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INVESTIGATION OF THE OBSERVATION CONDITIONS ON THE TERRAIN OF WAR OPERATION USING GIS TECHNOLOGY

The modern geoinformation systems (GIS) have been widely applied in Armed Forces for preparation and control of battle operations, for information providing of tactic activities, for improvement of topographic maps etc. In real situations during war activity the Geography information about situation on the terrain can be ofthen changed. So, in this cause the application of usual maps isn't effective. Only the modern automated control systems can provide fast changing information documenting. The observation condition is one of the terrain features for providing information about enemy troops position and facilities. This feature helps to detemine the distance of sight between any observation points, the invisibility factors of terrain. It is depended on nature of relief plant cover, human settlements and other objects, also meteorological conditions, influencing on the visibility. As result of correct organization of observation, the obtained data help commander to estimate completely the military operation area and adopt a reasonable decision. In paper the observation conditions between two points of mountain terrain during battle operation have been investigated using GIS technology. The experiments for estimation of observation situation in mountain terrain has been carried out for one of the chosen region of the Caucasus. The visible and invisible areas have been revealed on the line of sight between two selected oversight points. The invisibility factors have been calculated and studied in depended on camera platform height. The visible and invisivle areas are determined under 0-180° angle in range 17941.16 m. The height profile between observations points and the digital heights model of investigated terrain have been constructed and analysed. At the various heights of camera observation platform the 3D heights models of the visible and invisivle areas have been constructed The invisibility factors between two delected viewpoints have been calculated. It is determined that if the heght of camera platform is increased above-ground level then the invisible area is decreased. ArcGIS software has been used for development and calculation measured results.

Keywords: observation conditions, mountain terrain, GIS, invisibility factor, height profile, ArcGIS software

Background

The modern geoinformation systems (GIS) have been widely applied in Armed Forces for preparation and control of battle operations, for information providing of tactic activities, for improvement of topographic maps, for determination of location on the ground of the land forces etc. [1-4].

In real situations during battle operations the Geography information about situation on the terrain can be ofthen changed. So, in this cause, the application of usual maps isn't effective. Only the modern automated control system can provide fast changing an information documenting. The modern GIS electron maps, video data editing systems, the especial GIS softwear in modern computer-driven control system (Windows 8, 10, 13 etc.) have been developed [5,6]. They provide a creation of the vector, rastr and matrix maps, moreover, and give possibilities efficiently data about terrain updating.

In previously works [7-11] using GIS technology the relief digital model application and the terrain observation conditions were investigated for possibility of planning war operations.

In given paper using GIS technology for one of the chosen region of the Caucasus the observation conditions from one supervision point, the visible and invisible areas have been investigated.

The observation condition is one of the terrain features for providing information about enemy troops position and facilities. This feature helps to detemine the distance of sight between any observation points, the invisibility factors of terrain, and it is depended on nature of relief plant cover, human settlements and other objects, also meteorological conditions, influencing on the visibility. As result of correct organization of observation, the obtained data help commander to estimate completely the military operation area and adopt a reasonable decision.

If there are many ravines, valleys, hills, trees and bushes, various buildings on the terrain then the visibility conditions are such unfavourable. In mountain conditions during supervision it should be select such observation point from out of which it can be possible to see roads, precipices, paths and valleys. The observation conditions help a reconnaissance, organization of fire systems and control of military units, or make worse ones. It help to reveal surroundings terrain and targets, or make worse ones. The observation conditions are characterized by optical (radiolocating) visible distance in one of concrete sector (range) of elevations of the surroundings terrain and targets, also by the sizes of invisible areas and bounds.

As result of carried out and presented experiments, the estimation of observation situation in mountain terrain has been realized. The goal of work is to determine of visible and invisivle areas between two oversight points. The GIS analysis has been carried out at two stages. At the first stage, the visibility analysis on the line of sight between two oversight points has been carried out, then the visible and invisivle areas under 0-180° angle in range 18000 m are determined, and the terrain profile has been constructed. At the second stage, the terrain elevation 3D model has been constructed. GIS and ArcGIS software have been used for our calculations [5].

