Suitability of Open Street Map (OSM) for 1:50,000 Topographic Map

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Abstract: Open-source data is open for anyone and everyone for access, modification, reuse, and sharing for particular application. Open-source data is compiled from various sources using public user collaboration. Open street map is one of open-source vector provider. The suitability study of the use of open-source data for the production of topographic maps of various scales is important as a new approach. The importance of the feasibility study of the use of open-source data can help improve the efficiency of the production of mapping products. Many methods of producing topographic maps of various scales use various state-of-the-art technologies for fast and efficient map production. The objective of the study is to check the planimetric accuracy and feature geometry of open-source vector datasets. Conventional methodologies for the production of multi-scale topographic maps are time consuming and involve high costs. Therefore, open-source data is an alternative source for the production of topographic maps of various scales. This data source shows the potential use for generation of multiple data layers such as roads, points, places, waterways, railways, natural, buildings and land use. The planimetric accuracy of open-source vector data is ranging from 2-5 m. The overlay analysis between reference dataset and open-source data show the similarity geometry for 1:50,000 map scale. This method shows a high level of suitability for the efficient updating of topographic data and the production of topographic maps for 1:50,000 map scale.

1. Introduction

Topographic maps of various scales are the result of important topographic details taken through various methods manually or using automated technology. Details of topographic maps of various scales are extracted according to the requirements of the topographic map scheme of those scales. Topographic maps of various scales need to be produced because the results of the map determine the changes and behaviour of a disaster and the likelihood of an event occurring in a particular area.

Topographic maps are one of the most important elements to assess the risk of an event occurring in a place. Another perspective to be taken into account is the influence of topographic map information on economic development, security, planning, facility asset management and disasters mitigation. In addition, topographic maps of various scales need to be generated rapidly, accurately and updated with the use of open-source information that based on reliability, validity and completeness.

Geospatial technology has introduced a positive impact in topographic map production using open-source dataset. The existing methodology of generation of topographic map is time consuming, full work force and costly. Due to the dynamic nature of topographic, the updated datasets are crucial for various application. The use of open-source datasets for topographic map production
is practiced by Official Topographic-Cartographic Information System Federal Republic of Germany (ATKIS) for 50:1:50,000 topographic map (DLM). The root mean square of planimetric accuracy is 4 m (ATKIS, 2020). The feature geometry is suitable for 1:50,000 map scale. Therefore, this paper is intend to study the planimetric accuracy and features geometry of open source dataset for topographic map in Malaysia.

2. Data Source
Data Source for this study consists of reference topographic dataset 1:50,000 map scale from Department of Survey and Mapping, Malaysia and open street map vector for study area.

2.1 Vector Data Collection
Map data is collected from scratch by volunteers performing systematic ground surveys using tools such as a handheld GPS unit, a notebook, digital camera, or a voice recorder. The data is then entered into the OpenStreetMap database. Ground surveys are performed by a mapper, on foot, bicycle, or in a car, motorcycle, or boat. Once the data has been collected, it is entered into the database by uploading it onto the project's website together with appropriate attribute data. As collecting and uploading data may be separated from editing objects, contribution to the project is possible without using a GPS unit. Figure 1 shows the main OSM web with vector data (openstreetmap.org).

Figure 1: OSM Vector Dataset Portal OpenStreetMap vector data sets have the following layers (Figure 2):

i. Roads
ii. Points (features such as schools, houses of worship, ATMs, metro stops)
iii. Places
iv. Waterways
v. Railways
vi. Places (cities, towns, neighborhoods)
vii. Natural (forest, park, water, riverbank)
viii. Buildings
ix. Landuse industrial, farm, residential)
Figure 2: Open Street Map Main Web Service and Offline Vector Data

