Research Article

Test Verification of Two-Stage Adaptive Delay Compensation Method for Real-Time Hybrid Simulation

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Real-time hybrid simulation (RTHS) is a versatile testing technique for performance evaluation of structures subjected to dynamic excitations. Research revealed that compensation for the delay induced by the dynamics of the loading system and other factors is a critical issue for obtaining reliable test results. Lately, a two-stage adaptive delay compensation (TADC) method was conceived and performed on the benchmark problem of RTHS. For this method, the main part of the system delay is coarsely compensated by the classic polynomial extrapolation (PE) method; the second stage represents a fine remedy for the remaining delay with adaptive compensation based on a discrete model of the loading system. As an extension of this study, this paper aims to further verify and reveal the performance of this method through real tests on a viscous damper specimen. In particular, loading tests with a swept signal and RTHS with sinusoidal and seismic excitations were carried out. Investigations show that the TADC method is endowed with smaller parameter variation ranges, simple yet effective initialization or a soft-start process, less dependence on initial parameter estimation accuracy, and best compensation performance.

1. Introduction

Real-time hybrid simulation (RTHS) [1–4] is a versatile testing technique developed in the past three decades for performance evaluation of structures subjected to earthquake, wind, or other dynamic excitations. This technique divides the emulated structure into the numerical substructure (NS) and experimental substructure (ES), and a transfer system, that is, loading systems of actuators and/or shaking tables, is employed to ensure the deformation compatibility and force equilibrium at the interface between the two substructures [4–7]. Research reveals that loading phase errors–time delay–cause unreliable test results and even render the test instability [8].

In order to accurately reproduce the boundary conditions, numerous efforts have been paid and great progress has been made. To be specific, a polynomial extrapolation

(PE) method based on a constant delay assumption was proposed and improved [8–11]; various adaptive strategies for compensating variable delay have been conceived based on online delay estimation [10, 12, 13], synchronization error [14–16], adaptive inverse control [17–19], updated discrete models of the testing system [20, 21], and other techniques [22–24]. Additionally, sophisticated control strategies, such as robustness control [25–27] and nonlinear control [28, 29], have also drawn considerable attention in recent years for addressing displacement tracking and delay compensation problems.

For the purpose of realizing high-performance compensation, a two-stage adaptive delay compensation (TADC) method was recently developed and performed on the Benchmark problem of RTHS [30]. In the first stage of this method, the main part of the system delay is coarsely compensated by means of the classic polynomial extrapolation

(PE) method; the second stage represents a fine remedy for the remaining delay with adaptive compensation based on a discrete model of the loading system. Virtual RTHS showed the superiority of the TADC method. As an extension of this study, this paper aims to further verify and reveal the performance of this method through real loading tests and RTHS on a viscous damper specimen.

2. An Overview of Two-Stage Adaptive Delay Compensation (TADC) Method

In order to realize high performance for delay compensation in RTHS, a novel compensation strategy called a two-stage adaptive delay compensation (TADC) method was conceived and performed [30] with the benchmark problem of RTHS [31]. This method consists of two stages, as shown in Figure 1. In the first stage, a polynomial extrapolation (PE) compensation method is used to coarsely compensate the system delay, whereas in the second stage, an adaptive delay compensation based on a discrete loading system model [21] is employed to finely compensate the remaining time delay.

The conventional PE method is to establish a polynomial model based on structural displacements of the substructure interface at current and previous steps and then to predict the displacement response after a time delay. This predicted displacement is sent to the actuator controller at the current moment. Given the assumption that the loading system delay is constant, the predicted displacement is achieved after the time delay, which means this displacement is imposed on the specimen at the right instant; that is, the system delay is compensated. As an example, the TADC method adopts the second-order PE for the first stage, which can be expressed as

$$y_{c,i} = \left(1 + \frac{3}{2}\eta + \frac{1}{2}\eta^2\right)y_{ac,i} - (2\eta + \eta^2)y_{ac,i-1} + \left(\frac{1}{2}\eta + \frac{1}{2}\eta^2\right)y_{ac,i-2}, \quad (1)$$

in which y_c and y_{ac} are the output displacements of the first and second stage in the TADC method (refer to Figure 1), respectively, i represents the time step, and η is a constant value calculated by

$$\eta = \frac{\tau}{\Delta t}, \quad (2)$$

where Δt is the time interval between two adjacent displacement points and τ is the estimated system delay. It is worth mentioning that the size of Δt is often chosen at the same level as the system delay [30].

