Scientific Journals
Maritime University of Szczecin

Zeszyty Naukowe
Akademia Morska w Szczecinie

2013, 35(107) pp. 97–102
ISSN 1733-8670

2013, 35(107) s. 97–102

The methods of performing the viewshed analyses on inland waters for complex objects

Jacek Łubczonek

Maritime University of Szczecin, Chair of Geoinformatics
70-500 Szczecin, ul. Wały Chrobrego 1–2

Key words: viewshed analysis, sensors planning, radar, CCTV, inland navigation, RIS

Abstract

Observational sensors, such as CCTV cameras and radars, are part of the RIS system. These sensors should provide information about the current situation on the waterway and to a greater extent – aquatory. Barriers for the observational sensor, in the sense of reducing the view field, are various objects in the aquatory. This is one of the main factors that make it difficult to determine the proper location of the sensor. Currently, in order to increase the efficiency of determining the locations of the observational sensors are used different tools for performing spatial analysis. This applies to both the initial geographical identification as well as detailed analysis. Analysis efficiency, in turn, depends on the model of the environment, represented in the form of the Digital Surface Model. Given the complexity of some geographic features, it should be used the appropriate methodology for the visibility analysis, as well as the preparation of the input material. The following work includes the theme of visibility analysis on inland waters, with special emphasis on the complex objects. They include bridges, cranes, buildings, high vegetation and other engineering structures.

Introduction

The purpose of RIS is to provide harmonized information services to support traffic and transport management in inland navigation, including – as soon as it is technically possible – interfaces to other transport modes. The aim of RIS is to increase the safety and efficiency of the transport process and the full use of inland waterways. Part of river information is obtained by means of sensors, which automatically binds to the specified information service and their customers. RIS applications are based on the use of systems in a given area or for a specific group of users, with the specific local, functional and process requirements. The use of the RIS is defined as the provision of river information services through dedicated systems. In order to provide services in a single application can be used one or more systems. In [1] are summarized the connection between the various systems and services. As can be seen, some of the services are performed by radar and CCTV systems. For successful implementation of these systems should be prepared the design, which allows correct operation, mainly in respect of the information acquisition. In the end, it comes down to, inter alia, determine the proper location of the sensor.

Currently, in order to determine the location of the sensors are often used GIS software and their tools for performing spatial analysis. This software is often varied and offers different functionality [2]. It should be noted that the primary method in the evaluation of surveillance coverage of any area is the viewshed analysis. It consists in determining the parameters of observation (observer height, the height of targets, horizontal, vertical sectors and others) and then simulates the visibility. Key to success for the proper visibility analysis is appropriate numerical model of the geographical environment. Currently in widespread form it is in the form of numerical model of land cover (Digital Surface Model), which consists of a digital terrain model and all geographical objects located on its surface. In particular, attention should be paid to the level of detail of objects, which in most cases are in urban and port areas. In these places there are numerous engineering structures such as bridges, chimneys, handling equipment and much more.

Some of them, such as cranes, are mobile, which further complicates assessment of the visibility from chosen point. The complexity of the geometry of these objects often required to conduct analyses by using the three-dimensional vector model and its equivalent raster form. In previous work this issue has been thoroughly presented [3, 4, 5], and in this paper focuses on performing the visibility analysis for complex objects. It should also be borne in mind that the correct placement of the sensors is essential to effective targets tracking, which is also important subject of research [6, 7, 8].

Visibility analysis by using three-dimensional vector model

The three-dimensional aquatory vector model enables for performing the visibility analysis close to the real conditions. Of course, the realism of the modelled geographical environment and its detail will affect the final outcome analysis. In general, for economic reasons, as well as the time, this model should be developed taking into account the different levels of detail of objects. The level of simplification will depend on the complexity of the object, as well as the needs of mapping elements that could potentially restrict the view field. Analysis of this type may be sufficient in the case of optical sensors, but not necessarily in the case of radar sensors. The reason for this is distortions of radar image, which may be variable. In particular, the radial and angular distortion of radar echoes, what in the case of river basins is of particular importance. However, this form of analysis can also be carried out for geographical identification and initial location of the sensor. The complexity of geographical objects is related to the nature of the area where they are located. The common areas may include the port, urban and non-urbanized areas.