2.2 **OSM Data Vector**
OpenStreetMap represents physical features on the ground (e.g., roads or buildings) using tags attached to its basic data structures (its nodes, ways, and relations). Each tag describes a geographic attribute of the feature being shown by that specific node, way or relation. OpenStreetMap's free tagging system allows the map to include an unlimited number of attributes describing each feature (Figure 2). Table 2 tabulates the list of OSM vector feature is attached (Map Features) as mentioned in OpenStreetMap Wiki (https://en.wikipedia.org/wiki/OpenStreetMap#Contributors).
**Table 1: OSM Data Vector Features (OSM Wiki, 2020)**

| Contents                                                                 |   |
|--------------------------------------------------------------------------|---|
| **Primary features**                                                     |   |
| Aerial way                                                               |   |
| Aeroway                                                                  |   |
| Amenity                                                                  |   |
| Sustenance                                                               |   |
| Transportation                                                           |   |
| Financial                                                                |   |
| Healthcare                                                               |   |
| Entertainment, Arts & Culture                                           |   |
| Others                                                                   |   |
| Barrier                                                                  |   |
| Linear barriers                                                          |   |
| Access control on highways                                              |   |
| Boundary                                                                 |   |
| Boundary types                                                           |   |
| Attributes                                                               |   |
| Building                                                                  |   |
| Accommodation                                                            |   |
| Commercial                                                               |   |
| Religious                                                                |   |
| Civic/Amenity                                                            |   |
| Agricultural/Plant production                                           |   |
| Sports                                                                   |   |
| Storage                                                                  |   |
| Cars                                                                     |   |
| Power/Technical buildings                                               |   |
| Other buildings                                                          |   |
| Additional attributes                                                   |   |
| **Craft**                                                                |   |
| Railway                                                                  |   |
| Tracks                                                                   |   |
| Additional features                                                     |   |
| Stations and stops                                                       |   |
| Other railways                                                           |   |
| **Route**                                                                |   |
| **Shop**                                                                 |   |
| Food, beverages                                                          |   |
| General store, department store, mall                                   |   |
| Discount store, charity                                                  |   |
| Health and beauty                                                        |   |
| Do-it-yourself, household, building materials, gardening                 |   |
| **Emergency**                                                            |   |
| Medical rescue                                                           |   |
| Firefighters                                                             |   |
| Lifeguards                                                               |   |
| Assembly point                                                           |   |
| Other structure                                                          |   |
| **Geological**                                                           |   |
| Highway                                                                  |   |
| Roads                                                                    |   |
| Link roads                                                               |   |
| Special road types                                                       |   |
| Paths                                                                    |   |
| Lifecycle                                                                |   |
| Attributes                                                               |   |
| **Other highway features**                                               |   |
| **Historic**                                                             |   |
| Landuse                                                                  |   |
| Common Landuse Key Values – Developed land                              |   |
| Common Landuse Key Values – Rural and agricultural land                  |   |
| Other Landuse Key Values                                                |   |
| Leisure                                                                  |   |
| Man-made                                                                 |   |
| Military                                                                 |   |
| Natural                                                                  |   |
| Vegetation or surface related                                           |   |
| Water related                                                            |   |
| Landform related                                                         |   |
| **Office**                                                               |   |
| Place                                                                    |   |
| Administratively declared places                                         |   |
| Populated settlements, urban                                            |   |
| Populated settlements, urban and rural                                  |   |
| Other places                                                             |   |
| **Power**                                                                |   |
| Public Transport                                                         |   |
| Railway                                                                  |   |
| Others                                                                   |   |
| **Sport**                                                                |   |
| Telecom                                                                  |   |
| Tourism                                                                  |   |
| **Waterway**                                                            |   |
| Natural watercourses                                                     |   |
| Man-made waterways                                                       |   |
| Facilities                                                               |   |
| Barriers on waterways                                                    |   |
| Other features on waterways                                              |   |
| **Additional properties**                                                |   |
| **Addresses**                                                            |   |
| Tags for individual houses                                               |   |
| For countries using hamlet, subdistrict, district, province, state      |   |
| Tags for interpolation ways                                              |   |
| **Annotation**                                                           |   |
| **Name**                                                                 |   |
| **Properties**                                                           |   |
| **References**                                                           |   |
| **Restrictions**                                                         |   |
| **Commercial**                                                           |   |
| building commercial                                                      |   |
| A building where non-specific commercial activities take place, not necessarily an office building. Consider tagging the surrounding area using “landuse-commercial”. Use retail if the building consists primarily of shops. |   |
| building industrial                                                      |   |
| A building where some industrial process takes place. Use warehouse if the purpose is known to be primarily for storage/distribution. Consider using “landuse-industrial” for the surrounding area and the proposed “landuse” tag to describe the industrial activity. |   |
| building kiosk                                                          |   |
| A small one-room retail building.                                        |   |

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OSM can certainly claim to be the largest freely and openly accessible database of geographic data in the world. Indeed its rate of growth in terms of geographic data and frequency of contributions and editing brings OSM into the realm of geographic big data. The quality of OSM data can be accessed online using https://osmose.openstreetmap.fr/, all data quality in terms of completeness will be shown as follows Figure 3 (https://osmose.openstreetmap.fr/en/control/update_matrix).