The PE method exhibits satisfactory compensation performance, provided the constant delay assumption is met. However, the loading system delay often varies owing to the nonlinearities of the loading system and the specimen behavior and other reasons. Additionally, not only time delay but also the amplitude errors of the loading system have to be tackled to obtain accurate and reliable test results. Therefore, an adaptive method based on discrete loading system models is adopted to compensate for the residual time delay and amplitude errors. A three-parameter difference equation

model is employed to simulate the loading system compensated by the PE method; namely,

$$y_{ac,i} = \theta_{a1}y_{m,i} + \theta_{a2}y_{m,i-1} + \theta_{a3}y_{m,i-2}, \quad (3)$$

where y_m is the measured displacement of the loading system and θ_a are the model parameters. This model is utilized to identify the system parameters in conjunction with the displacement data. Subsequently, the command is generated using the identified model; namely,

$$y_{ac,i} = \hat{\theta}_{a1}y_{a,i} + \hat{\theta}_{a2}y_{a,i-1} + \hat{\theta}_{a3}y_{a,i-2}, \quad (4)$$

where y_a is the desired displacement of the loading system and $\hat{\theta}_a$ are the estimated model parameters. The recursive least square method with a forgetting factor is employed to online estimate the parameters. This algorithm features small amount of calculation and fast speed, which can effectively overcome the data-saturation issue. The algorithm expression is

$$\hat{\theta}_i = \hat{\theta}_{i-1} + \frac{\mathbf{P}_{i-1}\psi_i}{\rho + \psi_i^T \mathbf{P}_{i-1} \psi_i} [y_{ac,i} - \psi_i^T \hat{\theta}_{i-1}], \quad (5)$$

$$\mathbf{P}_i = \frac{1}{\rho} \left[\mathbf{I} - \frac{\mathbf{P}_{i-1}\psi_i\psi_i^T}{\rho + \psi_i^T \mathbf{P}_{i-1} \psi_i} \right] \mathbf{P}_{i-1}, \quad (6)$$

$$\psi_i = [y_{m,i} \ y_{m,i-1} \ y_{m,i-2}]^T, \quad (7)$$

in which ρ is the forgetting factor satisfying $0.9 \leq \rho \leq 1$. The larger the forgetting factor ρ is, the greater effect the previous data have on the current estimated parameters. When $\rho = 1$, the algorithm degenerates to the recursive least-squares method. $\mathbf{P}$ is a covariance matrix, while $\mathbf{I}$ denotes an identity matrix.

The parameters $\hat{\theta}_i$ and $\mathbf{P}_i$ in (5) need to be initialization before RTHS. Assuming that the PE method in the first stage can achieve the ideal situation, that is, the time delay is fully compensated, the initial value of the parameters in the second stage can be taken as $[1; 0; 0]$, which results in $y_{ac,i}$ equal to $y_{a,i}$ according to (4). As for the initial covariance matrix, one identity matrix times a value between 100 and 1000 is usually employed. Additionally, a soft start of this identification process can also be designed by initializing the parameters through loading prescribed desired displacements to the testing system prior to final RTHS.

3. Test Verification of the TADC Method

3.1. Testing System. This study carried out RTHS with a damper specimen using the MTS-dSpace Testing system at the Structure and Seismic Experiment Center of Harbin Institute of Technology. As schematically shown in Figure 2, this testing system consists of a dSpace 1103 board and an MTS loading system. The actuator of this loading system is characterized in a capacity of ± 100 kN and a piston stroke of 254 mm. The dSpace system is responsible for the evaluation of the structural response and implementation of delay compensation methods, whereas the MTS loading system is in charge of imposing the command displacement to the specimen and measuring the actual displacement and

FIGURE 1: Schematic of the two-stage adaptive delay compensation method.

FIGURE 2: Schematic of the testing system for RTHS.

damping force. Note that the communication between the dSpace and MTS is achieved by digital-analog conversion and resampling. The viscous damper is characterized by a maximum length of 830 mm and a stroke of 256 mm. To further reveal damper properties, the relationship between the damping force and its displacement under sinusoidal excitation is depicted in Figure 3. Clearly, It can be seen in Figure 3, the damper exhibits a stiffness, indicating a combination of a viscous damper and spring.

