Research of Positioning Tracking on Dynamic Target Based on the Integral Complementing Algorithm

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Abstract. Aiming at the problem of single target object detection and tracking in unknown environment, we propose a dynamic target tracking and positioning method based on integral compensation algorithm. The discrete digital quantity is quantized and transformed into a continuous analog quantity, and the tracking direction is controlled by the angular rate control function. In the process of tracking, if the motion state of the target changes, the control function is directly integrated with the compensation algorithm to get a new tracking direction. Through the mathematical modeling analysis and experimental tests, experiments showed that in the single dynamic target object tracking, for the general object dynamic tracking, has a good dynamic, real-time. It has a certain application prospect in single target detection and multi-target tracking accuracy correction.

Keywords: Target location · Dynamic real-time tracking
Integral compensation

1 Introduction

Location is one of the key technologies of many intelligent applications, which is one of the most important problems in the realization of intelligent robots. It is also the basis of intelligent robot autonomous navigation and path planning. According to the presence or absence of the environmental model, the location method can be divided into the environment based on the model which can be divided into relative positioning, absolute positioning and combination of three types of positioning, no environment model positioning, and the establishment of simultaneous environmental modeling and simultaneous localization and mapping, [1, 2, 14]. The study method is carried out in the context of relative positioning. The current robot positioning algorithm is basically based on high-performance processor, with high detection accuracy of the radar, camera, ranging and other detection sensors. For robots with less processor performance and with limited hardware interface resources, however, it is less applicable. To solve this problem, this paper presents a simple digital sensor to achieve the goal of positioning and tracking.

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In order to solve this problem, this paper proposes a robot target tracking and positioning method based on integral compensation algorithm [6]. Robot in the unknown location of the limited environment uses its own relatively simple IO sensor for all-round detection, measures the relative direction of the target object [3, 5]. Through the processing of the integral compensation algorithm, the detected discrete digital quantity is quantized and transformed into continuous analog quantity to realize the tracking of the dynamic target object. For the detection of a single target object tracking, it avoids the use of complex sensors and high hardware processor. The sensor in its detection range gets the target mobile position information so that it can realize detection and tracking.

2 Integral Compensation Algorithm

2.1 Track Analysis

Robot detected the surrounding target object and achieved the target object positioning and tracking. If the target object was stationary, it could directly detect the angle θ of the target object relative to it, and perform the tracking target after the rotation angle θ. If the machine was moving and the target object was static or moving, the error in this way was very large, might not find the target object. At this time, the introduction of integral compensation algorithm could solve this problem. The machine was in the process of tracking the target object, and constantly corrected the direction with feedback relative to the robot. The walking path was shown in Figs. 1 and 2 (the green: robot; The yellow: target object).

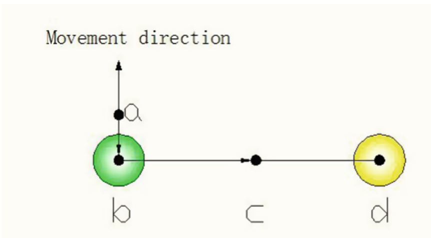


Fig. 1. Tracking path for fixed-point detection (Color figure online)

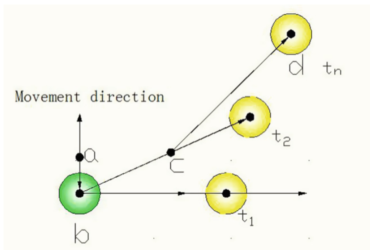
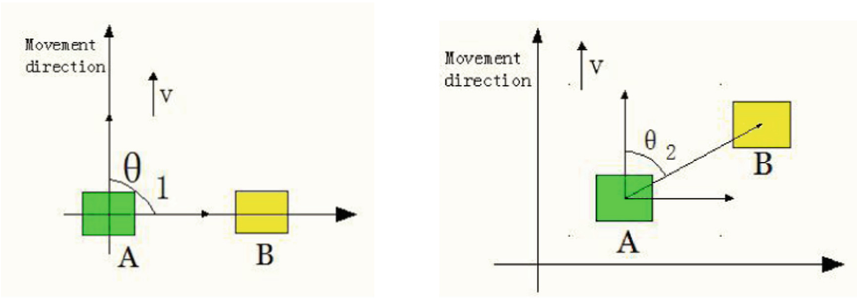


Fig. 2. Mobile detection walking path (Color figure online)

2.2 Integral Algorithm Principle

The angular rate control function required to make the robot needed to be rotated satisfies f(x). Assume that the target B was detected on the side at time t_1 (Fig. 3a).

