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Simulation of Tracking Time Delay Algorithm using Mathcad Package

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Abstract**—**This paper deals with tracking and estimating time delay between two signals. The simulation of this algorithm accomplished by using Mathcad package is carried out.

The algorithm we will present adaptively controls and tracking the delay, so as to minimize the mean square of this error. Thus the algorithm in this case has task not only of seeking the minimum point of error but also of tracking the change of position, leading to a significant improving of performance. The flowchart of the algorithm is presented as well as several tests of different cases are carried out.

Keywords**—**Tracking time delay; Algorithm simulation; Mathcad; MSE

I. Introduction

THE tracking time delay between the delayed signal with noise and the reference signal is important in various fields such as radar and sonar. The tracking time delay is very important for tracking the position of a moving target [2].

The Adaptive Time Delay Estimation (ATDE) is developed to tracking the movement of the moving target and estimating its time delay by Mathcad programming [2]. The tracking time delay algorithm has the same idea of the fixed (ATDE) but the fixed time delay D replaces here by Dp (moving time delay). Where p is a different position of the moving target. Then the configuration of the algorithm is shown in Fig 1.

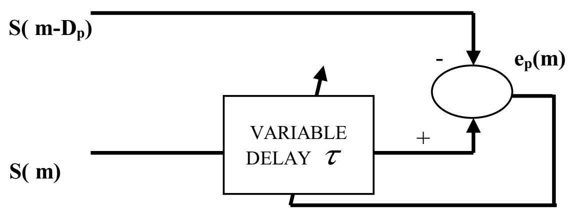

Fig. 1 Tracking time delay algorithm configuration

One channel contains the signal s(m) where m is time index or sample number, and the other channel contains the signal s(m- Dp), a delayed version of s(m), Dp represents the unknown moving target time delay in the system, and τ represents the variable delay.

To find the minimum value of the *M*ean *S*quare *E*rror (*MSE*) we will apply the same steps of derivation [13]-[2].

$$e(m) = s(m - D_P) - s(m - \tau)\,. \tag{1}$$

Then squaring the expression for e(m)

$$\left[e(m)\right]^2 = \left(s(m - D_P)\right)^2 + \left(s(m-\tau)\right)^2 - 2\cdot s(m - D_P).s(m-\tau). \tag{2}$$

When applying the expected value operator to both sides, then (2) becomes.

$$E\left[e(m)\right]^2 = E\left[\left(s(m - D_p)\right)^2\right] + E\left[\left(s(m-\tau)\right)^2\right] - 2E\left[s(m - D_p).s(m-\tau)\right]. \tag{3}$$

Thus

$$E\left[e(m)\right]^2 = 2R_{ss}(0) - 2R_{ss}(\tau - D_p)\,\cdot \tag{4}$$

The basic idea is well illustrated in Fig. 2. The Error function MSE has a clear minimum, at τ =Dp, and has a quadratic shape. At τ(m), ∇MSE exceeds zero, indicating that τ(m) ≠ Dp. If we desire to improve τ(m) , wehave to move in the direction toward Dp. In fact we don't know where Dp is , but by evaluation the derivative of minimum square error at τ(m), we obtain a clue. By evaluation the derivative we determine the first order change in MSE caused by a small change in τ [4]-[10].

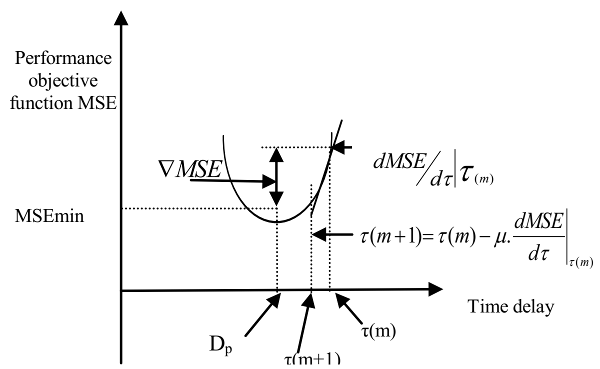

Fig. 2 Gradient decent on projection of the MSE Function

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Suppose, as shown, that $dMSE/d\tau$ is positive. Therefore, increasing τ will make MSE increase. Our goal, however, is to decrease MSE, and this may be done by taking a step in the negative direction. Thus a rule can be used as follows:

$$\tau(m+1) = \tau(m) - \mu.\frac{dMSE}{d\tau}\Big|_{\tau(m)}. \tag{5}$$

Where μ, is a small positive constant called convergent factor

The maximum of $R_{ss}(\tau - Dp)$ occurs when the variable delay τ that is equal to the moving delay D_p. The fact that D_p isn't unique in moving measurement and minimizes MSE depends on the movement of target [3]-[15].