The case of port engineering objects

Port areas usually have varied infrastructure. They include cargo handling equipment such as cranes and gantry cranes. These objects, in particular, have a complex geometry, which creates a problem for their implementation. Development of faithful models of these engineering devices requires a lot of time, which in turn may increase the cost of the project, as well as to extend the period of its realization. In this case, can be used successfully the prototype objects which, in the rich software libraries of three-dimensional models, should be representative with respect to their real equivalents. Prototype objects can be appropriately scaled and dimensioned, which in turn gives the ability to set the major dimensions of real objects, such as height, width and depth. Small deviations from the actual shape in this case can be considered as negligible. With the prototype models we are able to assess the degree of the surface water obscuration by these devices and the evaluation of visibility under them. For port areas it is particularly important because handling equipment generally

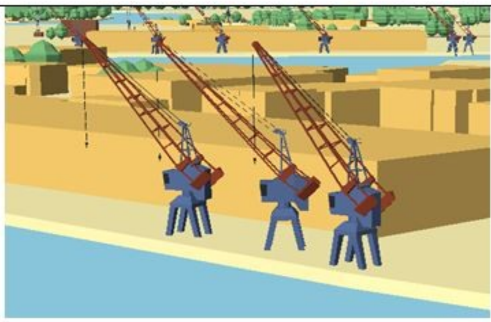
	Prototype 3D object	Real object
Gantry Cranes		
Cranes		

Fig. 1. Comparison of prototype complex 3D models with their real equivalents

are located near the shore, usually in large numbers. Examples of prototype objects for selected handling equipment are illustrated in figure 1.

Prototype objects can also be used for other objects, such as lattice masts, silos and vessels. The latter are also very important for the analysis of the visibility due to their large size and the possibility of causing a relatively large periodically overrides. Another advantage of vector models is that they can be shifted and rotated for better adjustment of their positions, though this implies the need to create additional points of reference objects.

The case of buildings

The buildings in some cases can significantly reduce the field of view. Most are in urban areas, creating a generally compact settlement. Depending on the architectural style and purpose, they can be characterized by varying complexity of the geometry. Similarly, port areas, where there may be industrial buildings with a relatively simple geometry and more complex in the case of older stores. The geometry of the building is particularly important if is planned to place on them the sensor. It should then take into account the increased detail of the building, which mainly amounts to the creation of detailed model the roof. Particular attention should be paid to the smaller elements that can contribute to the formation of the blind sectors of observation. They include various small outbuildings, chimneys, towers and attics. It should be noted that even the current methods of obtaining high-density data, such as the airborne laser scanning, do not provide the correct mapping of these details. This happens in most cases due to low data density compared to the size of smaller elements of the object. Completion of such data can be achieved with the use of geodetic measurement. On the basis of the study it can be concluded that the initial model of the building is a model for the level of detail LOD2, with the addition of selected elements adequate to LOD3 model [9]. Comparison of harbour buildings in the form of LOD1 and LOD2 models is illustrated in figure 2.

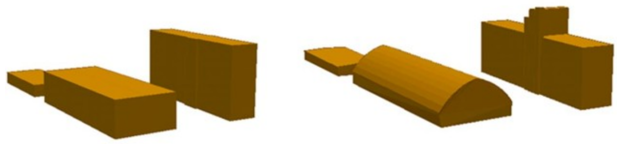


Fig. 2. The models of buildings in LOD1 and LOD2 version

The case of bridges

Bridges are important objects in terms of inland waterways, as well as the planning of observation sensors. Depending on the height, structure of the bridge and location of the sensor, it is possible to observe water area under its span or spans. Ability to perform such an analysis gives mainly vector 3D model that can take into account its clearance. Editing tools usually allow modelling of objects by a large number of options extruding the basic models to the desired height with possibly of setting the reference base height. A good example is the modelling of the bridge, as an object consisting of pillars, spans, railings, rails, trusses, radar reflectors and heating pipes (Fig. 3).

