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USING OF OPEN-SOURCE DIGITAL MAPS FOR ELECTRO-MAGNETIC WAVES PROPAGATION CALCULATION

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ВИКОРИСТАННЯ ЦИФРОВИХ МАП, ОТРИМАНИХ З ВІДКРИТИХ ДЖЕРЕЛ, ДЛЯ РОЗРАХУНКІВ ПОШИРЕННЯ ЕЛЕКТРОМАГНІТНИХ ХВИЛЬ

Розглянуто можливість використання відкритих растрових цифрових картографічних даних для розрахунку поширення електромагнітних хвиль. Надано основні критерії вибору цифрових мап. Наведено порівняння цифрових мап, отриманих шляхом використання різних технологій зондування земної поверхні.

Digital maps are widely used for the numerical estimation of the signal level in different communication systems. The mostly used applications of such calculations include the calculation of the following parameters of the radio communication links: signal level and quality parameters. The calculations are performed over raster digital map layers. The result of such calculations contains the value of a required parameter for each pixel in the map layer. Such calculations make sense in case of a sufficiently sophisticated electromagnetic waves propagation model is used to properly take into account the terrain substrate over the radio communication link.

In this paper, the possibility of using of open-source digital surface maps for different parameters of radio links is considered. For estimation of signal level, different specific values may be calculated depending on the type of the communication links. For instance, for mobile communication networks, RSSI (received signal strength indicator) parameter is calculated for GSM or UMTS networks [1], and RSRP (reference signal received power) parameter is calculated for LTE networks [2]. As a quality parameter, SNIR (Signal-to-interference-plus-noise ratio) parameter is used for GSM and UMTS networks, whereas RSRQ (reference signals received quality) parameter is used for LTE networks.

The results of such calculations are typically used in the following operations: planning of radio communication networks, control the quality and availability of existing mobile radio networks, electromagnetic compatibility assurance tasks and for the estimation of power budget during the process of design of microwave line-of-sight point-to-point links [3].

The results of abovementioned calculations are typically presented as coverage raster digital map layers. To provide signal propagation calculations, different electromagnetic waves propagation models are used. One of the key factors that affects the propagation of electromagnetic waves is terrain substrate. Terrain is modelled by the elevation model.

A digital map that presents the elevation model is a raster digital map layer, each pixel of which contains the value of elevation over the reference surface. There are two types of such digital maps: digital elevation map (DEM) and digital surface map (DSM).

A DEM contains the bare-Earth surface, without all natural and built features. A DSM contains both the natural and built/artificial features of the environment. In particular, while a DEM contains only the Earth surface, a DSM also takes into account forests, buildings, other artificial objects etc. Evidently, for precise diffraction calculation, DSM is required.

In commercial software that is aimed at electromagnetic waves propagation calculation, the three separate raster digital map layers are used to support the calculation: a DEM, a layer that contains the heights of natural and artificial object on the surface of Earth and a clutter layer. Clutter layer is a raster layer of the same dimensions as DEM. It contains the information about the type of terrain for each pixel, for example: water, forest, concrete buildings etc. The clutter layer information allows to take into account the impact of the surface type. It implies using of quite sophisticated propagation models that allow to take into account this information for more precise calculation.

As a source of DEMs and DSMs, remote Earth sensing data are used. The corresponding satellite missions employ different types of radars and lidars. Since different types of objects manifest various reflection capability in different frequency bands, it is possible to build both DEMs and DSMs on the results of the measurements, if the reflection coefficient data are taken from different sensing tools on the board of a satellite.

For the electromagnetic wave propagation calculation, typically commercial software is used, and commercial digital map layers are also prepared. However, the open-source DEM and DSM data that are available on the Internet can be used for the calculations. As an example, two data sources were considered, as follows:

– Shuttle Radar Topography Mission (SRTP) [4]. The pixel size is 30 (from North to South) by 20 (from East to West) meters.

– Advanced Land Observing Satellite (ALOS) mission. ALOS Global Digital Surface Model "ALOS World 3D - 30m (AW3D30)" [5]. The pixel size is 30 (from North to South) by 20 (from East to West) meters.

It is important to understand which type of digital map, DEM or DSM, is presented by a map source. For example, Fig. 1 and Fig. 2 contain the result of the comparison of the two abovementioned maps.

In Fig. 1, the test line for comparison is created. The line presents the radio link path to be analyzed in terms of radio wave propagation. For the comparison, an urban area was selected.