The minimum value for the error function can be found from the gradient $\nabla_\tau(m)$, which is obtained by differentiating the MSE in (4).with respect to τ.

$$\nabla_\tau(m) = \frac{d}{d\tau}\left[2.R_{ss}(0) - 2.R_{ss}(\tau - \mathrm{Dp})\right]. \tag{6}$$

and

$$\nabla_\tau(m) = \frac{d}{d\tau}.R_{ss}(\tau - \mathrm{Dp}). \tag{7}$$

Then the gradient is approximated to

$$\nabla_\tau(m) = -2\mu.e(m)\cdot(s(m-\tau-1) - s(m-\tau+1)). \tag{8}$$

When applied (8) in (5) we will obtain upon the following alternative equation.

$$\tau(m+1) = \tau(m) - 2\mu.e(m)\cdot(s(m-\tau-1) - s(m-\tau+1)). \tag{9}$$

Equation (9) illustrates the method of estimating time delay for a moving target where D_p is varied along a wide range and depending on e(m) values.

II. Implementation of The Tracking Time Delay Algorithm

The computational procedure and Flowchart for the tracking time delay are summarized below:

1. Initially, set iteration value, error value and variable time delay τ value.

Carry out steps (2) to (5) below:

2. Compute reference signal and delayed signal s(m) and s(m- Dp)
3. Compute the error estimate.

$$e(m) = s(m) - s(m- Dp). \tag{10}$$

4. Compute factor

$$g = 2\mu.e(m). \tag{11}$$

5. Update the next variable time delay τ.

$$\tau(m+1) = \tau(m) - g\cdot(s(m-\tau-1) - s(m-\tau+1)). \tag{12}$$

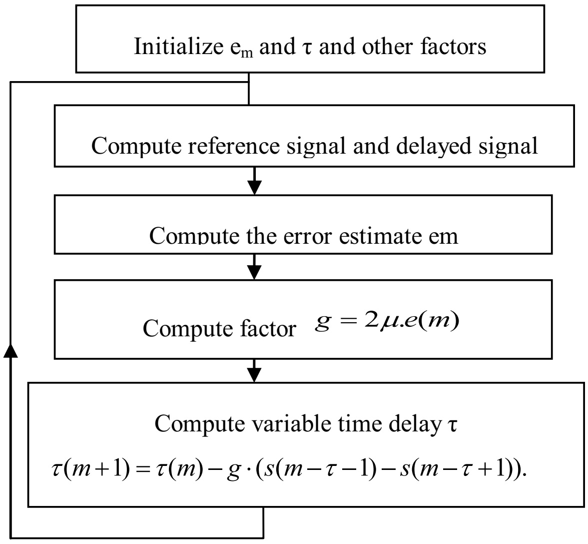

Fig. 3 Flowchart for the tracking time delay algorithm

III. Simulation Algorithm

A. Tracking Time Delay Algorithm

The algorithm of Tracking Time Delay is based on comparison of a sample from the reference signal with sample from the delayed signal. When the difference decreases to its minimum value the estimated time delay can be obtained. Tracking time delay algorithm it can be used to track a target and it can calculate its distance. Fig. 4 shows the case of target moves and the algorithm is tracking its movement continuously. There are two ways to increase the speed of tracking of the algorithm.

1. Using fast hard wave to implement the algorithm.
2. Increase μ (convergence factor) some extent figure.

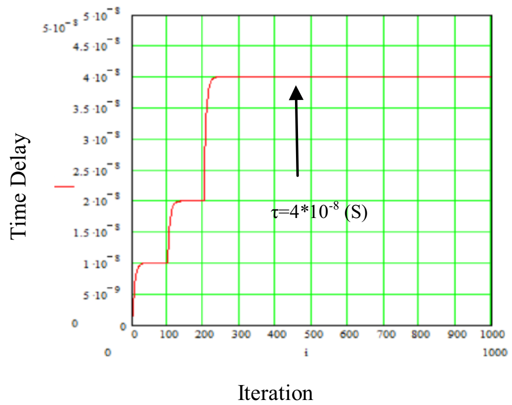

Fig. 4 Tracking Time Delay Algorithm

B. The MSE of Tracking Time Delay Algorithm

The MSE of Tracking Time Delay Algorithm is shown in Fig. 5.

