MIMO SYSTEM IDENTIFICATION OF INDUSTRIAL BUILDING USING N4SID WITH AMBIENT VIBRATION

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ABSTRACT
The engineering buildings are industrial buildings that have high construction costs and are difficult to construct. In addition, these industrial buildings must be in safe condition both in terms of production contributions and the health of employees and should be under constant supervision. It is known that both economic and life losses in such structures will be higher. These structures constantly vibrate under internal and external loads and deform. Temperature changes and material fatigue as internal forces, wind loads as external forces, traffic loads, moving loads of machinery and equipment and earthquakes have negative effects on industrial buildings. For all these reasons, mathematical model should be put forward experimentally and in place by making system definition in industrial buildings. In this study, industrial building was used. In this study, Multi input- multi output (MIMO) system identification method was used. Results demonstrated that N4SID multi input-multi output (MIMO) system identification method is efficient and accurate in identifying modal data of the industrial buildings.

KEYWORDS: N4SID, System Identification, Numerical Algorithms, Industrial Buildings, MIMO

INTRODUCTION
Most of structures located in regions prone to earthquake hazards suffer from various types of destruction caused by seismic loads. Under such earthquake occurring, the parts (especially the columns) of building structures suffer damage. Looking on the other side, especially considering the performance of such buildings under seismic occurrence, there is a great need to strengthen the columns even without changing their building masses; this clearly shows that there is a need to investigate the connection between technical repairing or strengthening procedures and the column capacity. In this understanding, more researches are being conducted to get required performance of structures under seismic loading, by means of looking at different point of view and directions. (Tuhta S.,Gunday F.,Aydın H.,2019).

In recent years, one of the reasons for increasing the importance of observing the health of the building civil engineering, scientific research circles; Which damage can be identified first? How long is the usable life of the building? to develop methods to answer questions such as. These studies are increasing. This issue is given importance due to factors such as the health of the structure against natural and artificial influences and its economic longevity. In all construction systems, damage starts at the material level. As the damage in the system increases, it reaches a value defined as deterioration. Civil engineering structures are exposed to a variety of natural and artificial effects throughout their lifetime. These effects are the forces that can affect the dynamic characteristics of the structure and thus the service life.

Stable adaptive controller designs have been one of the most important research topics in recent years as they can produce effective solutions against time-varying system parameters and disturbing effects in the desired system output monitoring problem.

System identification methods are used to determine the modal parameters of the system. These dynamic parameters in structural engineering, bridges, buildings and so on. it helps to understand the dynamic behavior of other structures. Modal system identification is used to check the reliability of structural structure under sudden and dynamic loads such as earthquake, storm and explosion.

Choosing the right model grade is an important step in system identification. If the degree of the model is too high, unreal modes will be able to produce results. Modal parameters may not be obtained when the model degree is selected too small.

Based on the information to be obtained from the examination of the characteristics of the data at the determination stage, the appropriate ones are selected from the general models. In other words, the inputs and outputs received from the system are examined and the model which is suitable for the system examined is investigated. Once the appropriate model is decided temporarily, the order of determination of the order of this selected model is reached.

Depending on the input and output sizes of these systems, In order to obtain a behavioral model, it is necessary to determine and measure the magnitudes affecting the structures.Model identification, system-related, based on physical laws based on the preliminary information and the size of the system (introduction magnitude or input signal) from the system's response to these magnitudes (output magnitude or output signal) It is exploited. Physical laws are defined by differential or algebraic equations. In this way model, not only the relationship between the input and output sizes, but also by determining the model structure are expressed. On the other hand, the lack of any preliminary information about the system or the system is too complex. In case of having, identification methods (such as parametric definition) are used in determining the model of the system. In this case, the model is obtained by using input and output sizes. This technique can be applied by making some preliminary assumptions regarding the choice of system grade, input and output sizes.

Especially in control engineering, it can be summarized as a mathematical model of a dynamic system by using experimental data, or it can be said that the dynamic behavior of the system is given by a mathematical model based on time and frequency. System identification models are divided into 3 different groups. These are White-box model, Grey-box model, Black-box model.