The case of vegetation objects

Vegetation is an important component of land cover, which can be in the compact or single form. In any case, it may be a problem related to the visibility reduction. Vegetation, particularly high, in itself is an object of complex geometry. In this case it is more difficult to apply a generalized form of the prototype in the 3D model, as in the case of anthropogenic products. Therefore, the spatial analysis carried out by using a three-dimensional map requires proper elaboration of 3D tree models. They should be adjusted to proper performing of the visibility analysis. Due to the existence of significant trees due to the shape of the crown and the height of the visibility analysis, should be applied

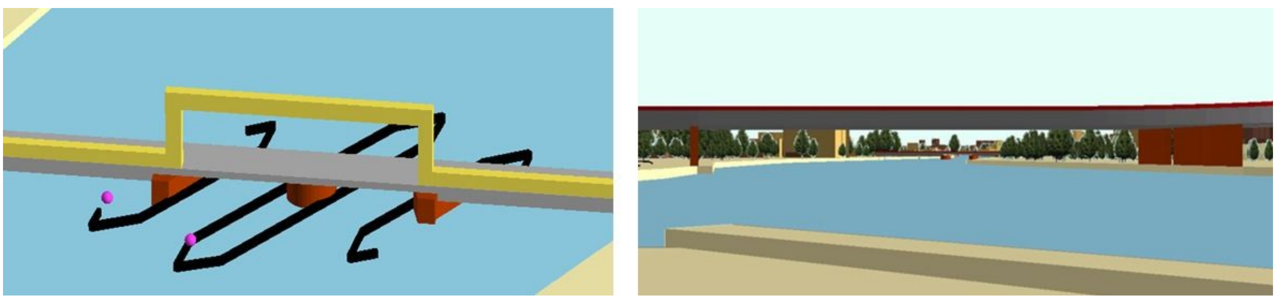


Fig. 3. An example of a railway bridge model created by an appropriate choice of height and elevation of pylons, spans, slides, heating tubes, radar reflectors (right); visibility analysis carried out under flyover (left)

Fig. 4. The prototype model of poplar and its implementation in the form of DSM

a method that allows to restore these features in a 3D model for a single tree (Fig. 4). In [10] was proposed a method based on a generalization of standard contour points on the example of black poplar and mixed trees. This method allows the development of a standardized model, adapted to the species of tree, as well as the automation of the selection to the desired width of the crown of the tree according its height.

In the case of a wooded area a solid model can be used, which is created by the extrusion for a given height the polygon, which represents the vegetation area. The height may represent the average height of a group of trees or average height of dominant trees. Solid model can be further combined with prototype objects, which allow further identification of trees significant in the visibility analysis and improves the interpretative potential of this model. Analysing this case, a dedicated model is a numerical model of the crowns surface, which allows creations a continuous statistically surface (Fig. 4). In this case, application of the appropriate method of surface interpolation or approximation, allows for better reconstruction of the wooded area surface than the simplified solid block model. Some imperfection of these methods to create models is limited opportunity to restore in special cases, such as a significant shift crowns over water (often resulting from the slope of the tree).

Visibility analysis by using the raster model

As already mentioned, an important element in the analysis of the visibility is the raster model, which represents the land cover. It allows for accurate determination of visible and invisible areas from the observer position [11]. The main limitation associated with its use, is fixed resolution grid for the entire DSM and the limited inclusion in the model details of objects, small objects and object with clearances.