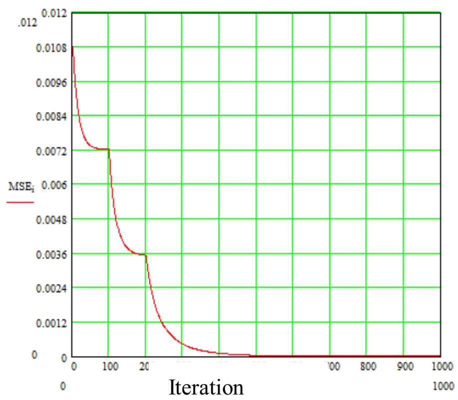

Fig. 5 Mean Square Error

C. Noise and Convergence Effect on Tracking

If the signal returned is contaminated with random noise, the tracking curve will be affected (i.e. the value of time delay obtained will be affected). Fig. 6 and 7 show the effect of the convergence factor value for different value of signal to noise ratio (In the first case SNR= -5dB & in the second SNR = 10dB).It can be seen that as (μ) decreases, the smoothness of the curve increases but the tracking capability decreases. Then it can be said that the value of μ acts as filter and a tradeoff should be made between the smoothness of the curve and the tracking.

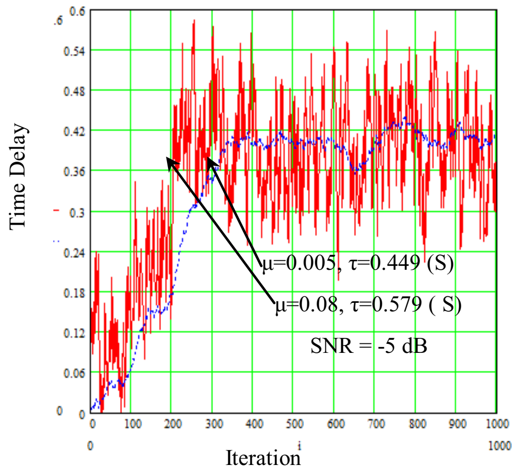

Fig. 6 The Noise and Convergence Effect on Tracking

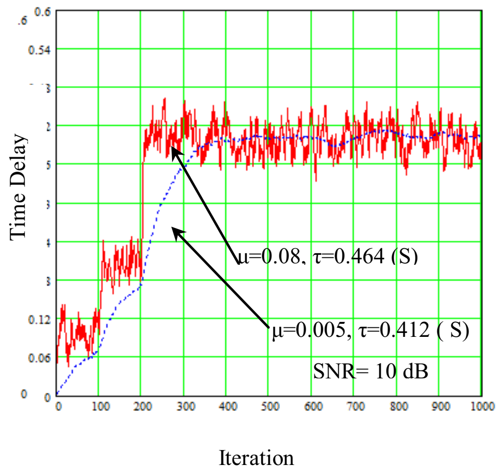

Fig. 7 The Noise and Convergence Effect on Tracking

D. Attenuation Effect on Tracking

The Tracking algorithm is failed when the assumed attenuation with the received signal gives a big difference in the time delay and tracking as shown in Fig. 8.

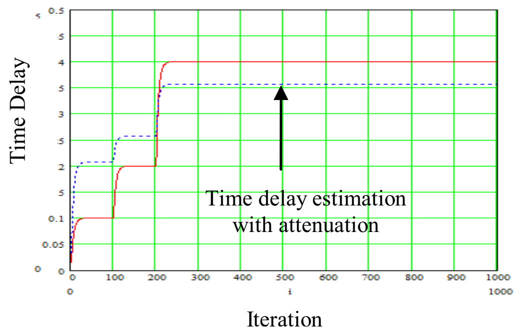

Fig. 8 Attenuation Effect on Tracking

IV. Conclusion

As conclusion of this work, the tracking time delay can be determined by using Mathcad program. The algorithm has a good-resolution time delay and efficient tracking capability that is illustrated in Fig. 4. The noise effect on the algorithm can be used to estimate the time delay and tracks the target successfully. The output of the algorithm can be controlled by changing the value of μ as shown in Fig. 6 and Fig. 7. Regarding the attenuation effect, the algorithm needs to amplify the return signal, to obtain the same amplitude for transmitted signal. If the return signal was not amplified the algorithm would fail to estimate the specific value of the time delay and the tracking.

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