Experimental results

Two viewpoints on the topographic map have been selected. The height of first point is 900.8 m, and the height of second point is 901.5 m. The distance between these viewpoints is 17941.16 m.The goal of this work is to study of the influence of relief, trees and bushes, human settlements, various buildings and the height of camera platform on the level of visibility.

I-st experiment. The result of analysis of the line of sight between two viewpoints is shown in fig. 1. The camera platform is located on the surface of ground (the height h = 1 m). The visible areas are marked by the geen lines, the invisible areas are marked by the red lines.

The visibility analysis of the line of sight between two viewpoints has been carried out with taken an account of Earth surface curvature.

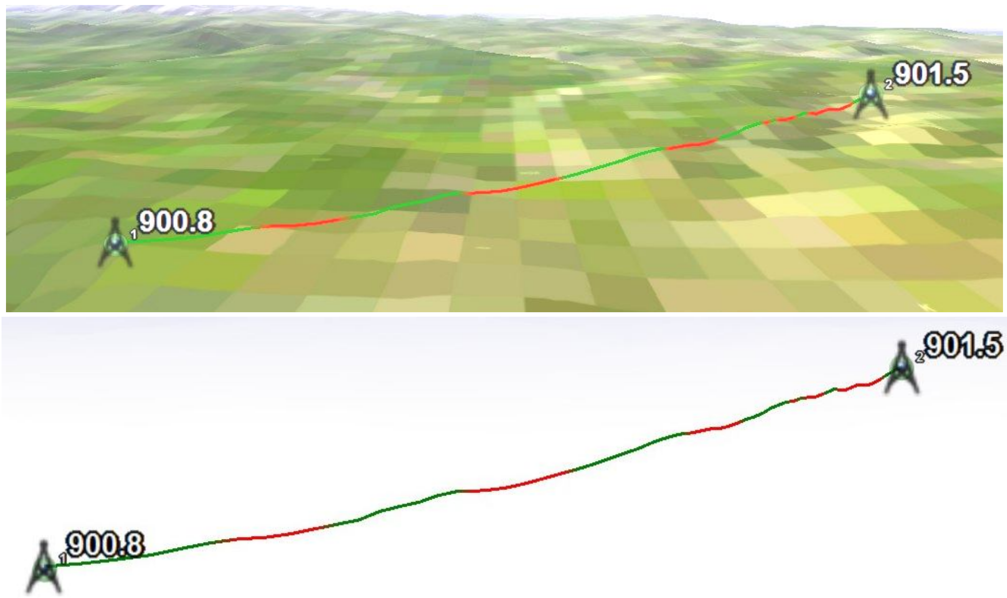

Fig. 1. The visibility analysis of the line of sight between two viewpoints

II-d experiment. The camera platform is lifted on the height $h = 10$ m above-ground level. Took 1-st viewpoint as basis, the visible and invisivle areas under (0 ÷ 180°) angle in range of 18000 m to direction to 2-nd viewpoint are determined by GIS analysis. The result of analysis of the line of sight between two viewpoints is shown in fig. 2.

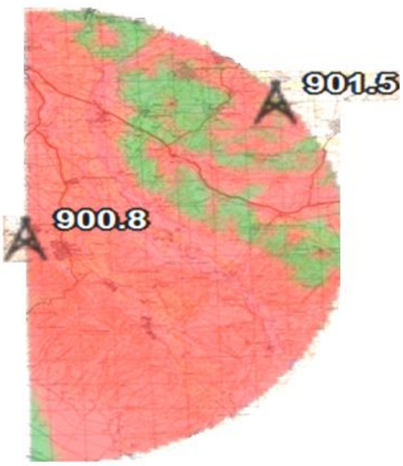

Fig. 2. The visible and invisible areas beween two viewpoints (h=10 m)

The 3D model of visible and invisible areas between two viewpoints (h = 10 m) is shown in fig. 3.