Figure 3: Osmose-QA is a quality assurance tool that detects issues in OpenStreetMap data. It detects a very wide range of issue types. It is also useful for integrating third-party data sets by conflation.

3. Reference Dataset: Department of Survey and Mapping Malaysia (DSMM) 1:10,000 Map Scale
DSMM 1:10,000 topographic vector is used as a reference dataset for comparative analysis. This reference dataset is superior compare to OSM vector in term of planimetric accuracy and scale (Figure 4).
4. **Research Methodology**

The research methodology comprise of 5 phases (Figure 5) as follows:

i. **Research Design**
   Selection of study area that consists of both reference dataset and OSM vector

ii. **Data preparation**
    Both datasets need to be transformed to homogenous coordinate system for overlay analysis. This is process is needed for comparative evaluation.

iii. **Planimetric Accuracy**
    Planimetric analysis is carried out based on ground control point with DSMM 1:10,000 vector as reference base map

iv. **Overlay Analysis**
    Evaluation of OSM suitability vector dataset comprise of geometry comparison, generalization aspects and completeness of features

v. **Conclusion**
   Findings of suitability evaluation
5. **Open Street Map Quality Assessment For Topographic 1:50,000 Map Scale**

The OSM data will be evaluated in terms of completeness, position accuracy, and geometry. The study area is located at Taman Universiti Skudai. Map tile 1:10,000 (FC4323) map scale is chosen due to the density of features and located in urban area.

5.1 **Completeness and Geometry**

Figure 6 shows the overall study area based on OSM vector that consists of building, transportation (centre line and edge) hydrography line (centre and edge) and other transportation features.

Table 2 tabulates the statistics of comparison between OSM vector and DSMM 1:10,000 vector. The statistic shows that for building footprint difference is 75% and 6% for transportation, respectively. The obvious difference for building is due to map scale (1:10,000 vs 1: 50,000). If comparison between same map scale 1:50,000 then the difference will be around 50% based on Figure 7 (a) – Figure 7 (d).
Figure 6: OSM Vector Data for Test area

Table 2: Statistic Comparison Between DSMM 1:10,000 Map and OSM

| Features Geometry                  | 1:10,000 DSMM (No of feature) | OSM Vector (No of Feature) | Difference Feature | Difference (%) |
|-----------------------------------|-------------------------------|---------------------------|--------------------|-----------------|
| Polygon (Building & landcover)    | 12,230                        | 3,016                     | 9,214              | 75              |
| Line (Transportation- centre line and edge) | 5282                          | 4966                      | 316                | 6               |
Figure 7 (a): Missing Polygon Vector (Online imagery) – Gross Generalization (Large Polygon) for Building Area

Figure 7 (b): For Urban Area Vector (Online imagery): Building Polygon is Generalized (according to small map scale)
Figure 7 (c): Comparison Between DSMM 1:10,000 and OSM Vector (Online imagery): YellowLine represent DSMM 1:10,000 map and Purple line is OSM.

Figure 7 (d): Comparison Between OSM Vector and Online Imagery: The completeness aspect: Missing Building Footprint and 100% Road Feature Covers The Study Area
Based on the Figure 7 (a) to Figure 7 (d), it shows that OSM building is generalized and inconsistent geometry with shape of the building for map scale 1:10,000. The availability of OSM vector coverage is limited in certain areas.

### 5.2 Features Accuracy

The positional accuracy for DSMM 1:10,000 map is ranging from 0.2 m to 2.5 m and RMSE is 0.750 and 0.924 for northing and easting components, respectively as tabulates in Table 3 and is based on the comparison between ground control and orthophoto.