The identified problems are small-sized objects that can be the cause of significant obscuration. The inclusion of small objects, such as 30–70 cm wide requires the use of high-resolution raster. This generates a problem, because its use can significantly increase the time of analysis or even prevent them. An important factor is also the size of the resulting raster files, which can significantly reduce the amount of hard drive space, and the effectiveness of their visualisation. The problem is the use of grid with the resolution of 1 m for larger areas. The solution to this problem can be application the raster model with the decomposition of complex objects or just reduction in area of DSM used for the analysis. Decomposition of the raster model is based on division of the complex model into smaller parts, what requires the creation of separated DSM with higher resolution. In this way is created model in the form of multi-layer raster with details adjusted to the real object. The general idea of decomposing a raster model was presented in [12] on the example of the bridge as an object consisting of pylons, fenders and spans with the application of modified visibility analyses. The following example (Fig. 5) shows another example of visibility analysis performed under bridge span through the decomposition of raster model on two elements: the pylons and the span. As can be noted, the use of raster model without decomposition of complex object performs an incorrect analysis of visibility.

A similar problem can occur with the elaboration of the sensor platform model, which is the building. In the case at the Maritime University of Szczecin building this was particularly referred to a smaller object, which was the attic (Fig. 6). It played an important role in the analysis of the radar image, because it was the source of a blind sector.

In the first approach, elaborating a model of a simplified building model of LOD1 was attached the model of the attic. During the analysis of the

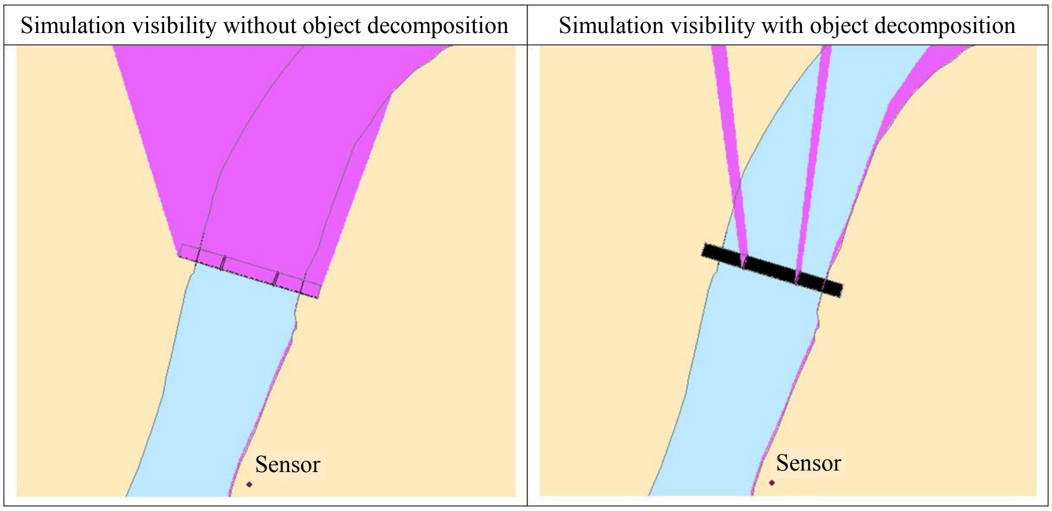


Fig. 5. Viewshed analysis under bridge span without and by using decomposition of the complex object of raster model for given sensor; invisible area is marked by magenta colour

Fig. 6. The radar sensor and an attic that is the source of blind sector

visibility the objective has been achieved, however, an oversimplification of the building contributed to obtain very not precise result in the nearest vicinity of the sensor (Fig. 7a). Hence, it was necessary to increase the level of detail for building to the LOD2, what increased accuracy of analyses (Fig. 7c). In turn, using the model developed from the LIDAR data at a density of 8–14 points per square meter, it was not possible to obtain an accurate model of the attic. This translated into a very thorough analysis of visibility (Fig. 7b). Therefore, the model had to be corrected manually. As can be noted, in the next study case, which requires account of objects or elements essential for the observation, is important to implement their level of detail by additional model correction (Fig. 7d). In this case is required a direct geodetic measurement, which further allows the development of a complex and high detailed 3D model.