3.2. Structural Model. The emulated structure is a three-story frame installed with a viscous damper. The mass and interstory stiffness of each story are assumed as 2×10^4 kg and 4×10^7 N/m, respectively. These parameters result in the structural natural frequencies of 3.17 Hz, 8.88 Hz, and 12.8 Hz. The Rayleigh damping model is adopted with the first two modal damping ratios of 2%; and hence, the structural damping matrix is expressed as

$$C = \begin{bmatrix} 4.7302 & -2.3486 & 0 \\ -2.3486 & 4.7302 & -2.3486 \\ 0 & -2.3486 & 2.3816 \end{bmatrix} \times 10^4 \text{ N} \cdot \text{s/m}. \quad (8)$$

The viscous damper is installed in the first story and tested physically as ES. The remaining part of the structure is numerically simulated on the dSpace board with a time interval of 1/1024 s.

3.3. Offline Estimation of the System Delay. Prior to verification tests of the TADC method, a preliminary test was carried out to estimate the time delay of the testing system using a sinusoidal signal with a frequency of 2 Hz and an amplitude of 4 mm. The displacement time histories are depicted in Figure 4. From Figure 4(b), one can see that the

system delay is smaller than 15 ms. In order to accurately evaluate the system delay, the index J_1 expressed as

$$J_1 = \arg \max_k \left[\sum_i y_a(i) y_m(i-k) \right], \quad (9)$$

was calculated, and the system delay was found to be 13.7 ms in this case.

3.4. Loading Test with a Swept Signal. In this subsection, a swept signal with a start frequency of 0.1 Hz, a stop frequency of 10 Hz, and an amplitude of 1 mm was imposed on the specimen using the loading system. The command and the measured actuator displacement are plotted in Figure 5. It can be seen from this figure that, with the increase of the loading frequency, the measured displacement appears to decay. The average delay evaluated by means of the index J_1 using data of the last one second is 15.6 ms, indicating an increase of 1.9 ms compared with that in the sinusoidal command test. This delay variation is attributed to the flow nonlinearity of the hydraulic servo systems and uncertainties of the loading system, and it implies the necessity of adaptive delay compensation.

Subsequently, this signal was imposed on the specimen as a desired displacement with the system delay compensated by three schemes, namely, the traditional PE method, single-stage adaptive delay compensation (SADC) method, and the TADC method. For the PE method, the measured delay of 13.7 ms was set for compensation. The initial value of the parameter of the SADC method is calculated by the recursive least square method with a forgetting factor, which is [3.187; 0.428; -2.660]. The initial value of the parameter is [1, 0, 0] for the TADC method. The forgetting factors for both adaptive compensation methods are all taken as $\rho = 0.9996$, and the covariance is 1000 times an identity matrix with a size of 3×3 .

FIGURE 3: Relationship between damping force and displacement.

Obtained displacements with different compensation methods are illustrated in Figure 6. It can be seen that the PE method results in large amplitude errors and slight phase errors between the desired and measured displacements, whereas the two adaptive methods exhibit good compensation performance. Actually, the PE method often amplifies the amplitude of high-frequency signals; and hence, it is not suitable for compensation of relatively high-frequency signals. From Figure 6(a), one can summarize that the PE method is only suitable for signal compensation with a frequency of less than 6 Hz (corresponding to 30 s). Additionally, the two adaptive methods slightly amplify the command amplitudes to interact with the response decay owing to the testing system and finally provides satisfactory compensation accuracy, as shown in Figures 6(d) and 6(f). A careful comparison shows that the measured displacement provided by the TADC method matches the desired one better than that provided by the SADC method.

Figure 7 illustrates a comparison of measured displacements with different delay compensation methods. Figure 7(a) shows the large amplitude of the PE method at the earlier phase of the test, while Figures 7(b) and 7(d) depict two close-up views of displacement peaks to clearly reflect compensation performance. Figure 7(c) plots zero-displacement points at the later test phase to demonstrate phase errors, that is, residual delays. The method which provides measured displacements in better agreement with the desired one exhibits better compensation performance. It can be seen that the PE method shows a significant displacement amplitude and phase errors at the later phase of the test and comparative amplitude errors at the earlier test phase. Figures 7(b)–7(d) show outstanding agreement between the desired displacement and the measured displacement obtained with the TADC method. In summary, in terms of tracking accuracy, the TADC method is superior to the other two methods and the PE method performs the worst.