**Table 3:** Check Point Accuracy for DSMM 1:10,000 Map

| PT   | Orthophoto Coordinate | GCP     | Differences | Displacement |
|------|-----------------------|---------|-------------|--------------|
|      | N (m)                 | E (m)   | N (m)       | E (m)        | (m)          |
| TS01 | 329902.7407           | 411091.7551 | 329902.529  | 411093.0844  | 0.211 -1.329 1.346 |
| TS02 | 326988.8182           | 413644.1745 | 326987.882  | 413641.8035  | 0.936 2.371 2.549 |
| TS03 | 326134.7256           | 410166.9472 | 326133.799  | 410167.5105  | 0.927 -0.563 1.085 |
| TS04 | 324810.7385           | 413220.1708 | 324809.173  | 413220.1955  | 1.565 -0.025 1.565 |
| TS05 | 322383.0559           | 410761.0505 | 322381.666  | 410761.4155  | 1.390 -0.365 1.437 |
| TS06 | 320506.8679           | 411533.8576 | 320507.025  | 411535.1009  | -0.157 -1.243 1.253 |

Min  -0.157 -1.329 1.085  
Max   1.565 2.371 2.549  
RMSE 0.750 0.924

**Table 3 (a):** Check Point Accuracy for DSMM 1:10,000 Map

| PT   | Orthophoto Coordinate | OSM Vector | Differences | Displacement |
|------|-----------------------|------------|-------------|--------------|
|      | N (m)                 | E (m)      | N (m)       | E (m)        | (m)          |
| TS01 | 329902.7407           | 411091.7551 | 329899.65   | 411091.9238  | 3.090 -0.169 3.095 |
| TS02 | 326988.8182           | 413644.1745 | 326986.75   | 413644.8776  | 2.068 -0.703 2.184 |
| TS03 | 326134.7256           | 410166.9472 | 326132.387  | 410168.1806  | 2.338 -1.233 2.644 |
| TS04 | 324810.7385           | 413220.1708 | 324805.809  | 413225.9355  | 4.929 -5.765 7.585 |
| TS05 | 322383.0559           | 410761.0505 | 322380.798  | 410765.5091  | 2.258 -4.459 4.998 |
| TS06 | 320506.8679           | 411533.8576 | 320506.037  | 411535.0133  | 0.831 -1.156 1.424 |

Min  0.831 -5.765 1.424  
Max   4.929 -0.169 7.585  
RMSE 2.119 2.266

The positional accuracy for OSM vector is ranging from 0.8 m to 6 m and RMSE is 2 m as tabulates in Table 3 (a) and is based on the comparison between orthophoto and feature vector. Figure 8 and Figure 9 show the accuracy of OSM building and Road Centre line compare to DSMM 1:10,000 Reference Dataset. The planimetric accuracy (displacement) is ranging from 1m to 2m.
DSMM MS ISO 9001:2015 standard stated that planimetric accuracy for 1:50,000 map scale is 8.5 m. Based on the Figure 8 and Figure 9, the planimetric accuracy of open source data is still in the tolerance of the standard. According to Hongchao et al (2014) the position accuracy is investigated by calculating the average distance among the corresponding points of footprints pair in two data sets. Hence, only the buildings with 1:1 relation is involved in the analysis. The average offset of OSM building footprints to ATKIS building footprints is 4.13m with the standard deviation of 1.71 meter.

According to the Official Topographic-Cartographic Information System Federal Republic of Germany for digital topographical geodata, an offset of about four meters (4 m) on average in terms of
position accuracy. With respect to shape, OSM building footprints have a high similarity to those in ATKIS data 1: 50,000 map scale (DLM 50). However, some architectural details are missing.

6. Concluding Remarks

Based on the abovementioned evaluation on the planimetric accuracy and suitability of open source vector for generation of topographic map it shows that the planimetric accuracy of OSM vector for 1:10,000 map scale is in tolerance of DSMM standard. The features geometry of OSM is suitable and has similarity with 1:50,000 map scale. The completeness of OSM vector for different features are varies from building footprint, road features and land cover. This shown that the potential uses of OSM vector as 1:50,000 map scale topographic map with additional vectorization process.

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