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Study on Data Generating Method for Communication Area of Shortwave Communication Radios under Terrain shading

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Abstract: Whether the communication is smooth or not is an important factor that affects intelligence transmission, command, guidance and combat synergy. Calculating the communication area of communication equipment and achieve visualization can well demonstrate the communication efficiency, and guide commanders scientific decision-making. However, the existing communication area calculation model is mainly based on the smooth ground assumption, less consideration of the problem of unblocked communication caused by the terrain shading, and cannot be completely applied the actual combat environment. So, taking shortwave radio as an example, this paper puts forward the method of data generation and visualization in the communication area under the condition of terrain shading, and achieves better results.

1. Introduction

Shortwave communication usually refers to radio communication using electromagnetic waves having a wavelength of 10-100m [1]. Shortwave radios have played an important role in military communication due to their simple equipment, low cost, convenient assumptions and flexible maneuvers since they came out [2]. The basic modes of shortwave propagation include ground wave propagation and sky wave propagation. Among them, the ground wave mode of propagation is close to the ground and propagates along the interface between earth and air. The propagation depends on the unevenness of the ground [3]and the electrical properties of the geology [4]. The article mainly focuses on the former, analyzes the shortwave ground wave propagation model under the condition of masking, provides a method for calculation and simulation of the communication area of shortwave radios, and makes it easy for commanders to make accurate judgments and make scientific decisions.

2. Visibility Analysis Theory

The principle of visibility analysis is based on the judgment between point to point. In the use of computer to determine the visibility, using the calculation method, the principle is as follows:

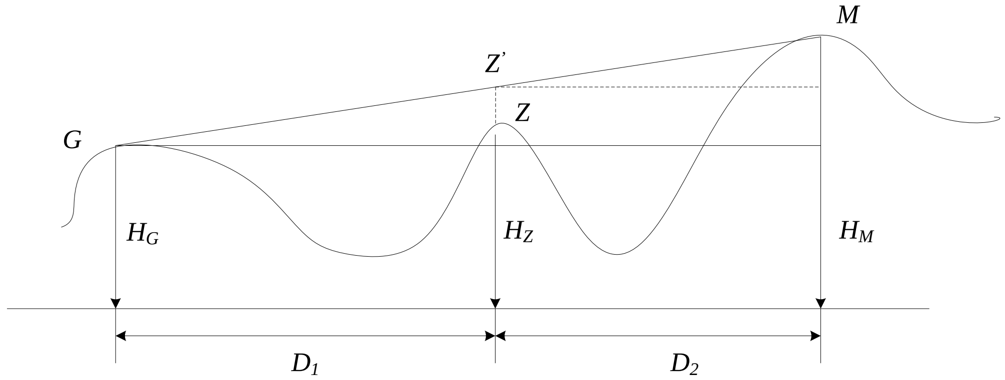


Figure.1 terrain shading diagram

As shown in figure.1: let G, M, Z be the observation point, the target point and the shadowing point respectively, and their elevation are H_G, H_M and H_Z respectively. The distance between the observation point and the shadowing point is D_1, and the distance between the target point and the shadowing point is D_2.

Set the shadowing point Z along the vertical extension of the intersection of the horizon and the point Z', and this is called the hypothetical shading point. If we ascertain the elevation $H'Z$, when $H'Z > HZ$,it must be visible.

3. Shortwave Communication Distance Calculation Model

3.1 Shortwave Communication Distance Calculation Model when there's no shades

Literature [5][6] proposed that when the radio wave is transmitted planely, the maximum communication distance satisfies:

$$P_t G_t \left(\frac{\lambda}{4\pi R_{\max}}\right)^2 q_{rt} \ W^2 = P_{r(\min)} \tag{1}$$

In where, P_t is the transmitting signal power of the shortwave communication station; G_t is the gain of the signal transmitting antenna in the receiving equipment direction; q_{rt} is the gain of the receiving antenna in the direction of the signal transmitting station; λ is the wavelength of the communication signal; $P_{r(\min)}$ is the minimum detectable signal power of the communication receiver; W is the Ground attenuation factor.

The ground attenuation factor can be expressed as follows [7]:

$$W = \frac{2 + 0.3x}{2 + x + 0.6x^2} \tag{2}$$

In where, x is Middle amount

$$x = \frac{\pi R_{\max}}{\lambda} \frac{\sqrt{(\varepsilon - 1) + (60\lambda\sigma)^2}}{\varepsilon'^2 + (60\lambda\sigma)^2} \tag{3}$$

In where , ε is the relative permittivity of the ground; σ is the ground conductivity.