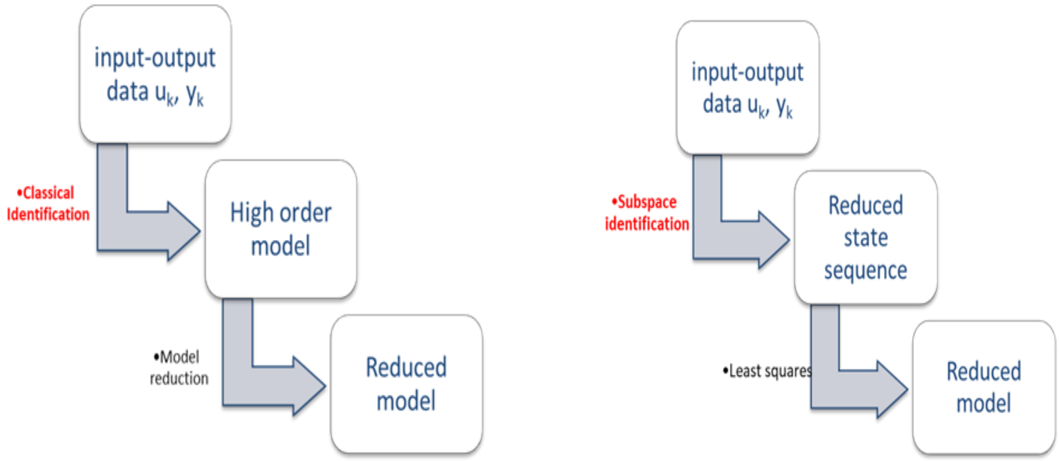

Figure 1. System İdentification with Classical Identification and Subspace Identification

In some cases, there is insufficient preliminary information to calculate all parameters of the process. That's why identification techniques are needed to find appropriate values. The parameter values of a model are input and It can be determined by measuring the output signals. This technique is based on the selection of system grade, input and output signals. Some preliminary assumptions. To obtain information about the system in this way induction is called.

System theory, system description, mathematical-physical transfer function of a dynamic system representation. Many different types of transfer functions model are defined. Such models are examined in both time and frequency domain. From Time Zone the transition to the frequency domain is realized by Fourier transform.

Another widely used method for defining systems is time series. With time series the expected value of the system and the autocorrelation function can be determined. In addition, modeling of time series and forward-looking forecasts of the system can be made. An effect-response the cross-correlation process can also be used to determine whether the response of the system is delayed according to the effect. So, if the effect size caused a reaction, no delay occurs in the system. If one if there is no change, a delay occurs in the system.

DESCRIPTION OF INDUSTRIAL BUILDING

The building is 8.5 m in height from the ground level. Story height is 8 m appropriately. All slabs are two-way waffle slabs. Total area of slabs are 108 m x 54 m = 5832 m2 in area. Construction of the building began in the fall of 2003 and was completed (retrofitted) during the winter of 2005. Picture and a typical floor plan of the building are shown in (Fig.2 a, b, c).

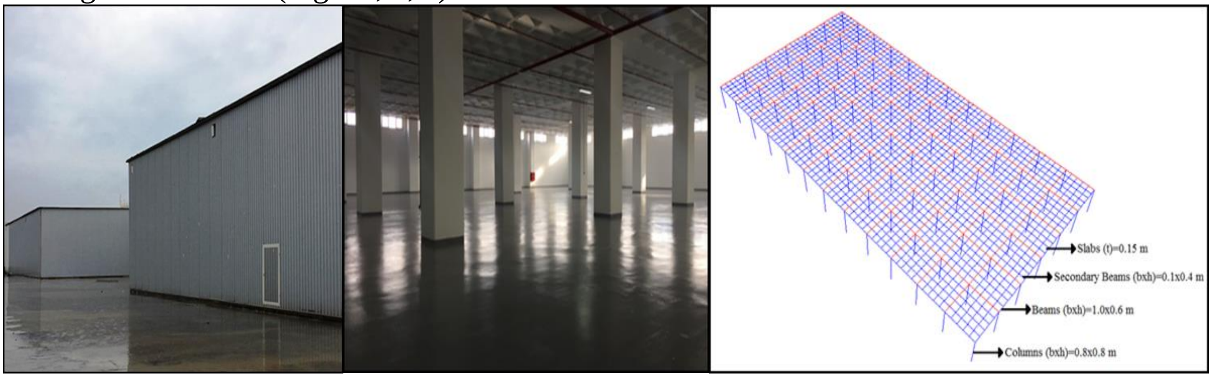

Figure 2a, b, c. Pictures and dimensions of the industrial building

Story dimensions of Industrial building are six bay (x direction) and twelve bay (y direction). Both bay are 9 m. Concrete C16 f_{ck}=16 MPa and steel S220 f_{yk}=220 MPa are respectively used. The building was designed accordance with Turkish reinforced concrete design standard TS-500 and design loads for buildings TS-498.

