A Novel Digital Sight Based on Intelligent Dynamic Parameters Modification Algorithm

Hao Xu[1, a], Mengying Wu[1, b], Lu Zhao[1, c], Jiani Zhang[1, d] and Zhongwei Zhao[1, e]

[1]No.7, Xuezheng Street, Jianggan District, Hangzhou City, Zhejiang Province, China.

[a]199510030@qq.com, [b]409487014@qq.com, [c]1255161048@qq.com, [d]409487014@qq.com, [e]525074092@qq.com

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Abstract. This paper proposes a novel digital sight by dynamic modifying external ballistic parameters based on embedded Linux system. The external real-time ballistic parameters will be achieved by laser sensor and high-speed image sensor with high-speed Processor platform. With the combination of real-time modification of fault bit on external ballistic parameters and compensating algorithm, the actual ballistic point will be located. At the same time, the CPU will synchronize image data by downloading ballistic trajectory database in the cloud server. Simulation result shows that within 500 meters, the accuracy of impact point reaches to more than 90%. Compared with traditional optical aiming device, this novel digital scope device shortens the reaction time from aiming so that it can substantially increase the shooting rate of moving targets.

Introduction

Optical scope always has been as a necessary configure device in the outdoor firearms since the mid-19th century, but there are still some drawbacks because of device reasons. The main drawback is lack of convenient and flexible Trajectory settings. Recently, there is some novel scope proposed. Specially focus on the digital Aiming System. In this paper, a new digital sight scheme is proposed, which adopts B / S architecture, in which the terminal part mainly uses ARM multi-core processor and laser sensor to collect high-definition images and relative environment data, by cooperating with the sight of the intelligent point-to-point algorithm software, accurate estimation of the outer trajectory point, suggesting to the user, the principle of the intelligent algorithm is to download the latest firearm trajectory database or ballistic point database, The current altitude, temperature, wind drift and other environmental parameters, through the external trajectory parameters of real-time error correction and compensation algorithm to develop a precise measurement of the distance under the impact point. At the same time, the whole test system integrates wireless sensor network technology, embedded system, B / S technology and wireless data transmission technology into one, which is safe, convenient, mobile, intelligent and accurate.

Algorithm Procedure

Realization Diagram. The realization of the program block diagram shown in Fig. 1:

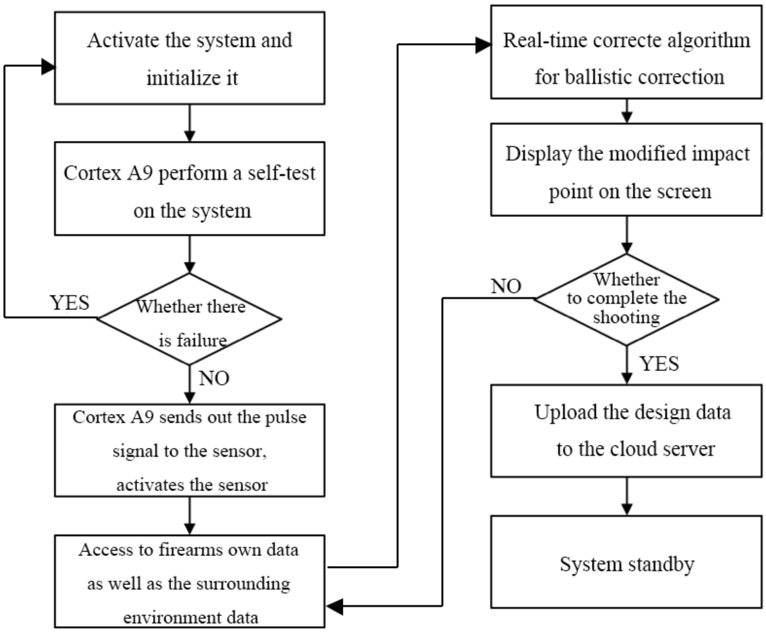

Figure 1. Algorithm procedure

When the user ready to shoot, the system will be activated, CPU will be completed in a short time initialization and self-test, if the problem is returned to reinitialize. Upon completion of the self-test, the chip will send a pulse signal to each sensor to activate the sensor. CPU will be the data integration, through the ballistic parameters of real-time error correction and compensation algorithm to correct the impact point, and displayed on the screen. If the shooting has not yet completed, CPU will continue to activate the sensor to collect real-time data acquisition and correction trajectory, otherwise the system will upload the data to the cloud database, and standby mode to wait for the next shot.

