# Model updating from results found by Stochastic system identification (SSI) from vibration data

## Introduction

This code conducts model updating based on the sensitivity approach with modal features extracted by system identification method from vibration measurements. In the subroutine, "*main()*", the user must provide input and execute the code. The inputs, used from the system identification method, are loaded through a *json* file: ‘*sys.json’*. The output of the code is stored in ‘*modUpd.json’* containing the updated mass, damping, and stiffness matrices along with information on the output DOF and the modes used in the model updating.

The user must, in the command window, specify the modes to use in the updating during the run of the code. This can be based on a figure showing the modal assurance criterion (MAC) values and the modal complexity factors (MCFs) that will appear during the run. The reference figure for MAC and MCF will be as follow:

A chart of a graph

Description automatically generated with medium confidence

## Organization of the code

The code is scripted in a single file. The user needs to modify in the subroutine of ‘*main()*’. The code will ask to user to provide the modes number needs to be updated (i.e. *"Choose the physical modes to use for updating (ex.: [1,3,4]): "*) and it will be provided as follows:

A screenshot of a computer

Description automatically generated

Depending on the system, the mass and stiffness matrices need to initialize. Also, there is a provision to declare the expected number of elements in stiffness matrix need to be updated.

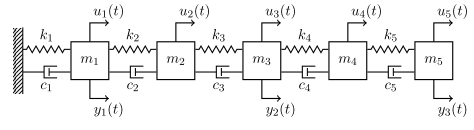
The output will include the modified mass, damping, and stiffness matrices. It will also save information about the number of modes investigated for updating as well as the location of observation. This data will be saved in the output file *'modUpd.json'*. Once completed, it will provide a comparison of eigen-frequencies and MAC values before and after model updates. The results will be shown in the image below:

A comparison of a diagram

Description automatically generated with medium confidence

## Example overview

This application shows a sensitivity-based model updating technique on a 5 degrees of freedom (DOF) spring-dashpot series system. The system is the same as used in the previous example. A repetition is followed for clarity. The system, which is simulated with a sampling frequency of 100 Hz, is subjected to stochastic input, *u(t)*, that has been low-pass-filtered such that it excites the first three eigenmodes of the system. The simulated output, *y(t)*, is composed of accelerations at DOF 1, 3, and 5. During this example, it is considered that the values regarding 1st, 2nd, 4th and 5th stiffness element will be updated.



### Example inputs

The input for this code is taken from system identification methods (provided in the *‘sys.json’* file) i.e. from SSI method and the subjected parameters are :

1. omegas: eigen-frequencies,
2. zetas: damping ratios,
3. Phis: mode shapes,
4. FS: sampling frequencies,
5. otype: response type

The initialization of parameters needs to be provided by users and here, it is given as follows:

1. *m = [1]\*5 # initial mass of the model*
2. *k = [1000]\*5 # initial stiffness of the model*
3. *PaR = np.array([1,2,4,5]) # number of parameters will be updated in stiffness matrix*

The code will ask the user to provide the number of modes needed to consider for the model update. For this example, all five modes are chosen, and the input is given as: *[1, 2, 3, 4, 5]*.

### Example outputs

After a successful run, it will produce a figure comparing the eigen-frequencies and MAC values before and after model updating. It will also save the updated system matrices (mass, damping, and stiffness) in the *'modUpd.json'* file. It will save information about the number of modes utilized in model updating as well as the location of the observed response.

## Lifecycle phases

I am not sure about it. I need your help to complete this.

## Run the example

The example is run in python 3.11.7 environment. Please let me know if you need any help regarding this.

### Install

I am not sure about it as well. I need your help to complete this.

### Create

Same. I am not sure about it as well.

### Execute

Same. I am not sure about it as well.

### Clean

Same. I am not sure about it as well.

## References

More information on model updating is available in the following book:

M. I. Friswell, J. E. Mottershead, “Finite Element Model Updating in Structural Dynamics”, 1st Edition, Springer, 1995. ( <https://doi.org/10.1007/978-94-015-8508-8>)

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