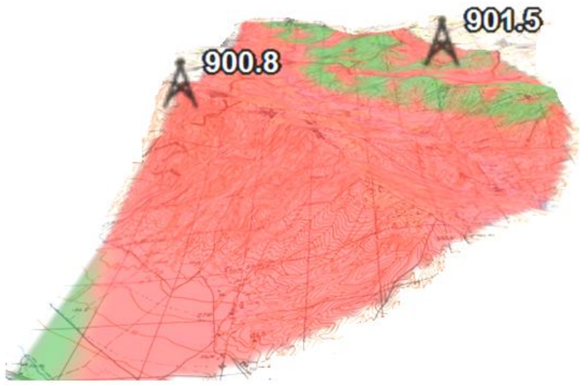

Fig. 3. The 3D model of visible and invisible areas between two viewpoints (h= 10 m

III-rd experiment. The camera platform is lifted on the height h = 20 m above-ground level. Took 1-st viewpoint as basis, the visible and invisivle areas under 0-180° angle in range ≈ 18000 m to direction to 2-nd viewpoint are determined by GIS analysis.The result of analysis of the line of sight between two viewpoints is shown in fig. 4.

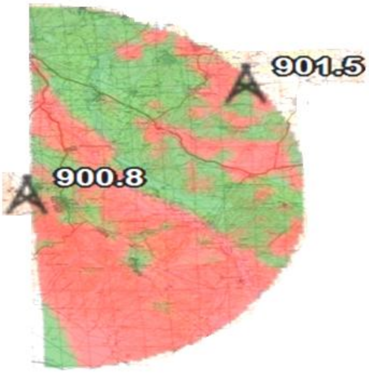

Fig. 4. The visible and invisible areas beween two viewpoints (h = 20 m

The 3D model of visible and invisible areas between two viewpoints (h = 20 m) is shown in fig. 5.

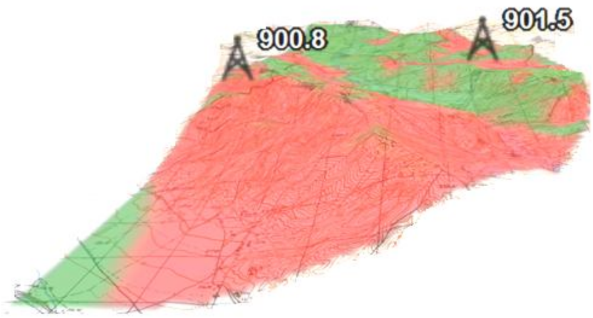

Fig. 5. The 3D model of visible and invisible areas between two viewpoints

IV-th experiment. The camera platform is lifted on the height h = 30 m above-ground level. Took 1-st viewpoint as basis, the visible and invisivle areas under (0 ÷ 180°) angle in range of ≈ 18000 m to direction to 2-nd viewpoint are determined by GIS analysis. The result of analysis of the line of sight between two viewpoints is shown in fig. 6.

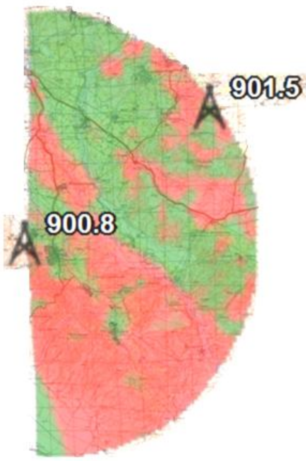

Fig. 6. The visible and invisible areas beween two viewpoints (h = 30 m)

The 3D model of visible and invisible areas between two viewpoints (h = 30 m) is shown in fig. 7.