Dynamic Parameter Modification Algorithm (DPM). The DPM algorithmic principle is as follows

The First Step. The processor uses three-axis gyroscope and gravity acceleration sensor to collect real-time data and determine the gun in three-dimensional space of the rotating posture and the angle of view. Where the three-axis gyroscope contains intelligent compass sensor and acceleration sensor, the use of its data can be determined in three-dimensional guns in the direction of movement and mobile acceleration. The relationship among acceleration a, initial velocity v_0, final velocity v_1 and time t is as follows:

$$v_1 = v_0 + at \tag{1}$$

Where v_1 represents current time of speed, By comparison with the initial velocity v_0, determine a possible movement trajectory.

The Second Step. The processor will utilize the laser ranging sensor to acquire the target and the relative distance of firearms, through the trilateral positioning method determines the relative speed of movement between the gun and the target, So as to determine the displacement coordinates of the object in the three-dimensional space. The trilateral positioning algorithm is show as follows:

Assuming three points' position (x_1, y_1), (x_2, y_2), (x_3, y_3) and the distances between the unknown point (x_0, y_0) to those points: d_1, d_2, d_3:

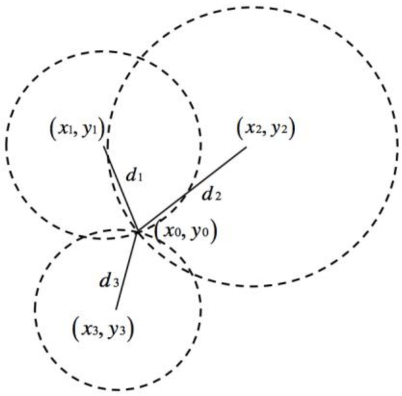

Figure 2. trilateral positioning algorithm

Where, three points d_1, d_2, d_3 represent the center circle. According with the Pythagoras theorem, the intersection point is unknown position calculation formula:

$$\begin{cases}(x_1 - x_0)^2 + (y_1 - y_0)^2 = d_1^2 \\ (x_2 - x_0)^2 + (y_2 - y_0)^2 = d_2^2 \\ (x_3 - x_0)^2 + (y_3 - y_0)^2 = d_3^2\end{cases} \quad (2)$$

In order to facilitate the calculation, we create a two-dimensional Cartesian coordinate system in Fig. 2, with the center of the first circle as the origin, the first circle and the second circle of the center of the circle x axis, as shown in Fig. 3:

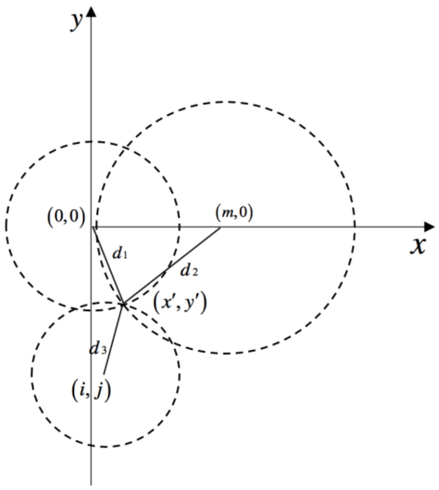

Figure 3. Three-sided positioning method to calculate the icon

Where, the coordinates of the center of the three circles are changed to: $(0,0)$, $(m,0)$, (i,j).At the same time according to the above figure, formula Eq. 2 can be simplified as:

$$\begin{cases}x'^2 + y'^2 = d_1^2 \\ (m - x')^2 + y'^2 = d_2^2 \\ (i - x')^2 + (j - y')^2 = d_3^2\end{cases} \quad (3)$$

Where,

$$x' = \frac{m^2 + d_1^2 - d_2^2}{2m}, y' = \frac{d_1^2 - d_3^2 - x'^2 + (x' - i)^2 + j^2}{2j}. \quad (4)$$

The Third Step. The processor calculates the offset error of the bullet in the current wind-drift environment. Considering the wind speed and wind direction is not stable, the processor will delete the data regularly to reduce the amount of memory occupied by the operation, to reduce the algorithm for the chip and the burden of storage.

