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RESEARCH ARTICLE OPEN ACCESS

A positioning method for single moving station based on DF with measuring height

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ABSTRACT:
Under the condition that the height can be obtained, the position of fixed or slow targets on the ground can be determined by the passive aerial motion detection platform only by one angle measurement in the vertical plane and the horizontal plane.

KEY WORDS： Single station location; DF; height measurement; passive location

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I. INTRODUCTION

The single motion station positioning method uses a single motion observation station to determine the position information of the measured target. Compared with the multi-station positioning system, the mobile single-station positioning system does not need a large amount of communication data transmission and has the advantages of simple structure and flexible equipment. Therefore, it has a broad application prospect in many civil and military fields, such as navigation and aviation, satellite positioning and early warning, anti-radiation weapon guidance, and electronic reconnaissance[1].

Existing methods for passive detection keep emerging. After the research methods based on kinematics[2-9], a direct positioning method based on data processing[10-14] has emerged.Location algorithms seem to be getting more and more complex. But as far as air-to-ground passive detection is concerned, the biggest advantage of the aerial mobile detection platform lies in its altitude. And in most cases, this height is obtained by the platform itself. The analysis in this paper shows that the detection platform can obtain the position information of ground target only by real-time angle measurement under the condition of height measurement.

II. GEOMETRIC MODEL

The geometric model of the air mobile platform P to detect ground targets T is shown in Figure 1.The platform is equipped with altitude meter and omni-directional direction finder.Assuming that the detection platform moves along a straight line in the horizontal plane, the altitude meter detects the height h between the platform and the ground in real time.At some point, the receiver detects radiation from a fixed or slow target on the ground.In the vertical plane, the direction finder detects an angle α between the radial direction of the radiation signal and the direction of the vertical height of the platform.

The geometric equation can be listed by using the geometric parameters obtained from the passive detection

$$r\cos\alpha = h \quad (1)$$

The radial distance between the aerial detection platform and the ground target is obtained

$$r = \frac{h}{\cos\alpha} \quad (2)$$

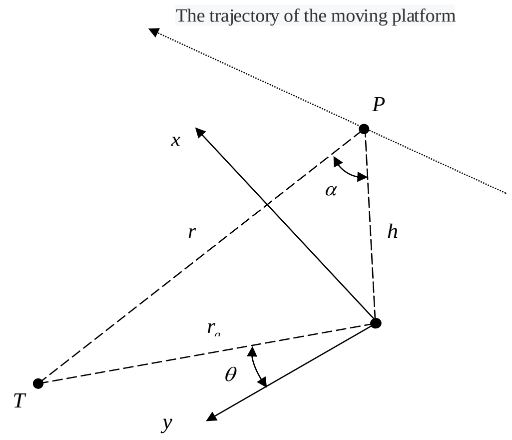

Fig. 1 Geometric model

Further, the projection length of radial distance r on the ground can be obtained

$$r_g = r\sin\alpha = \frac{h\cdot\sin\alpha}{\cos\alpha} = h\cdot tg\alpha \quad (3)$$

It is assumed that the detection platform moves on the horizontal plane and the positive Y-axis direction of the rectangular coordinate system in the ground plane is due north.The omnidirectional direction finder can give the angle between the horizontal projection line segment of the radial distance of the target and the due north direction. Thus the position information of the target in rectangular coordinates is determined

$$x = r_g \sin\theta = h \cdot tg\alpha \cdot \sin\theta \quad (4)$$

$$y = r_g \cos\theta = h \cdot tg\alpha \cdot \cos\theta \quad (5)$$

III. RANGING ERROR

The total differential method is used to analyze the relative ranging error.Theranging errors resulting from height measurements

$$\frac{\partial r}{\partial h} = \frac{1}{\cos\alpha} \quad (6)$$

The range error caused by angular measurement

$$\frac{\partial r}{\partial \alpha} = \frac{h\sin\alpha}{\cos^2\alpha} \quad (7)$$

When the error of each observation is zero mean value and independent of each other, the relative ranging error

$$\sigma_r = \frac{1}{r}\left[\left|\frac{\partial r}{\partial h}\right|\sigma_h + \left|\frac{\partial r}{\partial \alpha}\right|\sigma_\alpha\right] \quad (8)$$

Where, σ_h and σ_α are the RMS of the height measurement error and the Angle measurement error respectively.

During the simulation calculation, the flight height of the detection platform was set $h = 25km$, and the overlooking angle changed linearly within the range of $0^0 < \alpha < 90^0$.

Figure 2 shows the relative ranging error when the root mean square error of angle measurement error is different. As can be seen from the figure, when the overlooking angle tends to 90^0, the ranging error will increase rapidly.To be clear, the greater than 85^0 the relative ranging error curve has been deleted.Obviously, σ_α has a great influence on the ranging accuracy.If σ_α can be controlled to be less than 0.5^0, then within the range of $\alpha < 60^0$, the relative ranging error will be less than 2.5%.In the simulation, $\sigma_h = 50\text{m}$.

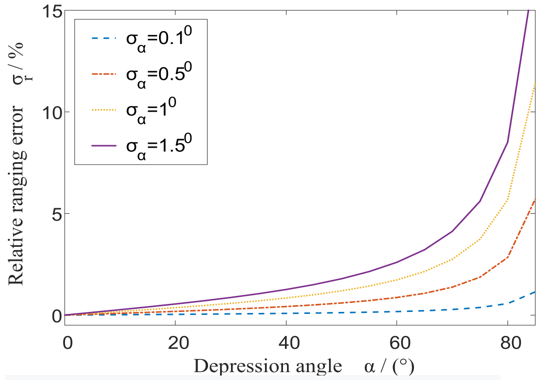

Fig. 2 Relative ranging errors under different σ_α

The simulation results show that the root-mean-square error of altitude measurement error has no effect on the relative ranging error, and the variation of flight altitude is also independent of the relative ranging error. Therefore, the error relation curves of them are no longer given.

IV. CONCLUSION

Under the condition that height measurement can be provided, the air motion detection platform can quickly locate fixed or slow targets on the ground only by direction finding, and can obtain high ranging accuracy.In this case, it seems that there is no more advantage based on frequency measurement, time measurement, etc.

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