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Analysis of Coverage by Fire Brigade Siren Signal in Olomouc District

Ing. Zdena DOBEŠOVÁ Ph.D., Bc. Petr PACHTA

Abstract

Fire alarm and other danger are notified by siren signal. Sirens are located mostly in towns. The spreading of sound of siren is under several influences. This article describes algorithm solving analysis of coverage by siren signal in Olomouc district, Czech republic. The algorithm is designed as a script in Python for software ArcGIS. In the end the results are visualized in map. The selected territory is Olomouc district which is operation area for Olomouc fire and rescue brigade (HZS).

Keywords: ArcGIS, Python script, siren signal, announcement of danger, coverage, analysis

Intoduction

The fire brigade is responsible to operate United notification warning system in very district in Czech Republic. This system consists of three parts: notification center, telecommunication network and terminal elements. Terminal elements are technical equipments, witch produce warning signal. In that case they are sirens. Sirens produce warning signal to inform inhabitants about forthcoming or come up danger and emergency. The early information about danger for inhabitants reduces influence and extensive damage of estate and nature.

Technical and spatial data

Two types of sirens are used. The first is rotary mechanical siren and the second is electronic siren. The power in wattage is from 250 to 5 000 W. The frequency of siren signal is 420 Hz.

Differences in altitude and segmentation of terrain have influence for sound spreading. The surface of Olomouc district is very various. There are Jeseníky mountains and flatted area around Olomouc city. The basic data are taken from ZABAGED in scale 1 : 10 000. The data are: contours (1 m interval), elevation point, roads, highways and polygons with block of buildings. The sirens are represented by point layer. From contours in ZABAGED is created TIN and after that grid surface 50 x 50 m.

Spreading and attenuation of noise

Air has an effect on sound attenuation. Falling off intensity of sound is dependent on temperature, humidity of air and atmospheric pressure. The atmospheric pressure has the lowest influence. Attenuation decreases according square distance on spherical wave front (Horák).

The intensity of noise L_D on wave front with consideration of attenuation is expressed by equation:

$$L_D = 10 \cdot \log\left(\frac{P}{4\pi d^2} \cdot I_0\right) - U \cdot \frac{d}{1000}$$

P …… power of siren [W],
d …… distance from source of sound siren [m],
U …….. attenuation of noise in atmosphere [Db.km^{-1}],
I_0 …….. hearing reference value [10^{12} W.m^{-2}] (Hálek).

Attenuation of noise in atmosphere (U) is taken from table, where are values for specific humidity (0 - 100 %) and temperature (-15 °C to 30 °C). Good audibility of siren is more 40 dB in real open space because the lower level of siren signal is mask with another noise. The equation is not considers variation of terrain.

Flat surface for example concrete has good reflection of noise. Reflection is considered on building area. In open area is minimal reflection (woods, fields, meadows). The other influence is masking noise. The source of noise as a highways masked noise of siren. The human ear hears the loudest noise from several noises. This is phenomenon is called masking.

Algorithm in Python

For repeated calculation of signal coverage was designed script in Python 2.1. This script is run as tool in ArcToolbox for software ArcMap 9 produced by ESRI company (Tucker). The reason for designing script is change of number of siren or change of parameters of siren (power, location) in future.

At first the script counts the highest distance, where is reached the limit 40 dB for every siren. The value of distance is stored to attribute table of sirens. The input parameter of script is temperature for counting attenuation (Pachta).

The influence of surface is count by function VIEWSHED form 3D Analyst tools on grid surface from ZABAGED. Visual range corresponds with noise range (Pachta). The reflection is count by function Reclassify in Python script. In the building area is level of noise increase with 3 dB. The output grid from function VIEWSHED and with correction for reflection is the first stage of solution of coverage of siren signal.

In the end algorithm considers noise masking along highways a first class roads. There is generated grid of loud by function VIEWSHED around roads. The final grid is subtraction of first grid of coverage and grid of loud of roads. The levels of noise of sirens are divided to five levels form 40 dB to 90 dB and higher. The levels are visualized in map. The small part of map is on Fig.1. The positions of sirens are not correct, because positions are secret data.

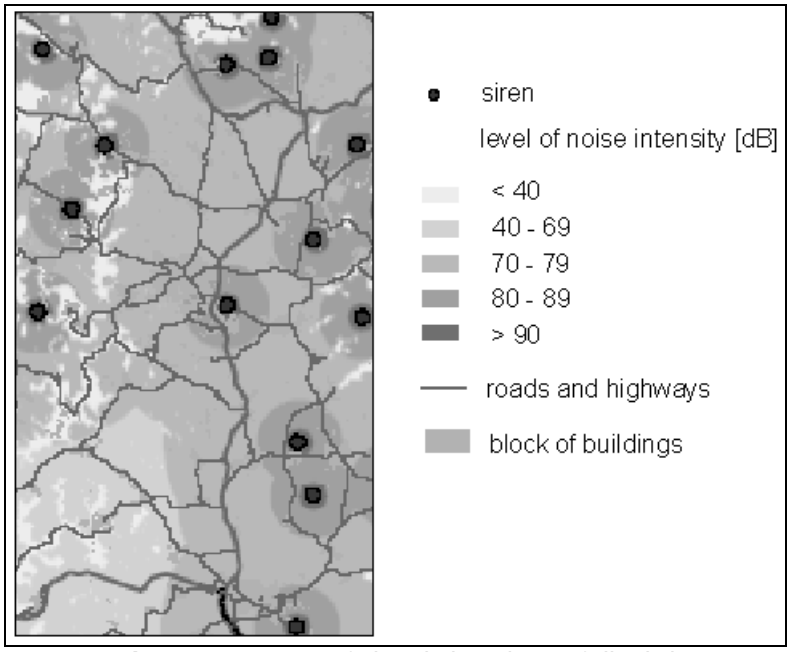

***Fig. 1** : Coverage of signal siren (part of dictrict)*

Conclusions

Some places are not covered in Jeseníky mountains by siren signal, they are out of range. Also problems are in rarely populated area in military area Libavá. The output script can be used repetitively by Olomouc fire and rescue brigade. The results also help improve situation in notification of inhabitants.

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Ing. Zdena DOBEŠOVÁ, Ph.D., Bc. Petr PACHTA

Department of Geoinformatics, Faculty of Sciences, Palacky University
Svobody 26, 771 46 Olomouc, Czech Republic
E-mail: *zdena.dobesova@upol.cz*