3.2 Calculation Model of Communication Distance under Terrain Shading

The main assumption is that the terrain obscuring model assumptions when the mountain block (Figure 1), assuming that the height of the mountain h .

3.2.1 Only a single shade.

If the shadow height is greater than 2 times the wavelength, that is $h \geqslant 2\lambda$, it is blocked. If the shadow height is less than 2 times the wavelength, that is $h < 2\lambda$,it can diffraction, and diffraction loss is 10lg (n +1) 2, that is, the equivalent transmit power of 1/4 of the original power after blocking.

3.2.2 If there are multiple shades, it is simplified as a sequentially diffracted single masking

If there are m shielding blocks in the azimuth, the next peak ($1 \leqslant i \leqslant m$) is removed in turn, and the calculation model of the communication distance R is as follows:

1) Calculation h_i / λ ;

2) Calculate the distance between the i-1and i mountain;

3) When the i mountain blocks, basing on Power equivalence principle of diffraction loss,we can calculate the propagation distance R_i after the wave passes over the i mountain.

3.2.3 The calculation model is as follows:

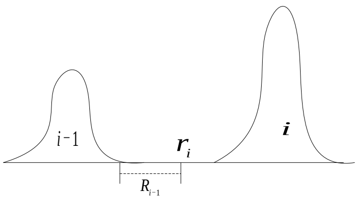
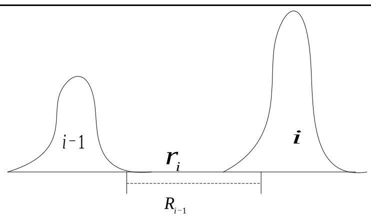
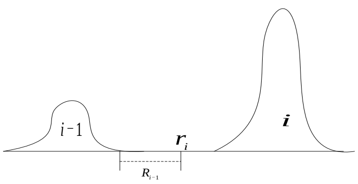
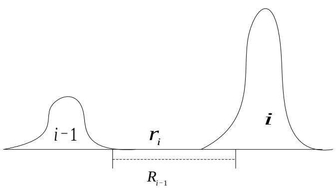
A sketch map of the shading of the mountain	Description of the situation	Communication distance calculation
	When $h_i / \lambda \geqslant 2$, $r_i > R_{i-1}$, it can't spread to the i mountain ; End of calculation	Assuming thecommunic ationdistance after the wave passes over the $i-1$ mountain, then $R = R_n + R_{i-1}$
	When $h_i / \lambda \geqslant 2$, $r_i \leqslant R_{i-1}$, it is blocked ; End of calculation	$R = R_n + r_i$
	When $h_i / \lambda < 2$, $r_i \leqslant R_{i-1}$, it can't spread to the i mountain ; End of calculation	$R = R_n + R_{i-1}$
	When $h_i / \lambda < 2$, $r_i \leqslant R_{i-1}$, Then the next mountain shading continues to be calculated until the above three cases appear.	$R = R_n + r_i + ...$

Figure.2 Propagation and calculation diagram

4. Simulation

4.1 Computer simulation steps

The principle of using computer simulation is as follows: a single HF communication station is used as the observation point, the maximum communication distance is the observation radius, the omnidirectional angle is used to calculate the communication distance under the terrain shadowing conditions, and the data is collected and drawn according to the azimuth and the corresponding communication distance Out of shortwave communications terrain under the conditions of the terrain masking communication smooth area image. Specific steps are as follows:

Step1: Load a high-resolution map to get the deployment location of the communication station;

Step2: Using the unobstructed short-wave communication distance calculation model, calculate the maximum communication distance without shielding.

Step3: Taking the position of the communication station as the center, the maximum communication distance is a radius, the horizontal azimuth angle is sequentially masked and analyzed from 0-360 °, and the communication distance of each azimuth is calculated R by using the communication distance calculation model under the shielding condition.

Step4: Triangular fan for drawing basic elements, according to the data obtained to draw the smooth area graphics.

4.2 Data sampling

Based on a high-resolution map, a short-wave communications station was deployed somewhere using the proposed solution and the maximum communication distance calculated using the function was 124884 meters. Follow the above steps to get the full range of communication distance. Figure.3 lists the data 0-100 °, Figure 4 According to the read 360 ° azimuth data, using excel to draw the communication unobstructed area graphics to verify the correctness of access to data.

