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Machine Learning: Optimizing Smart Systems with Artificial Intelligence

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RESEARCH REPORT

The present report approaches a way to improve smart systems. Through artificial intelligence applied in the mechanical engineering field, it provides a consistent algorithm that can reads data, trains the machine and provides results about the situation and what to do with it. It will be studied two cases, one of them using machine learning classical techniques to determine the forces applied to a unnamed aerial vehicle and other using deep learning techniques like neural networks in the structural health monitoring area.

Complete after the research is done.

Keywords: machine learning, structural health monitoring, unnamed aerial vehicle

CONTENTS

1 INTRODUCTION

The use of Artificial Intelligence (AI) is very present nowadays. This area of statistics neither is new nor started just now with the autonomous cars and voice assistants (Muthukrishnan et al., 2020), but it is clear that in the last years it has been increasingly gaining more popularity. This happens mainly because of the advances that the World Wide Web has been had over the years, since dial up internet connection, back in the eighties, until now, with broadband internet and smartphones equipped with 5G connection. Another factor is that in the past, the cost to get a large capacity of storage memory was significantly more expensive than it is now, what makes today not only cheaper, but also easy to get memory to store information. With the amount of data available, internet and storage capacity evolution, now it is not difficult to obtain, keep and analyze them to make decisions (Goda and Kitsuregawa, 2012).

AI application is everywhere and today, more than ever, it is easy to realize that. Either to get multimedia recommendations on streamings platforms, like occurs at Netflix, YouTube, Spotify and so many others apps (Chan-Olmsted, 2019), or to make predictions on the financial market and sports betting (Milana and Ashta, 2021; Kollár, 2021; Hubáček et al., 2019), AI is there behind the scenes making all the magic happen. Evidently there is nothing really magical about them, it is pure mathematics combined with a programming language that produces the algorithm capable of doing those thing (Goodfellow et al., 2016; Aurélien, 2022; Raschka, 2015). The launch of ChatGPT–3, and shortly thereafter ChatGPT–4, has shown the power of those technologies and how they can change the way people do things (Biswas, 2023b,a; Lund and Wang, 2023; Baidoo-Anu and Owusu Ansah, 2023).

Getting into the smart systems application, the use of AI is widely used to Structural Health Monitoring (SHM), which is heavily used in the aerospace and civil fields, (Azimi et al., 2020; Ye et al., 2019). The level and the complexity of the AI to be applied to monitore the structure, whether is going to use Deep Learning (DL) and Neural Network (NN) or simpler methods of Machine Learning (ML) like regressions, is determined by the problem itself and the results desired (Farrar and Worden, 2012). In some cases, the standards methods use numerical techniques and they may not be viable, especially when there is a huge data to be analyzed. Thus taking the AI road is an alternative to get the needed results for

the monitoring in a more pratical way (Smarsly et al., 2007; Sun et al., 2020).

Still in this context, but in the field of Unnamed Aerial Vehicle (UAV), the use of AI can be combined to integrate UAV through wireless communication networks (Lahmeri et al., 2021) what can be useful in the agriculture sphere (Ahirwar et al., 2019) with technologies like Internet of Things (IoT) (Verdouw et al., 2016; Tzounis et al., 2017). Also, the use of the AI can be subtle, such as the use of a built-in MATLAB function to make a simple NN to determine the final pose of a UAV based on the initial pose and the forces applied on it (Geronel et al., 2023), or can be more sophisticated, like the use of ML and DL algorithms to predict materials properties, design new materials, discover new mechanisms and control real dynamic systems (Guo et al., 2021; Assilian, 1974).

It is clear, therefore, that AI can transit into different fields, such as entertainment, business, health care, marketing, financial, engineering, among others (Pannu, 2015). The use of the Big Data (BD) can not only make it clear the scenario to be studied, but also to support making decisions. The internet and hardware improvement (Baji, 2018) with the facility of storage of data with accessible costs encourage the use and the benefits that an AI can provide.

1.1 Objective

To develop a AI algorithm based on NN to apply in smart systems. The cases to be studied are:

- the dynamic of an UAV to determine the relation of forces used to move it based on its initial and final pose; and
- crack detection on railways for SHM.

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APPENDIX A – Codes