At this time, it needed to adjust their own posture and to achieve tracking, and the angle required static point rotation was $\theta_1 = 90°$; If both robots were moving system, status change, t_2 moment, the robot ended its rotation and began to track when objects located, The rotation angle required for execution at this time was θ_2, $0 < \theta_2 < 180°$ (Fig. 3b).

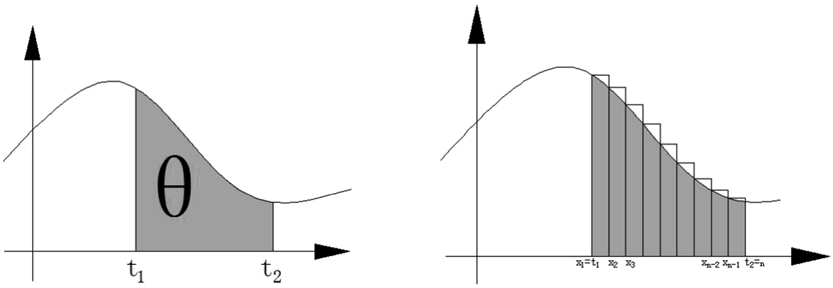


(a) (b)

Fig. 3. Position analysis before and after rotation

In the figure, v was the direction of normal advance, A was our robot, and B was the opposite robot.

In the course of the process, we had integral process for ω to get the angle θ according to state diagram of Fig. 3, the state analysis before and after rotation positioning. The integral interval of function–f(x) was $[t_1, t_2]$, the area surrounded by $\omega = 0$, $x = t_1$, $x = t_2$, $\omega = f(x)$. As shown in Fig. 4.



(a) (b)

Fig. 4. Integral interval diagram

The interval $[t_1, t_2]$ divided into n smaller interval $[x_1, x_2]$, $[x_2, x_3]$……$[x_{n-2}, x_{n-1}]$, $[x_{n-1}, x_n]$, The intersection of the upper left corner and the function was parallel to the x-axis parallel to form a narrow square rectangle. It's length was:

$$\Delta x_1 = x_2 - x_1, \quad \Delta x_2 = x_3 - x_2, \ldots \Delta x_i = x_{i+1} - x_i \tag{1}$$

Take a little ε_i freely in each small interval $[x_i, x_{i+1}]$, $[x_i, x_{i+1}]$ as its end, $f(\varepsilon_i)$ as its high, the area of the narrow square rectangle was s_i, and the rectangles in the interval were summed:

$$\theta = \lim_{n\to\infty}\left(\left(\sum_{n=1}^{n} f(\xi_i)\right)\Delta x_i\right) = \lim_{n\to\infty}\sum_{n=1}^{n} s_i \tag{2}$$

If the longest length of the narrow square rectangle in these cells was λ, when $\lambda \to 0$ ($n \to \infty$), we could get a more accurate target angle of myopia, and it was,

$$\theta = \int_{t_1}^{t_2} f(x)dx = \int_{t_1}^{t_2} s_i dx \tag{3}$$

In practical applications, we made $t_1 = 0$, t_2 be the time to end the rotation ($t_2 \leq T_{max}$, T_{max} was the time required for the sensor to achieve 360° omni-directional scanning).

2.3 Algorithm Flow Chart

After the robot was powered on, all ports and peripherals were initialized, and the robot used a relatively simple IO sensor in a limited environment for unknown locations for omni-directional detection. The robot used the angular rate to control the movement direction of the robot after detecting the relative direction of the target object. When the target changed the movement state, the robot directly integrated the control function to correct the direction of the target relative to the robot, and kept the motion orientation detection of the target object at the same time as the tracking object. Through the processing of the integral compensation algorithm, the discrete digital quantity was processed and converted into continuous analog quantity to realize the tracking of the dynamic target object. The algorithm flow chart was as follows in Fig. 5.

