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Data Article

Piezoelectric micromanipulator dataset for hysteresis identification

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1. Data description

The dataset is composed of two input/output data pairs. The system is excited with a sine voltage input of (a) 150 V and 1 Hz; and (b) 5 V and 300 Hz. The dataset (b) has been employed for identification in Refs. [1,2]. The goal of measuring both datasets is to evaluate the modelling activity when working...
under different frequencies and amplitudes. Dataset (a) has not been explored thus far in any publications.

The datasets (a) and (b) are provided in two comma separated values (CSV) files. In these files, which can be visualized in any text editor, each line refers to a sampling time instant. Both CSV files are zipped in a single file, which is provided as a supplement to this article. In this zip file, there is also a MATLAB code to plot the data. It is possible to find below a detailed description of both datasets, according to their filename:

(a) **h50us.csv**: this dataset contains 200,001 measurements sampled in time every 50 microseconds. The second, third, and fourth columns are respectively the vector with time, output displacement, and input voltage. The measurements are drifted, so a pre-processing is needed (in the code provided this is already arranged).

(b) **hysteresis_v_150_1hz.csv**: the second dataset has the same file structure with respect to the columns as (a) but measured every 20 milliseconds with 50,001 samples. The sinusoidal signal starts at approximately 3.25 seconds, so the first samples of the dataset should be discarded (in the code provided this is already arranged).

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**Specifications Table**

| Subject            | Control and Systems Engineering |
|--------------------|---------------------------------|
| Specific subject area | System identification and hysteresis modelling |
| Type of data       | Deflection and displacement measurements |
| How data were acquired | Optical sensors |
| Data format        | Raw |
| Parameters for data collection | The piezoelectric actuator was excited using a sine driving voltage. The amplitudes and frequencies tested were 5V and 150 V and 300Hz and 1 Hz, respectively. |
| Description of data collection | The entire test bench constructed to collect data is composed of (a) the piezoelectric actuator, (b) an optical sensor (LK2420 from Keyence company) which is employed to measure the deflection (displacement) of the above actuator and has been tuned to have 10nm resolution and in excess of 5kHz bandwidth, (c) a computer which is used to generate the sine driving voltage and to acquire the measurement from the optical sensor, (d) a dSPACE (type DS1104) acquisition board that serves as digital-to-analogic and as analogic-to-digital converters between the computer and the rest of the physical setup, with sampling period set as 50 μs, and (e) a high voltage amplifier that multiplies by 20 the driving voltage from the computer before sending it to the actuator. |
| Data source location | Institution: ENIT/Toulouse University, University of Toulouse |
| Data accessibility | With the article |
| Related research article | Helon Vicente Hultmann Ayala, Didace Habineza, Micky Rakotondrabe, Leandro dos Santos Coelho, Nonlinear Black-box System Identification through Coevolutionary Algorithms and Radial Basis Function Artificial Neural Networks, Applied Soft Computing, vol. 87, 105990, 2020. |

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**Value of the Data**

- The dataset provided is important for nonlinear modelling of hysteretic systems
- Researchers in the system identification community at large may benefit for testing nonlinear modelling techniques. Researchers and engineers working with piezoelectric actuators for high precision positioning applications may also be interested with and benefit from the data.
- The present dataset enable comparison among methods for modelling a phenomenon that is frequently found in positioning applications, but not only.
Datasets (a) and (b) characteristics are summarized in Table 1 and depicted graphically in Fig. 1. They are sampled at different rates as the dynamics due to the excitation is faster in case (a). It is possible to see that the voltage amplitudes and frequencies are different for each file, as Table 1 shows. Nevertheless, the amplitudes for the deflections are in the same order of magnitude, as the input/output gain for each frequency is different for the system. For the sinusoidal-like type of input, it is possible to plot the graph with input versus output through time, where the hysteretic behaviour can be clearly observed.

### Table 1

Dataset characteristics for each file provided.

| Dataset | Input Amplitude [V] | Input Frequency [Hz] | Sampling Frequency [kHz] | Time [s] |
|---------|---------------------|----------------------|--------------------------|----------|
| (a)     | 5                   | 300                  | 20                       | 10       |
| (b)     | 150                 | 1                    | 5                        | 10       |

**Fig. 1.** Input and output data for case (a) – top - and (b) - bottom. On the left we see the time histories for both input and output and on the right the semi-static curves (input vs. output) are given.

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2. **Experimental design, materials, and methods**

A schematic of the experimental benchmark setup is described in Fig. 2. The components used in this setup are described in detail in Table 2. The piezoelectric micromanipulator is manufactured with
15 × 2 × 0.3 (length, width, and thickness, in millimetres), where the piezoelectric and passive layers have, respectively, 0.2 and 0.1 mm. For a real picture of the setup with the measurement device, please refer to Fig. 3.

The dataset is provided with a MATLAB code (read_plot_data.m) that reads the data into memory and plots the graphs given in Fig. 1.

**Table 2**

| Hardware       | Manufacturer | Purpose                                                                 |
|----------------|--------------|-------------------------------------------------------------------------|
| DS1104         | dSPACE       | - converts the sine driving voltage generated from MATLAB-Simulink in the computer into analogic voltage outside the computer,  
                 |               | - converts the measured displacement from the sensor into numeric measurement inside MATLAB-Simulink. |
| LK2420         | Keyence      | Optical sensor that measures the deflection (displacement) of the piezoelectric actuator. |
| A400DI         | FLC          | Amplifies the voltage from the acquisition board and computer before driving the piezoelectric actuator. |
| Computer (with MATLAB-Simulink) | Any          | MATLAB-Simulink has been used to program the voltage to be amplified and sent to the actuator and used to save or display the measurement from the sensor. |

**Fig. 2.** Schematic of the measurement setup and the data flow among its components.
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**Conflict of Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105175.
References

[1] Helon Vicente Hultmann Ayala, Didace Habineza, Micky Rakotondrabe, Leandro dos Santos Coelho, Nonlinear Black-Box System Identification through Coevolutionary Algorithms and Radial Basis Function Artificial Neural Networks, Appl Soft Computing (2020). https://www.sciencedirect.com/science/article/abs/pii/S1568494619307719.

[2] Helon Vicente Hultmann Ayala, Didace Habineza, Micky Rakotondrabe, Carlos Klein, Leandro S. Coelho, Nonlinear black-box system identification through neural networks of a hysteretic piezoelectric robotic micromanipulator, IFAC-PapersOnLine 48 (28) (2015) 409–414.