Figure 8 demonstrates the time histories of the estimated parameters. In the tests, parameter updating started at about 0.5 s. As can be seen in the figure, the variation ranges of the parameters of the SADC method are large, reaching about 6,

whereas the TADC method has a maximum parameter variation range of 3. That is to say, the parameter variation for the TADC method is smaller, indicating that the difficulty in identifying them is decreased and hence more satisfactory compensation performance is expected. Smaller parameter variation indicates that the parameters are closer to constants, and that it is easier to identify these nearly constant parameters. Note that estimated parameter variation does not necessarily mean property change of the loading system. The three-parameter model for the loading system might insufficiently simulate all dynamics of the loading system, that is, insignificant dynamics unmodeled. Owing to the unmodeled dynamics, even though the system parameters are constant, the estimated parameter can vary to fit different groups of the displacement data. Notably, the parameters of the TADC method were initialized by $[1 \ 0 \ 0]$, which means that the TADC method depends less on its initial parameters and that it is considerably easy to set these parameters.

In order to quantitatively compare compensation performance, two indexes for evaluating the tracking performance are employed, defined as (Silva et al. [31])

$$J_2 = \sqrt{\frac{\sum_{i=1}^N [y_m(i) - y_a(i)]^2}{\sum_{i=1}^N (y_a(i))^2}} \times 100\%, \quad (10)$$

$$J_3 = \frac{\max |y_m(i) - y_a(i)|}{\max |y_a(i)|} \times 100\%, \quad (11)$$

where y_m and y_a represent the measured and desired displacements, respectively; N is the total number of data points. Clearly, J_2 is the normalized root mean square (RMS) of the tracking error of a compensator, representing the difference between y_m and y_a . J_3 is the peak tracking error, namely, the normalized maximum synchronization error between the measured and desired displacements. The evaluation indexes of the three compensation methods are collected in Table 1. For both J_2 and J_3 , the TADC method is superior to the other two methods, and the PE method

FIGURE 4: Time histories of command and measured displacements for offline delay estimation. (a) Global view. (b) Close-up view.

FIGURE 5: Time histories of commanded and measured swept displacements. (a) Global view. (b) Close-up view.

performs the worst. Note that the indexes are improved by the TADC method compared with the SADC method by 22.22% $(=(2.61 - 2.03)/2.61)$ and 36.04% $(=(5.91 - 3.78)/5.91)$, respectively. These results reveal the efficacy of the TADC method.

3.5. RTHS with Sinusoidal Excitation. In this subsection, a series of RTHS with different compensation methods were performed on the three-story frame structure excited by a sinusoidal signal with a frequency of 3 Hz and an amplitude of 5×10^4 N. The offline estimated delay, that is, 13.7 ms, was first compensated by the PE method. The SADC method was employed as well to compensate for the system time delay. The forgetting factor ρ was set as 0.9996, and the initial

covariance matrix P was defined as the identity matrix multiplied by 1000. In order to softly start the algorithm, a sinusoidal signal with varying amplitudes and a frequency of 3 Hz was imposed as a prescribed desired displacement. This soft start process led to the initial parameter values of $[3.1648; -1.6895; -0.54155]$. The TADC method was used to carry out RTHS. In the first stage, a PE method was used to roughly compensate the system time delay of 13.7 ms. In the second stage, adaptive control was employed to finely compensate for the residual time delay. The initial covariance values and forgetting factors were the same as those for the SADC method. The initial values of the parameters provided by the soft start process were $[1.3317-0.57548 \ 0.23305]$. The approximation of these values to $[1 \ 0 \ 0]$ validated the possibility of initializing the parameters with $[1 \ 0 \ 0]$.

FIGURE 6: Displacement time histories with swept loading target. (a) Displacements obtained with the PE method. (b) Enlarged view of (a). (c) Displacements obtained with the SADC method. (d) Enlarged view of (c). (e) Displacements obtained with the TADC method. (f) Enlarged view of (e).

FIGURE 7: Comparison of measured displacements with different compensation methods. (a) Global view. (b) Close-up view of the earlier phase. (c) Close-up view of zero-displacement points of the later phase. (d) Close-up view of one peak of the later phase.