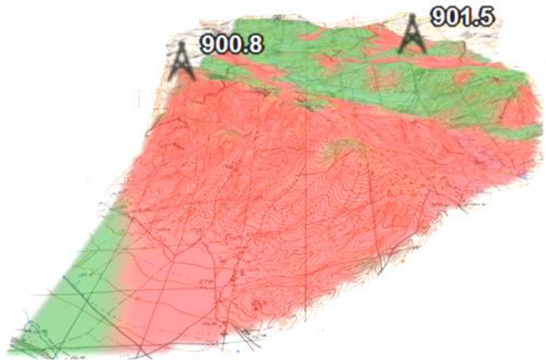

Fig. 7. The 3D model of visible and invisible areas between two viewpoints (h = 30 m)

The investigated terrain were classified on heghts and were divided on 13 zones (fig. 8).

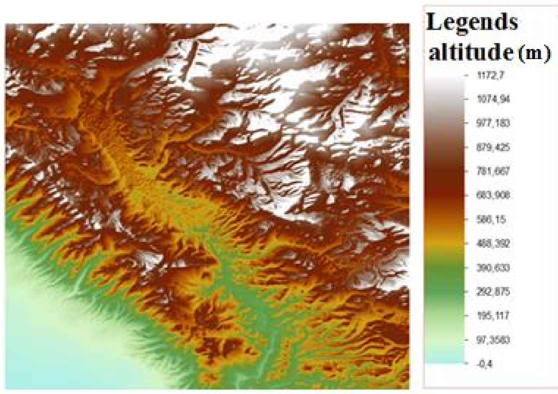

Fig. 8. The digital heights model of terrain

Using GIS softwear the profile on the line of sight between two viewpoints has been constructed (fig. 9). This profile is applicated for determination of double-sided invisible areas between selected viewpoints, for investigation more precisely of terrain profile, for study of terrain slope etc.

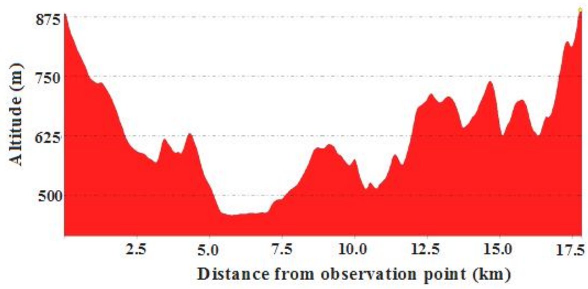

Fig. 9. Constructed profile between two viewpoints

From fig. 9 it is clearly seen, that how the terrain relief is changed step by step by distance and by heights.

Analysis and disscusion

The investigation of observation condition on the war operation region has a goal to determine of visibility and invisibility levels (factors) on the most suitable viewpoint of terrain. By construction of the heights profile of terrain, the visible and invisible areas are determined below method. Let us explain it using fig. 10.

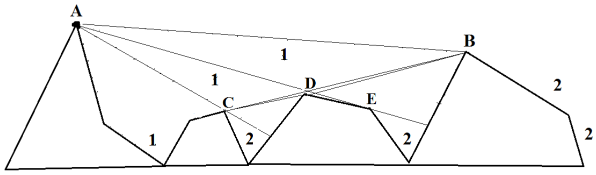

Fig.10. The profile of conditional mountain terrain

The profile of conditional mountain terrain is shown in this figure 10. The two viewpoints are selected on the high posts. Here: ***A*** is the first viewpoint selected on the top of mountain, ***B*** is the second viewpoint (enemy target) selected on the top of another mountain. Between ***A*** and ***B*** viewpoints on the line of sight the heights profile is constructed by use GIS software. As results, visible (1) and invisible (2) areas (figures 10) are determined. From analysis of obtaining information the command staff located in the *A* post make at a decision that the enemy troops and armoured machineries located in areas (2) will be unobserved. On the other hand, if enemy troops will be located in areas (1) then they will be observed from *A* viewpoint.

If *C*, or *D*, or *E* points are selected as viewpoints then, by the same rule, the invisible areas can be determine on *CD*, *DE* or *EB* lines of sight.