Fig. 4 shows the bullet trajectory and the existence of the wind when the bullet trajectory :

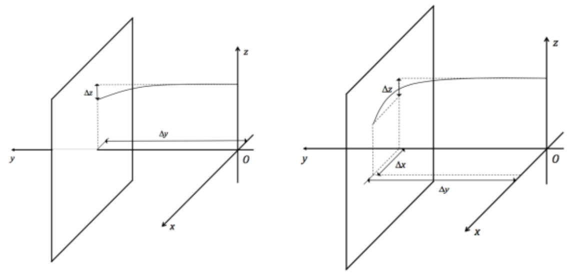

Figure 4. Wind drift on the impact point of impact diagram

The Last Step. According to the target and the firearms in the space of the plane distance, the processor computes the real-time trajectory database in the plane from the actual test point in the display pixel coordinates, combined with the wind drift offset error, The target distance from the bullet at the exact point of the bomb point coordinates, also displayed on the screen.

Simulation Result

We use Matlab platform to simulate above dynamic parameters modification by program the simulation environment such as wind-speed 5m/s, bulletin speed 800m/s etc. The simulation data are listed as following Table 1 and 2.

Table 1 System simulation test data table in windless environment

Bullet caliber /mm	Shooting times	Predict point of impact /m	The actual impact point /m	Relative error /%
3	1	(114,127,100)	(115.7,128.9,100)	0.52%
	2	(135.7,133.2,79)	(133.3,130.9,79)	0.77%
4	1	(120.8,133.4,97)	(121.8,134.5,97)	0.84%
	2	(158.9,144.5,56)	(159.6,145.2,56)	0.46%
6	1	(233.4,177.4,65)	(232.5,178.1,65)	0.38%
	2	(144,165,33)	(144.6,165.7,33)	0.44%

Table 2 System of live ammunition test data table

Bullet caliber /mm	Shooting times	Predict point of impact /m	The actual impact point /m	Relative error %
3	1	(46.7,44.5,116.5)	(47.2,45.0,117.9)	1.20%
	2	(132.8,144.9,133.4)	(134.3,146.5,131.9)	1.11%
4	1	(78.4,56.8,34.5)	(79.3,56.2,34.1)	1.09%
	2	(58.8,34.9,33.5)	(58.1,34.5,33.1)	1.22%
6	1	(89.5,123.1,56.6)	(90.5,124.4,57.2)	1.08%
	2	(13.3,48.1,45.8)	(13.1,47.5,45.2)	1.23%

From above Table 1 and 2, these test data show that the accuracy of trajectory point more improve with proposed dynamic parameters modification algorithm than previous algorithm. At the same time, whether it is no wind or wind floating environment, the system's prediction of the impact point and the actual impact point is very small error, which also shows that the system has a good performance in practical applications.

Conclusion

This paper proposes a novel digital sight by dynamic modifying external ballistic parameters based on embedded Linux system. The external real-time ballistic parameters will be achieved by laser sensor and high-speed image sensor with high-speed Processor platform. With the combination of real-time modification of fault bit on external ballistic parameters and compensating algorithm, the actual ballistic point will be located. At the same time, the CPU will synchronize image data by downloading ballistic trajectory database in the cloud server. Simulation result shows that within 500 meters, the accuracy of impact point reaches to more than 90%. Compared with traditional optical aiming device, this novel digital scope device shortens the reaction time from aiming so that it can substantially increase the shooting rate of moving targets.

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