In Fig. 2, the profiles, built for the test line using SRTM and ALOS data sources, are presented. As it can be seen, the SRTM data (red line in Fig. 1) represent a DEM, whereas ALOS data represent a DSM. Therefore, ALOS data shall be chosen for electromagnetic wave propagation calculation.

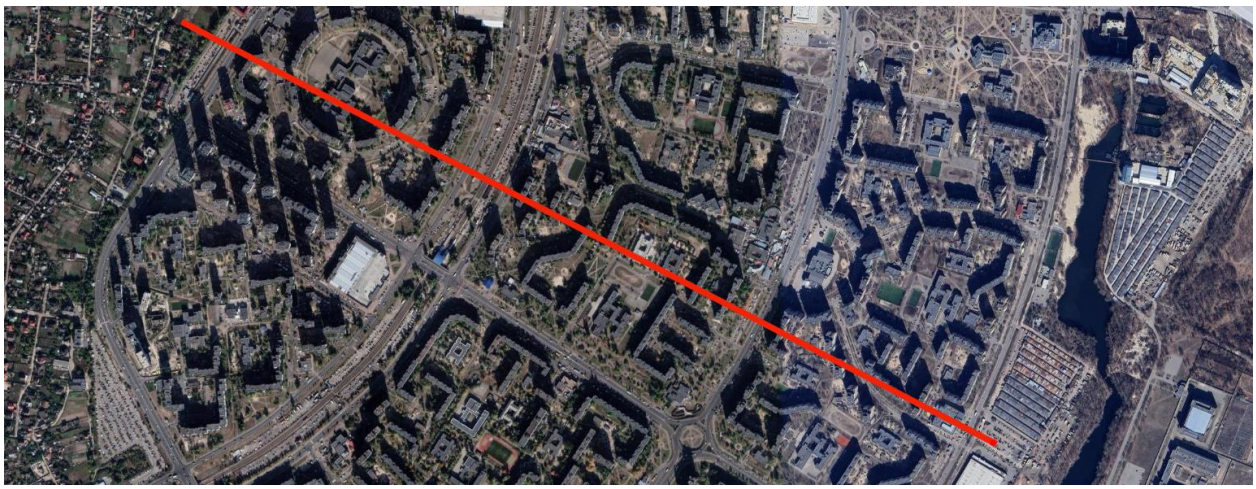

Fig. 1. Test line that simulates the radio waves propagation path for a radio link.

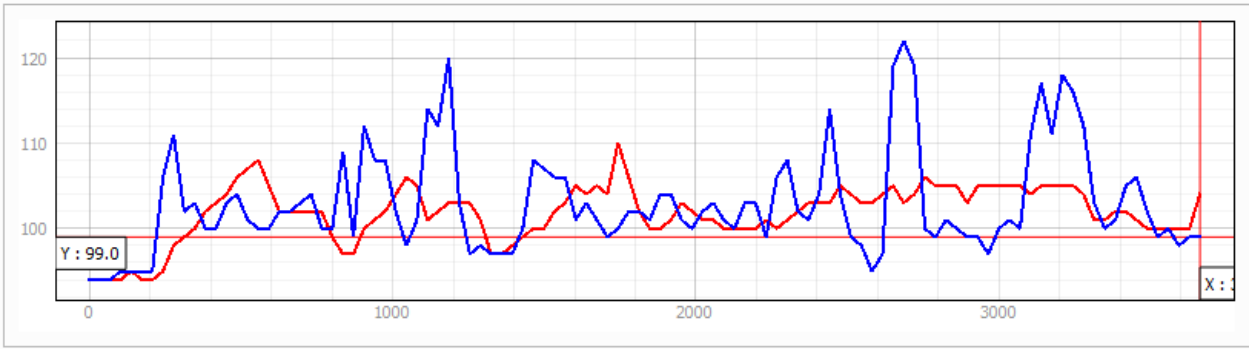

Fig. 2. Profiles of the test line, built using SRTM (red line) and ALOS (blue line).

The drawback of using open-source DSMs is the absence of clutter layer, which leads to using of the simplified propagation models that don't take into account the nature of the on-surface objects.

The strength of using open-source DSMs is using only a single value for each map pixel, which contains the total height of the surface. Therefore, there is no need to use additional map layers containing the heights of the on-surface objects.

Different comparison operations have shown that ALOS data correctly take into account different terrestrial objects, such as forests, separate trees, buildings etc. Therefore, ALOS digital map can be used for electromagnetic wave propagation calculation.

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