Such viewpoints can be selected on the various peaks of the terrain. For the right and correct decision making the commander must to choose such viewpoint that the sum of the invisible areas is minimal. For this, let us apply and use an invisibility factor *P* for various peaks:

$$p = \frac{1}{n-1} \cdot \sum_{i=1}^{n-1} \frac{1}{S_i^0} \cdot \sum_{j=1}^{n-2} S_{ij}^{in} \; . \qquad (1)$$

Here: S_{ij}^{in} is an invisible area between *i* and *j* peaks, S^o is a total area between *A* and *B* peaks; *n* is a number of peaks.

After calculation P_1, P_2,... invisibility factors for various viewpoints to the lines of sights to the enemy post *B*, the minimym of them can be determined::

$$P_{min} = \min \{P_1, P_2, ...\}.$$

So, after calculation of the minimal invisibility factor P_{min} by this method, the cammander can choose a right viewpoint. From this viewpoint (a peak) on the line of sight to ememy point *B* the invisible areas are minimal. Based on this method let us determine an invisibility factor *P* in our experiments.

I-st experiment: the camera platform is located on the ground, then from analysis of data on the fig. 1 we can calculate the invisibility factor P_1 from *A* viewpont on the line sight to *B* post:

$$P_1 \approx 0{,}55 \text{ or } P_1 \approx 55\ \%.$$

That is, 55% of total area between viewpoints *A* and *B* are invisible.

II-nd experiment: the camera platform is lifted on the height of *h* = 10 m above-ground level. Then from analysis of data on the figures 2 and 3 we can calculate the invisibility factor P_2 from *A* viewpont on the line sight to *B* post ((*h*=10 m, figures 2 and 3):

$$P_2 \approx 0{,}42 \text{ or } P_2 \approx 42\ \%.$$

That is, the camera platform is lifted on the height of *h* = 10 m above-ground level, then 42 % of total area between viewpoints *A* and *B* are invisible.

III-nd experiment: the camera platform is lifted on the height of *h* = 20 m above-ground level. Then, from analysis of data on the figures 4 and 5 we can calculate the invisibility factor P_2 from *A* viewpont on the line sight to *B* post ((*h*=20 m, fig. 4 and 5):

$$P_3 \approx 0{,}36 \text{ or } P_3 \approx 36\ \%.$$

That is, the camera platform is lifted on the height of *h* = 20 m above-ground level, then 36 % of total area between viewpoints *A* and *B* are invisible.

IV-th experiment: the camera platform is lifted on the height of *h* = 30 m above-ground level. Then. from analysis of data on the figures 6 and 7 we can calculate the invisibility factor P_4 from *A* viewpont on the line sight to *B* post ((*h*=30 m, fig. 6 and 7):

$$P_4 \approx 0{,}22 \text{ or } P_4 \approx 22\ \%.$$

That is, the camera platform is lifted on the height of *h* = 20 m above-ground level, then 22 % of total area between viewpoints *A* and *B* are invisible. So, we have

$$P_4 < P_3 < P_2 < P_1.$$

We can conclude that if the heght of camera platform is increased above-ground level then the invisible area is decreased.

Conclusion

The experiments for estimation of observation situation in mountain terrain has been carried out.

Using GIS technology and ArcGIS software the visibility analysis on the line of sight between two selected oversight points has been carried out. The visible and invisivle areas under 0-180° angle in range 17941.16 m are determined. The terrain profile and the digital heights model of investigated terrain have been constructed. At the various heights of camera observation the 3D heights model of the visible and invisivle areas have been constructed. The invisibility factors between two delected viewpoints have been calculated. It is determined that if the heght of camera platform is increased above-ground level then the invisible area is decreased.