N4SID RESULTS

If After analyzing the data in MATLAP using N4SID with multi input – multi output (MIMO) method the following results are summaries in figures 2- 14.

They were examined respectively; İnput and Output Signals, Model Outputs, A, B, C, D and K matrices, Fit to estimation data, Transient Responses, Frequency Functions, Poles and Zeros, Noise Spectrums

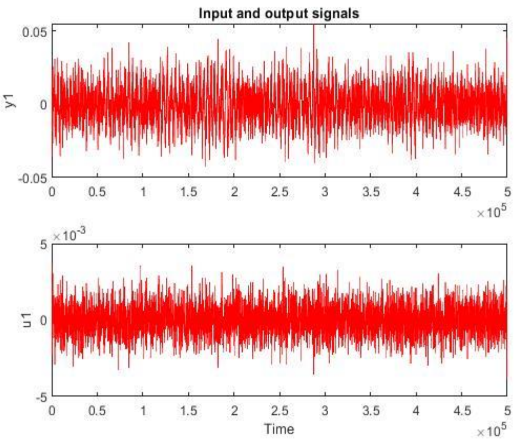

Figure 3. İnput and Output Signals u1->y1

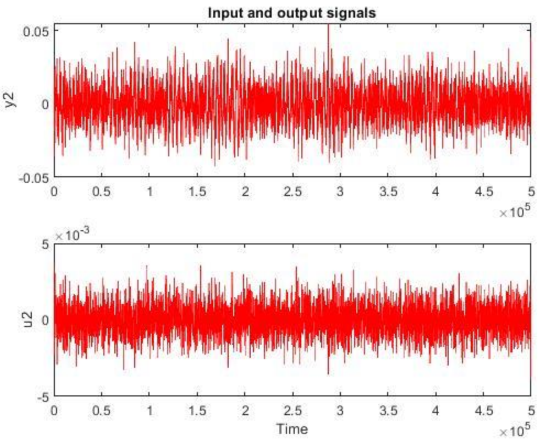

Figure 4. İnput and Output Signals u2->y2

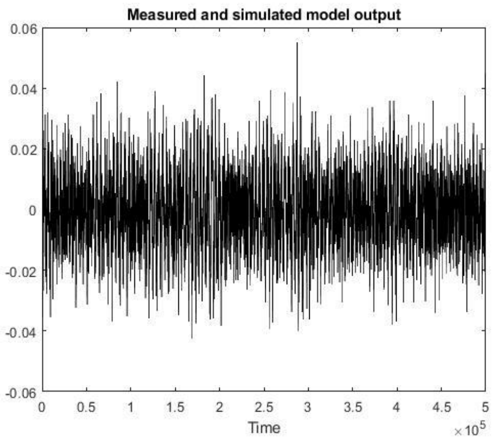

Figure 5. Model Output y1

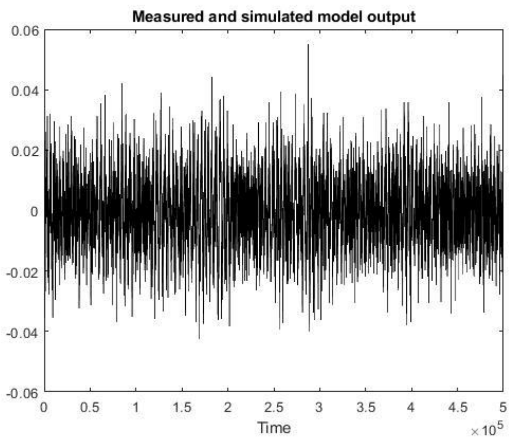

Figure 6. Model Output y2

Fit to estimation data 99.79%
A, B, C, D and K matrices are given below;

$$A=\begin{matrix} 0.989 & -0.142 & -0.000189 & 9.31e-05 \\ 0.147 & 0.975 & -0.0006 & 0.0002 \\ 0.0004 & 0.009 & 0.563 & -1.405 \\ -0.003 & 0.008 & 0.283 & 0.546 \end{matrix}$$

$$B=\begin{matrix} 0.225 & 0.225 \\ -1.252 & -1.252 \\ 0.374 & 0.374 \\ 0.313 & 0.313 \end{matrix}$$

