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IDENTIFICATION OF EIGENFREQUENCY OF A MOVABLE INVERTED PENDULUM

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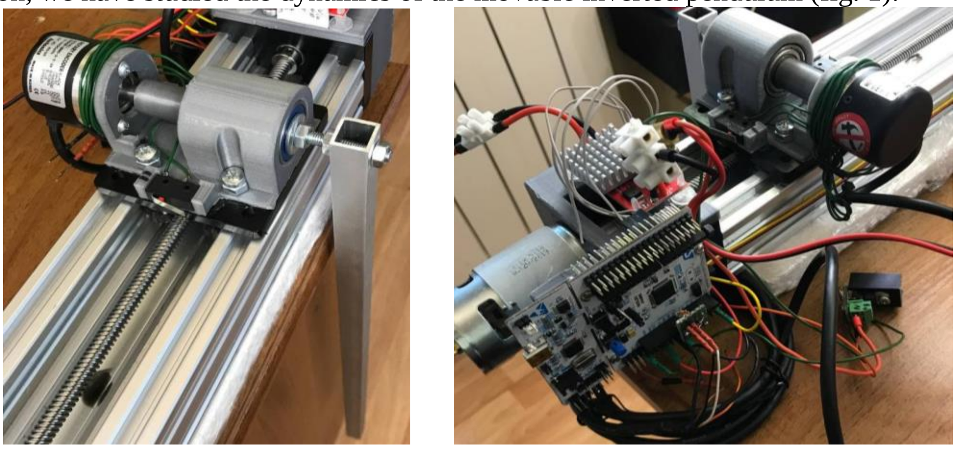
Abstract. *In the work, an underactuated dynamical system (a movable inverted pendulum) has been studied. The main goal of the investigation (detection of the value of its eigenfrequency) has been achieved by providing an analysis of the graphical dependencies of inverted pendulum movement. They have been recorded during control procedure of the movable inverted pendulum. A detailed explanation of the procedure is given in the work. Obtained results may be used for the development of a mathematical model of the dynamical system*.

Keywords: dynamical system, control, eigenfrequency, experimental data.

The inverted pendulum is a well-known dynamical underactuated system [1], which might be described with nonlinear differential equations. Investigation of its dynamics allows to synthesize new approaches and method in control theory, particularly, for nonlinear systems. It, in turn, leads to practical outcomes – new algorithms of control electromechanical systems (quadrotors and other UAVs, self-balancing hoverboard scooters, mobile robots, hoisting machines, etc.).

One of the problems that appear during an investigation of movable inverted pendulum control is connected with determination of its parameters (masses, moments of inertia, coefficients of stiffness of the elements, geometrical parameters, etc.). Their values influence the character of the system movement. Little variations in lengths, masses, and their positions may greatly affect the deviation of the system movement from the desired law of motion. Thus, there is a need to detect the parameters of the dynamical system as they are, in a direct manner.

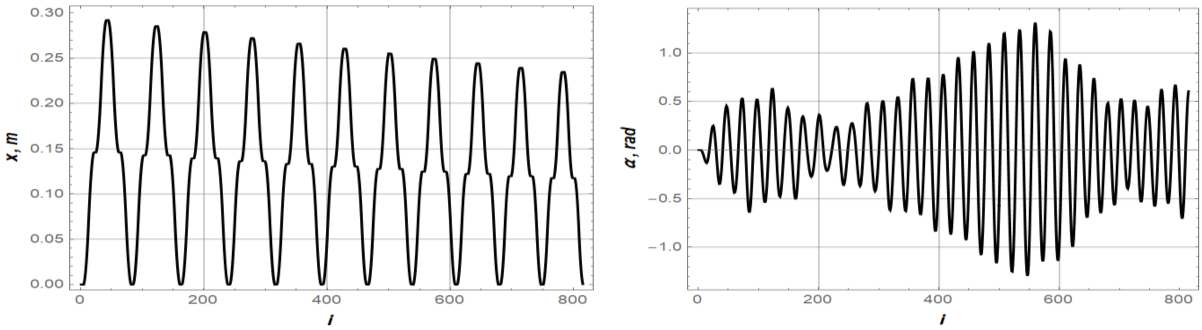
One of the possible approaches in this direction is connected with determination of eigenfrequency (natural frequency) of the system oscillations. This value is an important, as it causes the pattern the system oscillates. It includes a few parameters (mass, stiffness, length of the rod, etc.). Knowing the eigenfrequency and some parameters brings the opportunity of determinate other ones. In the current investigation, we have studied the dynamics of the movable inverted pendulum (fig. 1).



a) b)

Fig. 1. Overall view of the movable inverted pendulum (the lab installation): a) the cart and the rod; b) electric motor and microcontroller

In order to detect the eigenfrequency of the system the cart, which carries the pivot, has been moved along the guide bars. This movement „pumps" an energy to the oscillation system and the rod oscillates. The angle of the rod deviation and the cart position were being recorded (fig. 2).



a) b)

Fig. 2. Experimental data: a) the cart position; b) the angle of the rod deviation

Indicator „*i*” in fig. 2 shows the current number of the measurement. The duration of time between neighbor measurement is 0.05 s. From fig. 2 we may directly find the period of oscillations. It equals T=1.2 s. Thus, the eigenfrequency is $f=T^{-1}$=0.83 Hz.

The main goal of the determination of the eigenfrequency is connected with the calculation of the inertial features of the rod. In further studies, its value will give the complete mathematical model of the movable inverted pendulum and will provide the opportunity to develop new control algorithms.

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ВИЗНАЧЕННЯ ВЛАСНОЇ ЧАСТОТИ КОЛИВАНЬ ОБЕРНЕНОГО МАЯТНИКА З РУХОМОЮ ТОЧКОЮ ПІДВІСУ

Анотація. *У роботі досліджена малоприводна динамічна система (обернений маятник з рухомою точкою підвісу). Основна мета дослідження (виявлення значення власної частоти коливань системи) була досягнута шляхом аналізу графічних залежностей руху оберненого маятника. Вони були зафіксовані при виконанні керування рухом перевернутого маятника. Детальне пояснення процедури наведено у роботі. Отримані результати можуть бути використані для розробки математичної моделі динамічної системи.*

Ключові слова: *динамічна система, керування, власна частота, експериментальні дані.*

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