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Дослідження умов спостереження с використанням ГІС технологій на території військових дій

Е. Г. Гашимов, А. А. Байрамов

Сучасні геоінформаційні системи (ГІС) широко використовуються в Збройних Силах для підготовки і управління бойових операцій, для інформаційного забезпечення тактичних дій, для поліпшення топографічних карт. В реальній ситуації під час військових дій геоінформація про становище на місцевості може часто змінюватися. Тому, в цьому випадку застосування звичайних карт не ефективно. Тільки сучасні автоматизовані системи управління можуть забезпечити швидко мінливу інформаційну документацію. Умова спостереження є одним з властивостей місцевості, що забезпечує інформацією про позицію ворожих військ і військової техніки. Це властивість допомагає визначити відстань спостереження між точками спостереження, фактор невидимості місцевості. Це залежить від природи рельєфу рослинного покриву, поселень і інших об'єктів, а також метеорологічних умов, що впливають на видимість. Як результат правильної організації спостереження, отримані дані допомагають командиру повністю оцінити область військової операції і прийняти прийнятне рішення. У статті, використовуючи ГІС технологію, досліджені умови спостереження між двома точками гірській місцевості під час бойової операції. Експерименти по оцінці ситуації спостереження в гірській місцевості були проведені в одній з обраних регіонів Кавказу. По лінії огляду між двома обраними точками спостереження були виявлені видимі і невидимі області. Були розраховані фактори невидимості і вивчені в залежності від висоти платформи камери. Були визначені видимі і невидимі області в радіусі 17941.16 m під кутами 0-180 °. Був побудований і проаналізовано профіль висот між точками спостереження і цифрова модель висот досліджуваної території. Для різних висот розташування платформи з камерою були побудовані і досліджені 3D моделі висот для видимих і невидимих областей. Були розраховані фактори невидимості між двома обраними точками спостереження. Було встановлено, що чим вище платформа з камерою спостереження, тим менше невидима площа. Для обробки і розрахунку виміряних результатів було використано програмне забезпечення ArcGIS.

Ключові слова: умови спостереження, гірська місцевість, ГІС, фактор невидимості, профіль висот, програмне забезпечення ArcGIS.

Исследование условий наблюдения с использованием ГИС технологий на территории военных действий

Э. Г. Гашимов, А. А. Байрамов

Современные геоинформационные системы (ГИС) широко используются в Вооруженных Силах для подготовки и управления боевых операций, для информационного обеспечения тактических действий, для улучшения топографических карт. В реальной ситуации во время военных действий геоинформация о положении на местности может часто меняться. Поэтому, в этом случае применение обычных карт не эффективно. Только современные автоматизированные системы управления могут обеспечить быстро меняющуюся информационную документацию. Условие наблюдения является одним из свойств местности, обеспечивающее информацией о позиции вражеских войск и военной техники. Это свойство помогает определить расстояние наблюдения между точками наблюдения, фактор невидимости местности. Это зависит от природы рельефа растительного покрова, поселений и других объектов, а также метеорологических условий, влияющих на видимость. Как результат правильной организации наблюдения, полученные данные помогают командиру полностью оценить область военной операции и принять приемлемое решение. В статье, используя ГИС технологию, исследованы условия наблюдения между двумя точками горной местности во время боевой операции. Эксперименты по оценке ситуации наблюдения в горной местности были проведены в одной из выбранных регионов Кавказа. По линии обзора между двумя выбранными точками наблюдения были выявлены видимые и невидимые области. Были рассчитаны факторы невидимости и изучены в зависимости от высоты платформы камеры. Были определены видимые и невидимые области в радиусе 17941.16 m под углами 0-180°. Был построен и проанализирован профиль высот между точками наблюдения и цифровая модель высот исследуемой местности. Для разных высот расположения платформы с камерой были построены и исследованы 3D модели высот для видимых и невидимых областей. Были рассчитаны факторы невидимости между двумя выбранными точками наблюдения. Было установлено, что чем выше платформа с камерой наблюдения, тем меньше невидимая площадь. Для обработки и расчета измеренных результатов было использовано программное обеспечение ArcGIS.

Ключевые слова: условия наблюдения, горная местность, ГИС, фактор невидимости, профиль высот, программное обеспечения ArcGIS.