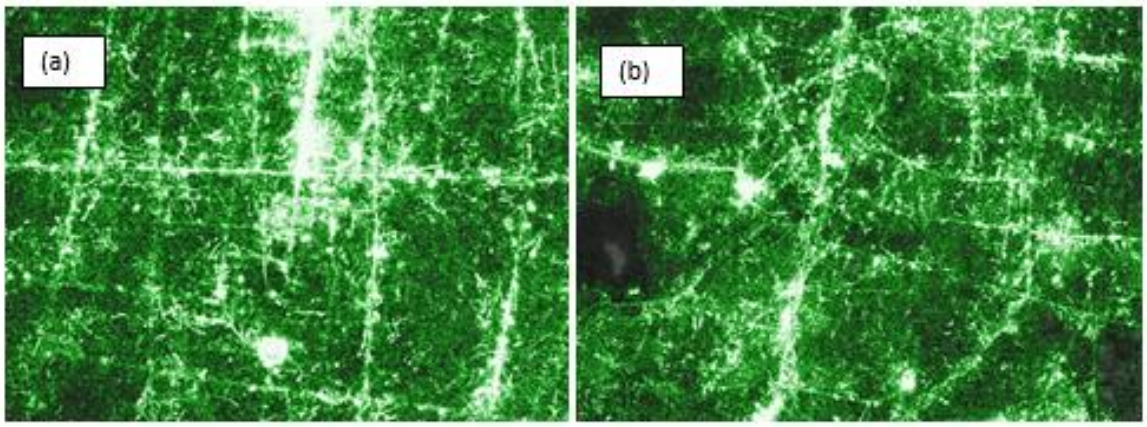


Figure 10. Random linear of spatial pattern in Yogyakarta City (a) and Surabaya City (b)

Spatial pattern from VIIRS image and geo-social media data has depict the same characteristic of urban spatial pattern. Mode detailed identification really depend on the level of analysis because different scale can give the different perform of spatial pattern to be analyse.

4. Conclusion

This research is still preliminary and using visual interpretation and analysis to recognized the urban spatial pattern. Future works will considering the developing semi-automatic or automatic spatial pattern recognition from these two kinds of dataset. We may conclude that integration of night time remote sensing data and geospatial footprint from geo-social media can help us in understanding urban development from spatial pattern and interaction.

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