3 Experiment and Result Analysis

3.1 Experimental Platform Introduction

The platform, used in the experiment, was composed of MultiFLEX™2 - AVR controller, digital sensor, motor-powered lithium battery, BDMC1203 motor drive, FAULHABER 2342 24CR geared motor and various robot hardware structure connected devices. As shown in Fig. 6.

3.2 Experimental Results

First, we simulated the static target tracking tests, as shown in Fig. 7. The green box at the center of the table represented the robot A and the yellow box B stood for the target. B was at (40 cm, 0) relative to A.

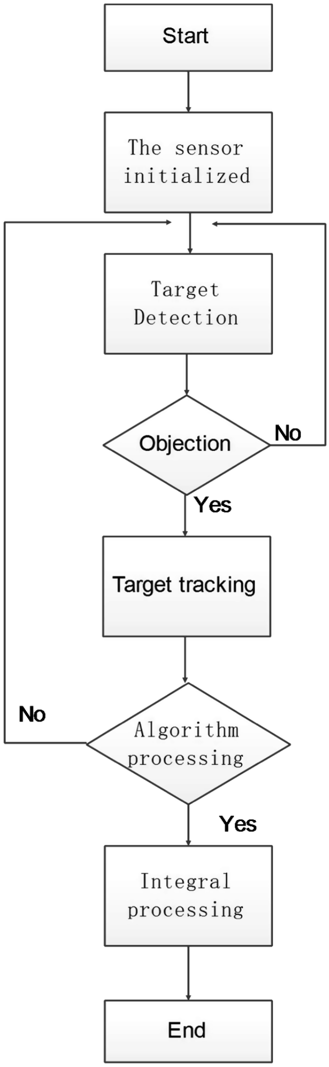


Fig. 5. Algorithm flow chart

In the test, we let B remain at (40 cm, 0), and the starting direction of the A robot was at an angle θ (0 ≤ θ ≤ 90°) from the horizontal axis. We made θ = 90° and reduce the angle of θ gradually until θ = 0°. At the same time, we recorded the time –T, required when A walked to B while the angle between A and B was 0°. Among them, three sets of static test data were recorded at table, as shown in Table 1.

We found that, due to the smoothness of the site, the roughness of the robot wheels, the battery provided for robot and other external factors [10], and relationship at angular rate function—f(x), when the angel was 0° between A and B, A might not immediately stop rotation and continued to move forward to find the target. It was

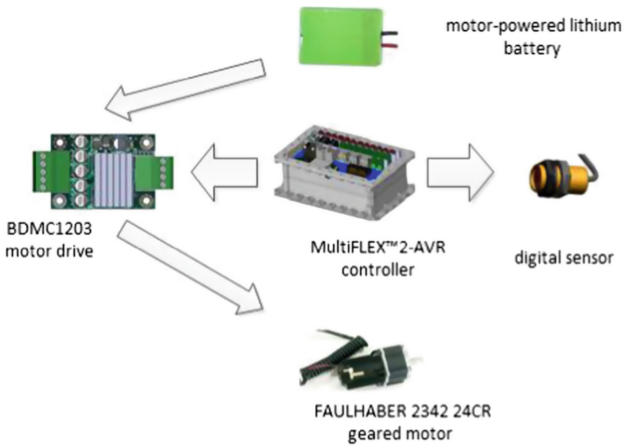


Fig. 6. Hardware structure diagram

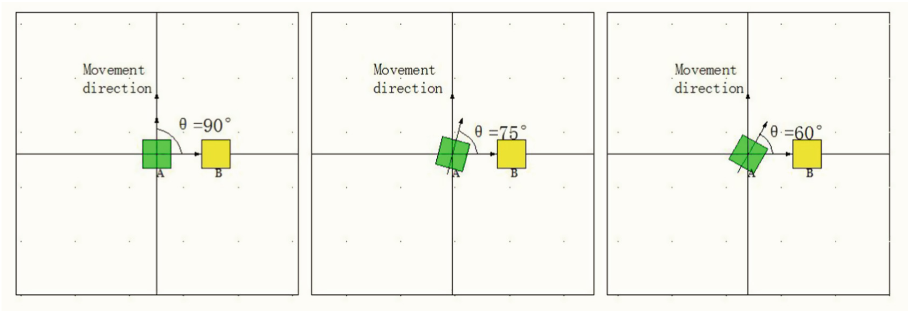


Fig. 7. Static test illustration (Color figure online)