It should be noted that the above considerations for the radar sensors should include the basic radar image distortion, due to the nature of radar, which reduce the scope of the field of view [13].

Conclusions

This paper summarizes the research related to the carrying out of the visibility analysis for complex objects. These objects are in principle in each of the analysed area. These should include a variety of engineering structures, buildings, bridges and vegetation. Depending on the role of these objects they can be divided into two types: the object for sensor platform and the object of forming a natural barrier, limiting the field of visibility.

In case of a sensor platform should be taken into account even small details that may affect the obscuration. It should be noted that even DSM developed from LIDAR data does not provide the correct mapping. In this case the direct geodetic measurement is recommended. The second group are objects others like sensor platform, limiting its view field. In this case, part of the objects can be reproduced as a three-dimensional map. These are objects with complex geometry, which are difficult to convert to raster. They include cranes, gantries and other handling equipment and engineering structures. In particular, they are objects, which requires consideration its clearance. Perfect examples are bridges, under which it is possible to observe waterways area.

More attention must be paid to the visibility analysis carried out by using raster model. For complex objects, such as bridges or buildings with a diverse topography of the roof, should be use a decomposition of the model. It boils down to separation of object components, adjustment of required resolution and performing individual analyses. In addition, the raster model should simulate the basic radar distortions and is, therefore, more useful in determining the real extent of visibility for radar sensors.

