Research on Arithmetic of Track Dynamic Drawing based on Window Function

WANG Yun-shuang, HU Lai-zhao, WANG Hai-bin,
（Science and Technology on Electronic Information Control Laboratory, Chengdu 610036, China,wyunshuang@163.com）
（China Southeast Research Institute of China Railway Engineering Company Limited , Chengdu 610031, China, 117125798qq.com）

Abstract

According to the concept and connotation of membership degree function, the arithmetic combines window function with T-S model to research fusional track dynamic drawing in Passive Detection and Location System, a certain extent solving the problem of dynamic distortion caused by irregularly spatiotemporal distributing, and the Icons can Move Smoothly and realistically in the Turning Movement. The practice proves that reasonable application of arithmetic can enhance the spatiotemporal continuity and the smoothness of the track curve, and it can make a good impression in vision.

1 Introduction

Whether in Single-Station or in multi-station Passive Detection and Location System, we both need to draw dynamic track of the targets detected after Signal Treatment and track fusion on map display. However, because of the complexity of environment signals and the ability of Detection and Location System, fusional tracks also exist incontinuity, miss some track dots, and error track dots.

Traditional Arithmetic of Track Dynamic Drawing needs to interpolate by Polynomial Functions when rack dots are sparse. This Arithmetic usually ignores time distributing, and also because of the track dots exist space incontinuity, the last result on map display exists dynamic distortion, even develops into a rupture[1-4]. For the sake of a factual support track to support display, and at the same time we also can get a smoothly curve, can make the Icons Move Smoothly in the Turning，this arithmetic according to the concept and connotation of membership degree function combines window function with T-S model to solve the problems.

2 Common Window Function and Import the Window Function

Window function in this arithmetic can help us to select track dots at the reasonable time. Because we need to interpolate when drawing track, so we must to get a number of dots before track coupling。And when track coupling we bring into window function. Some common window function such as these [5]:

Rectangular window function; triangle window function; Hamming window function; Blackman window function and so on.

By the application，the track dots chosen must be Real-time, and have the greatest weight value to the result。So we choose Rectangular window function to truncate the data. In the window data is efficiency and out the window data is inefficacy。In the window this arithmetic brings into membership degree function to calculate weight value of the input track dots。

3 Analysis of Membership Degree Function

An element belongs to a set can be described as a value from 0 to 1 by a membership degree function, and the Membership degree function can have any shape. The one and only condition is its value range is [0,1]. The shape lies on simple and efficacious application. In fuzzy system the common membership degree functions are gauss membership degree function, campaniform membership degree function, sigmoid membership degree function triangle membership degree function, trapezia membership degree function and so on.

978-1-4673-5225-3/14/$31.00 ©2014 IEEE

We need to calculate the cure which middle axes lays on the current time t, when we calculate the coordinates at t Time. The rule of the movement decides that the coordinates at the time have a minimal error to the last time $t-1$ and the next time $t+1$. We believe that the input value at time t have the greatest weight value to the result calculated at time t, and by time goes farther and farther onwards or backwards the weight value becomes smaller and smaller, and it becomes 0 at last. So to solve the problem, we choose r from -1 to +1, and $A = 1 + \cos(r * \pi)$, construct a function which range from 0 to +1 and it is symmetrical.

4 Research on The Arithmetic and Modeling

T-S fuzzy model can describe non-linear dynamic characteristic, it is deemed an expanding of subsection linearization.

Supposing there are a number of P inputs and one outputs, a number of n fuzzy rules can describe the T-S model. The fuzzy rule of the order i can describe as rules of if…then as:

R^i: if $y(k-1)$ is A_1^i, $y(k-2)$ is A_2^i, …, $y(k-n_y)$ is $A_{n_y}^i$, $u_1(k-t_{d1})$ is $A_{n_y+1}^i$, …, $u_1(k-t_{d1}-n_1)$ is $A_{n_y+n_1+1}^i$, …, $u_p(k-t_{dp})$ is $A_{n_y+n_1+\ldots+n_{p-1}}^i$, …, $u_p(k-t_{dp}-n_p)$ is $A_{n_y+n_1+\ldots+n_p+p}^i$, Then

$$y^i(k) = P_0^i + P_1^i y(k-1) + P_2^i y(k-2) + \ldots + P_{n_y}^i y(k-n_y) + P_{n_y+1}^i u_1(k-t_{d1}) + \ldots + P_{n_y+n_1+1}^i u_1(k-t_{d1}-n_1) + \ldots + P_{n_y+n_1+\ldots+n_{p-1}+p}^i u_p(k-t_{dp}) + \ldots + P_{n_y+n_1+\ldots+n_p+p}^i u_p(k-t_{dp}-n_p) .$$