0	37884.48368	40	6818.90773	60	124884	80	124884
1	30811.51252	41	7816.24243	61	124884	81	124884
2	46241.62691	42	124884	62	124884	82	124884
3	30664.30707	43	124884	63	124884	83	124884
4	7703.123199	44	28871.64221	64	124884	84	124884
5	7803.045185	45	28341.87707	65	124884	85	124884
6	15747.91499	46	28187.2836	66	124884	86	124884
7	8048.136834	47	124884	67	124884	87	124884
8	32928.82568	48	124884	68	124884	88	124884
9	8497.191808	49	124884	69	124884	89	124884
10	41506.31804	50	124884	70	124884	90	124884
11	6641.687539	51	124884	71	124884	91	124884
12	6494.632479	52	124884	72	124884	92	124884
13	6225.031519	53	45497.7319	73	124884	93	124884
14	5998.792935	54	34687.71924	74	124884	94	124884
15	5938.462643	55	43163.81478	75	124884	95	124884
16	5881.902994	56	124884	76	124884	96	124884
17	5827.228666	57	124884	77	124884	97	124884
18	5776.324979	58	124884	78	124884	98	124884
19	5727.306614	59	124884	79	124884	99	124884

Figure.3 Data sampling diagram

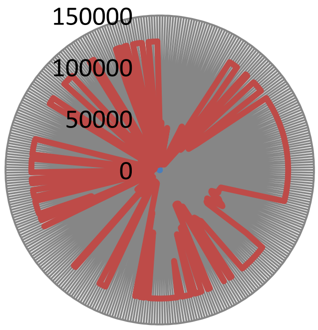


Figure.4 excel drawings

4.3 Draw method

Drawing shortwave communication station communication unobstructed graphics, the sampling of the azimuth and the corresponding communication distance is transmitted to the rendering end of the simulation system, the triangle fan for drawing basic elements, the adjacent azimuth will be the border point and the radio connection, get A triangular fan (Figure.5. b). And so on, traversing the azimuth, you can get the entire area, to achieve the visual communication of unobstructed area. Simulation results shown in Figure.5. b. The figure is basically the same as Figure 6.a, indicating that the data transmission and drawing process are both feasible.

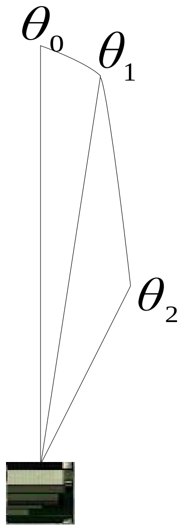


Figure.5.a Triangle fan rendering diagram

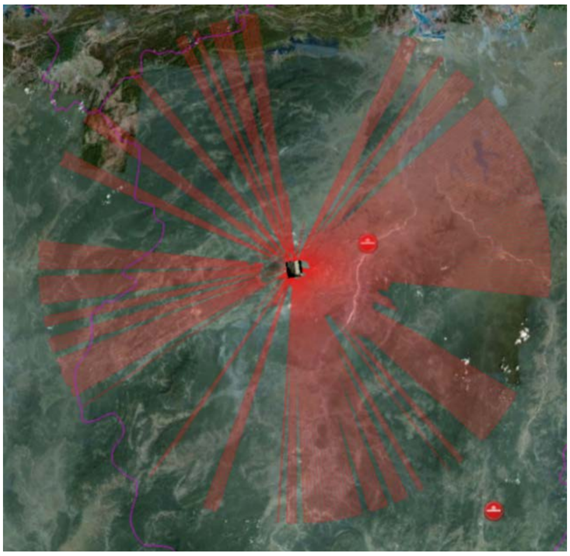


Figure.5.b Achieve renderings

Figure 5

5. Conclusion

Obtained by computer simulation of short-wave communication under cover conditions unobstructed area, is based on the location of the communication station as the center of the communication distance R_{max} (no shaded) or the R (shaded) vertex envelope surrounded by a collection of internal regions . Through the simulation and analysis of the unobstructed communication area of a single shortwave radio station, it is found that the visualization shows the communication effect of stations in different deployment locations well and can effectively guide the commanders in the deployment of the radio and the receiver, facilitating the quick judgment of the commander, decision making.

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