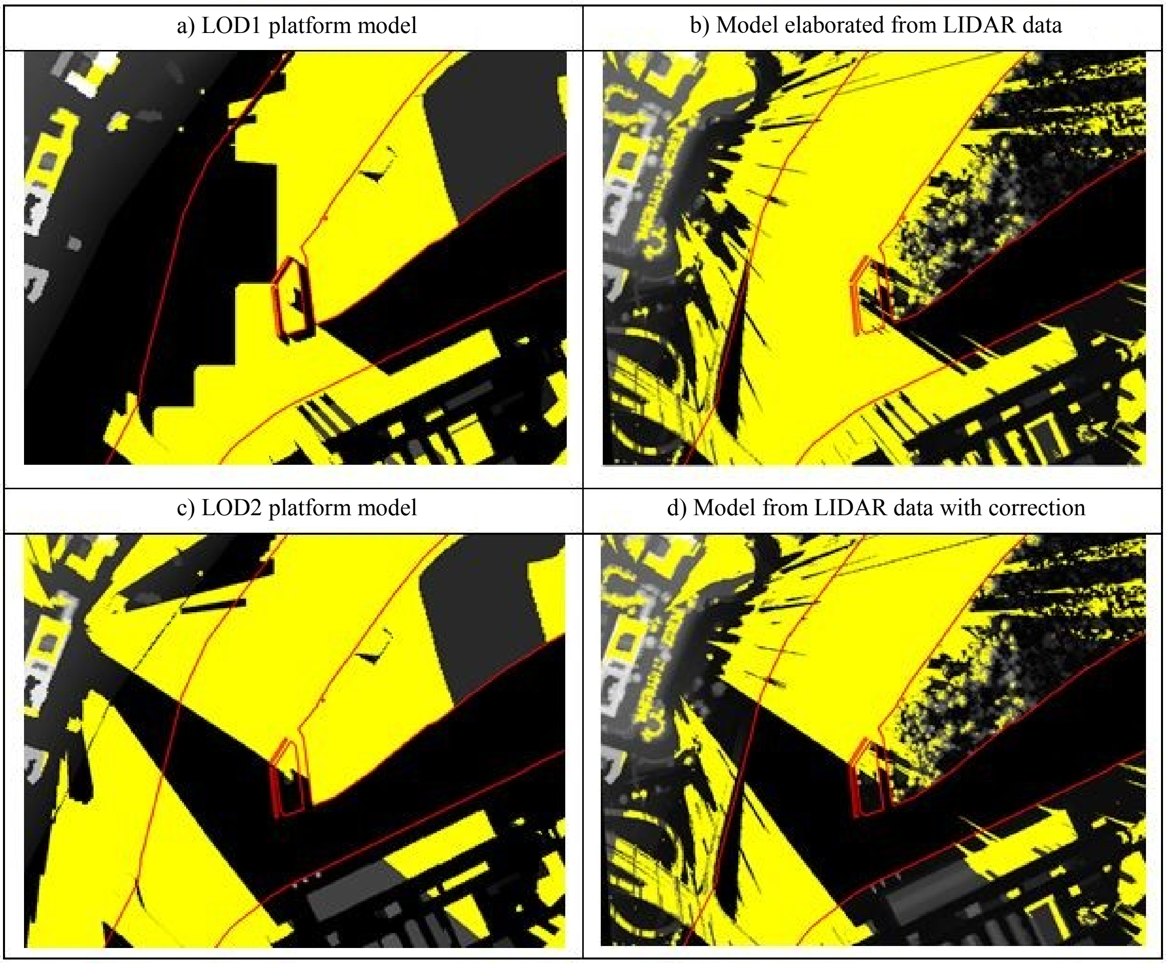


Fig. 7. The results of analyses before and after DSM adjustment for considered platform and DSMs; visible area is marked by yellow colour

References

1. Commission Regulation (EC) No 414/2007 of 13 March 2007 concerning the technical guidelines for the planning, implementation and operational use of river information services (RIS) referred to in Article 5 of Directive 2005/44/EC of the European Parliament and of the Council on harmonised river information services (RIS) on inland waterways in the Community.
2. Łubczonek J.: Evaluation of functionality of ArcGIS and ERDAS Imagine programs in the aspect of the spatial planning of the observational sensors. Annals of Geomatics, Vol. 9, No. 2(46), 2011 (in Polish).
3. Łubczonek J., Kazimierski W., Pałczyński M.: Planning of combined system of radars and CCTV cameras for inland waterways surveillance by using various methods of viewshed analysis. Proceedings of International Radar Symposium, Lipsk 2011.
4. Łubczonek J., Stateczny A.: Spatial planning of land-based marine radar sensors by using 3D carthographical model of the port and urbanized areas. CD edition. Coast-GIS Conference, Oostend 2011.
5. Łubczonek J.: Supporting design of observational sensors system on inland waterways by using ArcGIS software. CD edition. Logistics, No. 6, CD No. 3, 12, 2011 (in Polish).
6. Stateczny A., Kazimierski W.: Selection of GRNN network parameters for the needs of state vector estimation of manoeuvring target in ARPA devices. Proceedings of SPIE, Vol. 6159, 2006.
7. Stateczny A., Kazimierski W.: A comparison of the target tracking in marine navigational radars by means of GRNN filter and numerical filter. Proceedings of IEEE Radar Conference 2008.
8. Stateczny A., Kazimierski W.: Determining manoeuvre detection threshold of GRNN filter in the process of tracking in marine navigational radars. Proceedings of International Radar Symposium 2008, Wrocław 2008.
9. Łubczonek J., Beczkowski K.: Application of GPS / RTK – Trupulse 360B measurement set for 3D building modelling. Archives of Photogrammetry, Cartography and Remote Sensing, Vol. 23, 2012 (in Polish).
10. Łubczonek J., Wawrzyniak N.: Three-dimensional tree modelling in the context of spatial planning of observation sensors on inland waterways. Archives of Photogrammetry, Cartography and Remote Sensing, Vol. 23, 2012 (in Polish).
11. Smith M., Goodchild M., Longley P.: Geospatial Analysis - a comprehensive guide to Principles, Techniques and Software Tools. 3rd edition, 2009, 337–342.
12. Łubczonek J.: Application of modified method of viewshed analysis in radar sensor network planning on inland waterways. 13th International Radar Symposium (IRS), Warszawa 2012.
13. Łubczonek J.: The accuracy of determination of radar shadows. Annual of Navigation 19, 2012 (part 2).