The obtained displacement time histories are shown in Figure 9. Although global views are very similar to each other, enlarged views show different tracking performance. From Figure 9(b), it can be seen that the measured displacement (dash-dot line) and the desired displacement (solid line) obtained with the PE method are not in good agreement, especially at the peaks. This can be attributed to the prediction amplitude error of the PE method and the response amplitude error of the loading system. By comparing Figures 9(d) and 9(f) with 9(b), one can conclude that both adaptive methods are superior to the PE method owing to smaller synchronization errors. This is because the adaptive strategies can compensate not only the phase error but also the amplitude error and can accommodate properties variation and uncertainties.

From the time histories of the estimated parameters shown in Figure 10, the parameters of the TADC method have much smaller absolute values compared with the corresponding parameters of the SADC method. This is because the SADC method is to compensate for the whole delay of the loading system, whereas the second stage of the TADC method is to deal with the residual delay of the loading system compensated by the first stage, that is, the PE method. These results indicate that the coarse compensation based on the PE

method effectively reduces the parameter variation and facilitates the parameter identification. In fact, this is the reason why the TADC method performs better. Actually, stable estimated parameters often mean more satisfactory compensation performance. As shown in Figure 11, the TADC method provides results with smaller errors than the SADC method. This also implies that the TADC method shows less dependence on the initial parameter values, namely, more robust than the SADC method.

In order to more intuitively evaluate the performance of the compensation methods, J_2 and J_3 in (10) and (11) are calculated and presented in Table 2. Obviously, RTHS with the three methods under the excitation of a 3 Hz sinusoidal signal show good compensation effects. Comparatively speaking, the TADC method exhibits the best compensation accuracy. As the excitation is very regular, compensation for the delay is less complicated; even so, the TADC method is endowed with good robustness and good accuracy.

3.6. Real-Time Hybrid Simulation with Seismic Excitation. In this subsection, RTHS with seismic excitation was conducted to examine the performance of different

FIGURE 8: Time histories of estimated parameters with swept loading target. (a) The SADC method. (b) The TADC method.

TABLE 1: Evaluation indexes of 10 Hz swept signal loading.

Compensation method	J_2 (%)	J_3 (%)
The PE method	7.93	21.85
The SADC method	2.61	5.91
The TADC method	2.03	3.78

compensation methods. In particular, the El Centro (1940, NS) earthquake record was adopted to excite the structure with a peak ground acceleration of 783.7 Gal. The three aforementioned compensation methods were carried out herein with the same parameters and settings as those in the previous subsection. The model parameters of the two adaptive methods were initialized with the soft start scheme, yielding $[4.6278; -4.4702; 0.78133]$ and $[1.0771; 0.081833; -0.17691]$, respectively. Obviously, the latter one is very close to the common initial parameters, namely, $[1 \ 0 \ 0]$, and this validates the rationality of this initialization. RTHS of a multiple DOF structure was implemented because they were more challenging than previous tests owing to multiple-frequency-content structural responses and randomness of the seismic excitation.

The displacement time histories obtained with the three delay compensation methods are shown in Figure 12. It can be seen from Figure 12(b) that the error of the PE method is relatively large, especially up to 0.67 mm at 2.47 s. When the velocity approaches zero at the displacement peaks, the method predicts displacement responses based on the trends of several past steps, thereby causing errors in the displacement command. Compared with the PE method, the SADC method induces smaller peak errors, as shown in Figure 12(d). This is attributed to its online updated discrete model of the loading system, which can effectively capture the variation of the system characteristics and adjust actuator commands accordingly. In Figure 12(f), the desired displacement and measured displacement match very well

with the TADC method even at displacement peaks. This result shows that this RTHS of multiple degree-of-freedom structures subjected to an earthquake can be remarkably compensated by the TADC method.

Figure 13 shows the parameter evolutions of adaptive compensation methods. Through comparison, it can be found that the parameter variation ranges of the SADC method are much wider with a maximum value of about 9. Conversely, owing to the contribution of its first-stage compensation, that is, the coarse compensation based on the PE method, the parameters of the TADC method vary in very small ranges. This is because the delay compensated by the second stage of the TADC method, that is, the adaptive compensation method, is indeed the residual time delay of the first-stage compensation. As shown in this figure, the parameters with the TADC method are very close to constant ones, and the identification of these values is easy and accurate. Consequently, there is no doubt that the TADC method possesses favorable performance.