R^i is the order of I fuzzy rule; A_j^i is subset of the whole fuzzy sets; the parameters in membership degree function is premise parameter; y^i is the output of the order of I fuzzy rule; P_j^i is conclusion parameter; $u_1(\cdot),\ldots,u_p(\cdot)$ are inputs; $y(\cdot)$ is output; $t_{d1},\ldots,t_{dp}$ are lag times; $n_y, n_1, \ldots, n_p$ are ranks of parameters。Supposing there are generalized inputs $(x_{10}, x_{20}, \ldots x_{m0})$, so $y^i (i = 1, 2, \ldots, n)$ is calculated:

$$\hat{y} = \sum_{i=1}^{n} G^i y^i / \sum_{i=1}^{n} G^i \qquad (1)$$

n is the number of fuzzy rules; y^i is calculated by the conclusion equation of the order i rule, G^i is the weight value calculated by:

$$G^i = \prod_{j=1}^{m} A_j^i (x_{j0}) \qquad (2)$$

$\prod$ is the fuzzy operator, and we can get it by getting the smaller or multiplication.

We take planar map display for example。Supposing origin is at the passive detection and location station. After changing the reference frame we get X ,the x-axis value of track pots, and Y, the y-axis value of track pots。Supposing the input of the system is time. We calculate the cure X with t and the cure Y with t. At last we change reference frame to get longitude and latitude at time t to draw。

Because of the rule of the movement, we choose polynomial to describe the system:

$f(x) = a_0 + a_1 x^1 + a_2 x^2 + \ldots + a_m x^m$。If premise structures only have one, the conclusion parameters also have one set. So if that in formula（1）n=1, G^i =1, and formula（1）can be predigested as: $\hat{y} = \sum_{i=1}^{n} G^i y^i / \sum_{i=1}^{n} G^i = y^i = f(x) = a_0 + a_1 x^1 + a_2 x^2 + \ldots + a_m x^m$, it becomes a common polynomial。

We take planar map display for example。Supposing origin is at the passive detection and location station. After changing the reference frame we get X ,the x-axis value of track pots, and Y, the y-axis value of track pots。

We truncate X value in $t_2 - t_1$,and Y valve in $t_2 - t_1$ to calculate the T-S model。The length of $t_2 - t_1$ is also the length of the window function.

Parameter calculation of T-S model includes premise structure calculation and parameter calculation. Parameter calculation includes premise parameter calculation and conclusion parameter calculation. The conclusion is described by linear equation。

The calculation of premise structure and calculation of premise parameters visit literature [6]。The paper will describe arithmetic to calculate conclusion parameters 。

Supposing a set of Premise conclusions and premise parameters, we calculate conclusion parameters with a set of inputs and outputs.

$$Q_{\hat{y}}^{i}\square\hat{y} = [\sum_{i=1}^{n} G^{i}(p_0^i + p_1^i x_1 + \ldots + p_m^i x_m)] / \sum_{i=1}^{n} G^{i} = H\square\theta^{T} \quad (3)$$

Here: $H = (W^1, W^1 x_1, \ldots, W^1 x_m, W^2, W^2 x_1, \ldots, W^2 x_m, \ldots, W^n, W^n x_1, \ldots, W^n x_m)$, $\theta^T = (P_0^1, P_1^1, \ldots, P_m^1, P_0^2, P_1^2, \ldots, P_m^2, \ldots, P_0^n, P_1^n, \ldots, P_m^n)^T$, $Q_{\hat{y}}^i$ is the value calculated by the membership degree function according to the time of $\hat{y}$。How to calculate the membership degree function please visiting chapter 3.We choose t from -1 to +1， $A = 1 + \cos(t * \pi)$， to construct the symmetrical membership degree function which value range from 0 to +1. The relative value of t is real time value subtracts value of middle axes and then divides the length of the window.

