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Motion Control of a Pendulum via Magnetic Interaction

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Abstract. The present study introduces a modified version of PID Control for the case of a magnetically controlled pendulum. The response was observed in both experimental and numerical simulations taking into consideration the efficiency of the control and the non-linear forces exerted.

Introduction

Offshore wind turbines (OWT) are designed with larger dimensions and get installed by floating vessels in deeper waters due to the ever increasing energy demands. Hence, focus has been recently placed on the development of novel techniques for improving the efficiency of the installation process. Various motion compensation and position control techniques have been employed and tested in situ over the years [1]. All current methods, however, require mechanical equipment in direct contact with the payload as well as some human intervention. This fact, amplified by the delicate nature of positioning OWT components, the small error tolerances and the harsh offshore environment, illuminate a gap for a non-contact position technique for the OWT installation. The concept is based on the magnetic interaction between the component and an electromagnet actuator.

Methodology

In order to develop the contactless technique, a simple magnetically controlled pendulum is investigated (Figure 1a). A Proportional-Derivative (PD) Controller is employed in time domain to impose a desired motion upon a dynamic system with a fixed equilibrium and pivot point. This dynamic system introduces two main sources of non-linear behaviour. These sources are the distance-depended nature of force itself and the saturation of the control system. Thus, a method to improve the overall performance of the control without omitting the non-linearity was tested and compared to a regular linear PD. In order to further validate the control algorithm, a numerical model was developed and compared against experimental measurements to deduce the convergence of the prediction and the overall efficiency of the control.

Results & Discussion

The results, presented in Figure 1b, show that the control of the pendulum was successful at different excitation frequencies. Moreover, there is a satisfactory correspondence between the model predictions and experimental data verifying the predictive capabilities of the numerical model.

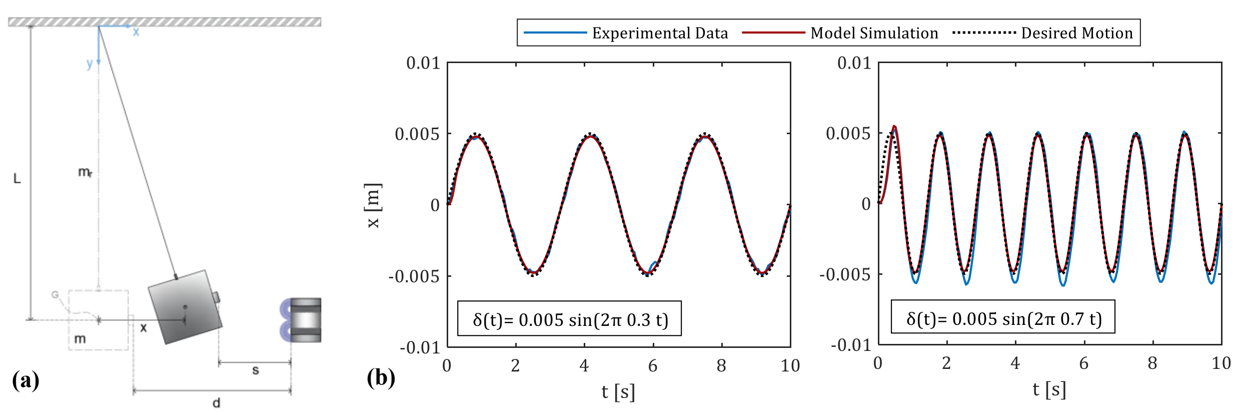

Figure 1: (a) Set-up, (b) Time series of controlled motion for different desired motion patterns.

References

[1] Sreenivasan, A., & De Kruif, B. (2022). Coupled Control for Motion Compensated Offshore Operations. (https://doi.org/10.5957/tos-2022-009)