$$C=\begin{matrix} 0.576 & -0.038 & 0.0001 & 5.45e-05 \\ 0.576 & -0.038 & 0.0001 & 5.45e-05 \end{matrix}$$

$$D=\begin{matrix} -4.9448 & -4.9448 \\ -4.9447 & -4.9447 \end{matrix}$$

$$K=[0]_{4X2}$$

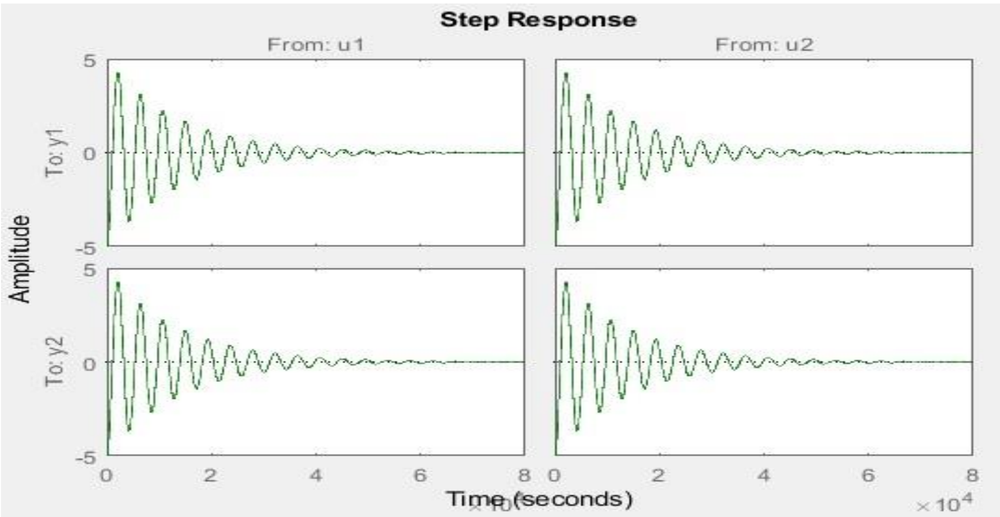

Figure 7. Transient Responses

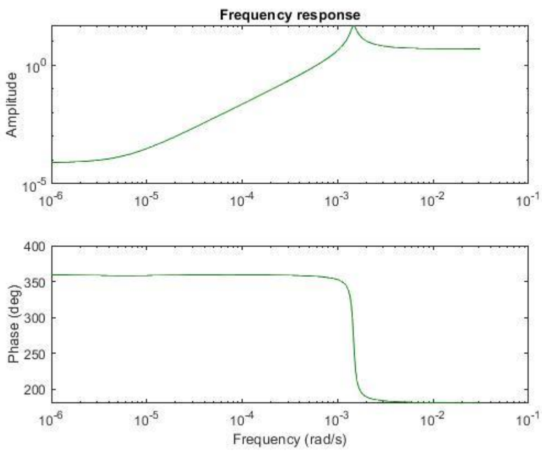

Figure 8. Frequency Function u1->y1

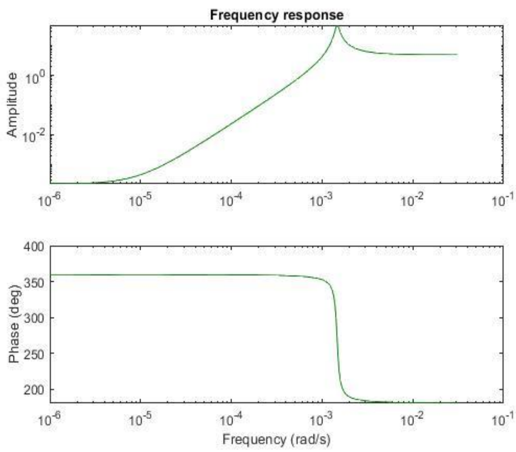

Figure 9. Frequency Function u2->y2

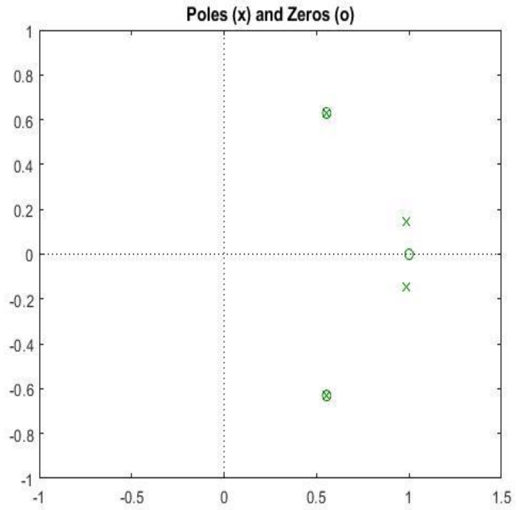

Figure 10. Poles and Zeros u1->y1

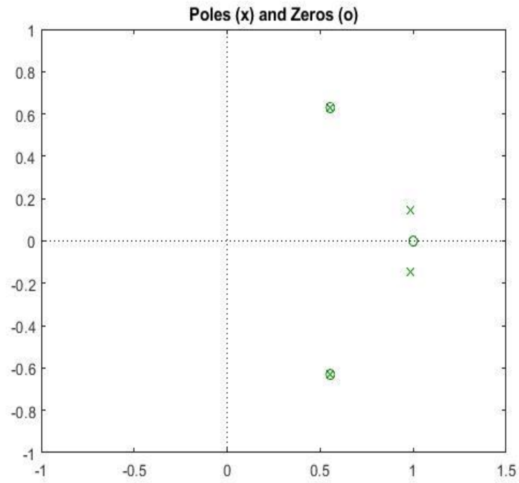

Figure 11. Poles and Zeros u2->y2

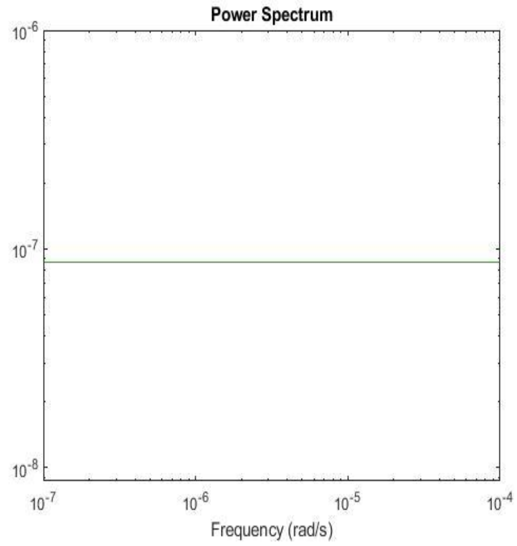

Figure 12. Noise Spectrum y1

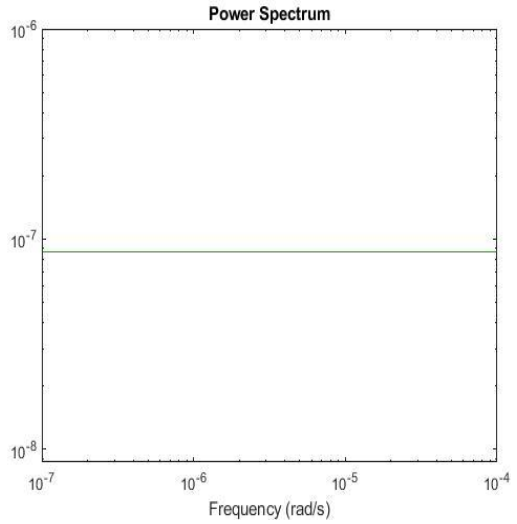

Figure 13. Noise Spectrum y2

CONCLUSIONS

In this paper reviews the theoretical principles of subspace system identification as applied to the problem of estimating black-box state-space models of support-excited structures (e.g., structures exposed to earthquakes). The work distinguishes itself from past studies by providing readers with a powerful geometric interpretation of subspace operations that relates directly to theoretical structural dynamics.

To validate the performance of subspace system identification, a series of experiments are conducted on a industrial building exposed to moderate seismic ground motions; structural response data is used off-line to estimate black-box state-space models. Ground motions and structural response measurements are used by the subspace system identification method to derive a complete multi input – multi output state-space model of the industrial building system. The modal parameters of the industrial building are extracted from the estimated multi input – multi output state-space model. With the use of only structural response data, output-only state-space models of the system are also estimated by subspace system identification.

In this paper, a new structural identification tool is proposed to identify the modal properties of industrial buildings. Results demonstrated that fit to estimation data was 99.79% and it can be concluded that N4SID multi input – multi output (MIMO) system identification method is efficient and accurate in identifying modal data of industrial buildings.

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