Subspace plots of the measured and desired displacements of the actuator are illustrated in Figure 14. It can be seen from the figure that the PE method has the worst compensation effect, which is attributed to the varying time delay and influence of multiple frequency contents of the desired displacement. The SADC method can realize better performance owing to its continuously updated system model, which can effectively capture the varying characteristics of the loading system and can compensate both the amplitude and phase errors. The TADC method performs the best because of its unique features such as coarse and fine compensation.

Evaluation indexes are calculated and collected in Table 3. As can be seen from this table, the TADC method provides results with the smallest J_2 and J_3 and hence is superior to the other two methods. This is consistent with the conclusion presented in Figures 12(b) and 12(c). Generally, index values in this scenario are larger than those in

FIGURE 9: Displacement time histories obtained in RTHS with sinusoidal excitation. (a) Displacements obtained with the PE method. (b) Enlarged view of (a). (c) Displacements obtained with the SADC method. (d) Enlarged view of (c). (e) Displacements obtained with the TADC method. (f) Enlarged view of (e).

FIGURE 10: Time histories of estimated parameters with sinusoidal excitation. (a) The SADC method. (b) The TADC method.

FIGURE 11: Time histories of displacements at the beginning of tests. (a) The SADC method. (b) The TADC method.

TABLE 2: RTHS evaluation index with 3 Hz sine signal excitation.

Method of compensation	J_2 (%)	J_3 (%)
The PE method	1.84	2.61
The SADC method	1.41	2.49
The TADC method	0.65	1.21

Subsection 3.5 and smaller than those in Subsection 3.4. That is to say, the RTHS with the sinusoidal excitation is the easiest one because of its regular input, compensation for the swept loading test is the most challenging one for its large frequency width of the desired displacement, and compensation for RTHS with seismic excitation has a medium difficulty level

owing to its random earthquake input. Among the three tests, the TADC method is consistently endowed with the best indexes, indicating the superiority of this method. One may argue that the improvement of this strategy is limited. Actually, the SADC method performs relatively well and any improvement is considerably difficult. Moreover, in this

FIGURE 12: Displacement time histories obtained in RTHS with seismic excitation. (a) Displacements obtained with the PE method. (b) Enlarged view of (a). (c) Displacements obtained with the SADC method. (e) Displacements obtained with the TADC method. (f) Enlarged view of (e).

FIGURE 13: Estimated parameters in RTHS with seismic excitation. (a) The SADC method. (b) The ADC method.

FIGURE 14: Desired-measured displacement plots with seismic excitation. (a) The PE method. (b) The SADC method. (c) The TADC method.

TABLE 3: Evaluation indexes of RTHS with seismic excitation.

Compensation method	J_2 (%)	J_3 (%)
The PE method	5.17	8.46
The SADC method	4.65	6.17
The TADC method	2.89	4.08

scenario, J_2 and J_3 are improved by 37.8% $[(4.65 - 2.89)/4.65]$ and 33.9% $[(6.17 - 4.08)/6.17]$ compared with the SADC method, respectively, indicating substantial improvement.

4. Conclusions

This study carried out a series of verification tests of a two-stage adaptive delay compensation (TADC) method for real-time hybrid simulation, in conjunction with the comparison with the polynomial extrapolation (PE) method and traditional single-stage adaptive delay compensation (SADC)

method. These include loading tests with a prescribed swept signal as the desired displacement, RTHS with a sinusoidal excitation, and RTHS with a seismic excitation. From this investigation, the conclusions can be drawn as follows:

- (1) The estimated parameters of the TADC method vary in smaller ranges than those of the SADC method owing to the first-stage compensation method, which reduces the difficulty in parameter estimation and hence results in better compensation performance.
- (2) The model parameters of the TADC method can be initialized either as $[1 \ 0 \ 0]$ or through a soft-start process. The first-stage compensation of the TADC method reduces the dependence of the performance on the parameter estimation accuracy, especially at the beginning of a test where the parameters vary apparently. The compensation accuracy benefits from this feature.

- (3) The TADC method exhibits the best tracking accuracy to the desired displacements among the three compensation methods owing to its features.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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