Table 1. Test time-consuming (target was static)

Angle\Time consuming	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
90°	0	0	0	0	0	0	0	0
	1″30	1″46	1″23	1″14	1″23	1″48	1″27	1″09
75°	0	0	0	0	0	0	0	0
	1″56	2″86	2″44	3″24	2″83	2″78	2″75	3″26
60°	0	0	0	0	0	0	0	0
	3″41	2″92	2″90	2″83	3″43	2″89	3″17	3″18

necessary to perform the integral compensation process again and continued the reverse adjustment so that the A could find the specific direction of B and finally tracked B. The main solution to the reverse adjustment was to select the appropriate angular velocity–f(x) or to increase the roughness of the robot wheel. These factor, however, did not affect the actual effect for A and B that are the moving system.

In the dynamic target test, as long as the time was limited at $t < T_{max}$, and the surrounding state information did not change, A did not have a reference to B in the forward direction, and would adjust its angle relative to B, according to the relative position of the target detected at time t_1.

Because they were both moving system, A was searched for a target in the range of $0 \sim \theta°_{max}$, as long as the enemy was detected and the relative coordinate angle θ° of the initial time was obtained. Through the integral compensation algorithm, A gained the actual rotation angle θ° of the coordinate axis at time t_1, so as to achieve the target tracking.

The effect of the robot's response was shown in Fig. 8.

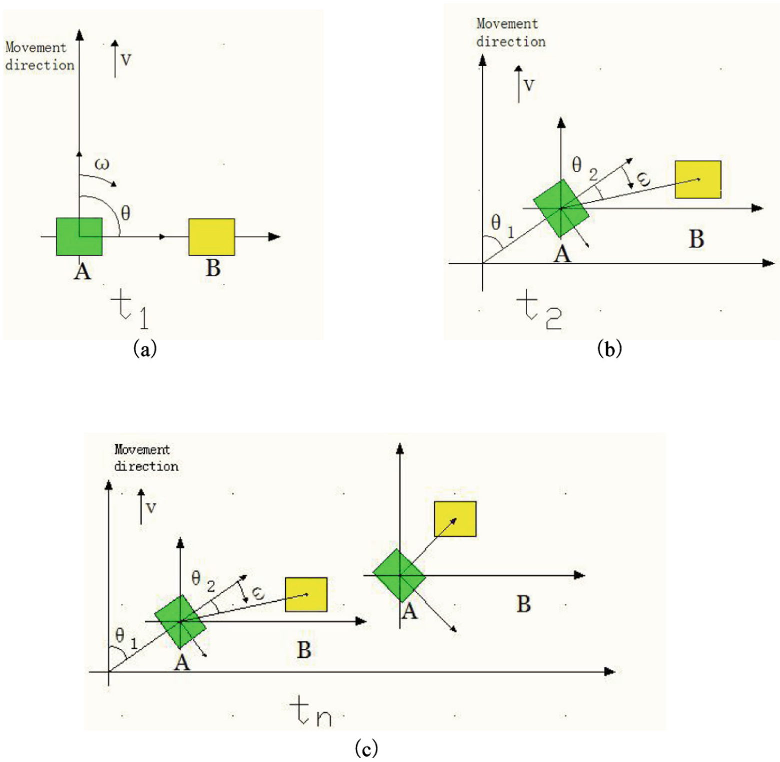


Fig. 8. State adjustment process

4 Conclusion

Based on the integral compensation algorithm, the robot target tracking and positioning method, by the digital sensor to detect the relative position of the target object direction, the robot converted the discrete digital signals detected and represented the enemy's direction into continuous analog by the integral algorithm. In the process of finding the target object, the robot performed integral compensation on the rotation function–$\omega = f(x)$, and quickly located the target object relative to its position. Through proper adjustment, the object was positioned and tracked. In the process of tracking, its system could still be aware of all the surrounding circumstances. When the surrounding situation changing, it would adjust its position to respond to this at any time, which verified that algorithm has real-time performance.

In the limited environment and limited resources of the controller IO port, the algorithm, to a certain extent, could solve the positioning and tracking of the target object within the effective range of the sensor detection, which had certain practical application significance.

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