H and θ are parameter vectors. Superscript "T"describes transpose.

$$W^j = Q_{\hat{y}}^j G^j / \sum_{i=1}^{n} G^i \quad , \quad j = 1, 2, \ldots, n \quad (4)$$

We calculate the least square value of error by least-square methods to get optimization of conclusion parameters. Step as：

1）Supposing a set of data, number of groups is L （$L > n*(m+1)$）, to every group of data $(x_{1k}, x_{2k}, \ldots, x_{mk}, y_k)$, we calculate: $H_k = (W_k^1, W_k^1 x_{1k}, \ldots, W_k^1 x_{mk}, W_k^2, W_k^2 x_{1k}, \ldots, W_k^2 x_{mk}, \ldots, W_k^n, W_k^n x_{1k}, \ldots, W_k^n x_{mk})$, $k = 1, 2, \ldots, L$ here $W_k^i = Q_{\hat{y}k}^i G_k^i / \sum_{i=1}^{n} G_k^i$, G_k^i is the value calculated by the group k data under the rule i, $Q_{\hat{y}k}^i$ is the membership degree value of the group k data。

2）Initialize parameters $\theta_0 = 0$， $S_0 = \alpha I$ 。

α is a larger value, such as 10^5； I is an identity matrix。

3）We calculate:

$F_k = S_{k-1} H_k^T / (1 + H_k S_{k-1} H_k^T)$, $S_k = S_{k-1} - F_k H_k S_{k-1}$,

$\theta_k^T = \theta_{k-1}^T + F_k (Q_{yk} y_k - H_k \theta_{k-1}^T)$

Here： F_k is plus matrix； S_k is covariance matrix； θ_k is parameters vector prepared to calculate； H_k is a line vector.

4） $k + 1 \to k$,if $k \le L$， going to 3）， otherwise，it is over，and θ_k is the conclusion parameter.

We calculate the cure must after get a set of data, and more we get the data smoother the cure is. So time lag is ineluctable. The length of the window is decided by time lag and smoothness of the system patient.

Theoretically, more premise structures there will be better precision, but it needs more time to calculate. If the length of the window is small enough, we can apart lesser premise structures, and even predigest the T-S model to a multinomial. So at last the length of the window, the interval time report of tracks the precision and time lag required decide parameters and the model style in practice.

5 The Conclusion of Simulation

We choose the data of the first 6 groups to model, and draw the tracks on the map. Fig4 is drawn by the common arithmetic to insert an invariable number of values. Fig5 is drawn by the new arithmetic. Contrast to the results, the display by the common arithmetic has a seriously asymmetrical distributing, and even the track is ruptured. The display of the new arithmetic always has a value at every drawn time, so it ensures time continuum when drawing. It repairs the rupture of tracks in some degree, and the smoothness of the cure is better。

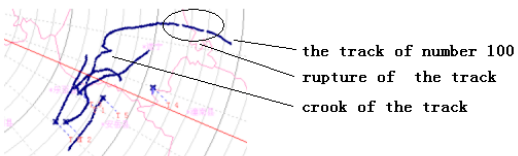

Fig1 The display of common arithmetic

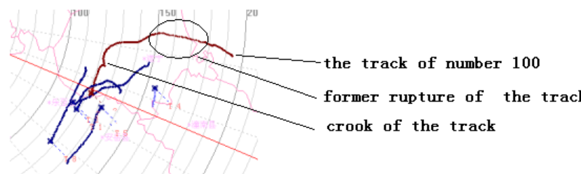

Fig2 The display of the new arithmetic

6 Conclusion

According to the concept and connotation of membership degree function, the arithmetic combines window function with T-S model to research track dynamic drawing in Passive Detection and Location System. The arithmetic at a certain extent solves the problem of dynamic distortion caused by irregularly spatiotemporal distributing, and the Icons can Move Smoothly and realistically in the Turning Movement. The practice proves that reasonable application of arithmetic can enhance the spatiotemporal continuity and the smoothness of the track curve。

7 References

1.Luo Guang-cheng,Yang Ri-jie. Research on the Track Smooth Processing for Military Icons Moving [J]. Command Control & Simulation，2011，33(4)；87-89.

2. ZHANG Feng,LI Sihai,LIU Jin. Application of Dynamic Track Drawing Algorithm in Ship Monitoring System [J]. Marine Science Bulletin，2008，28(3):68-69.

3. JI Bing, SHAN Gan-lin, CHEN Hai. Visual Simulation Method Based on VRML and Target Track [J]. Journal of System Simulation，2011，23(9)；1900-1903.

4. WU Xian-liang,GUAN Hui-feng, YIN Liang-ze~2. The Data Fusion and Tracks Prediction of Multiple Radar System [J]. Mathematics in Practice and Theory，2010，40(15)；160-171.

5. WANG Hua XU Jia-dong. Selection of Window Function in Range-Doppler Imaging Algorithm of Rotating Objects [J]. Journal of Projectiles,Rockets, Missiles and Guidance，2005，25(4)；753-758.

6. ZHANG Hua-guang, HE Xi-qin. Application and Theory ofm Fuzzy Self-adaptive Control [M]. Book Concern Beijing University of Aeronautics and Astronautics, 2002.