Chapter 22
Concerning the Integration of Machine Learning Content in Mechatronics Curricula

Jörg Frochte
Bochum University of Applied Sciences, Germany

Markus Lemmen
Bochum University of Applied Sciences, Germany

Marco Schmidt
Bochum University of Applied Sciences, Germany

ABSTRACT

Machine learning is becoming more and more important for mechatronic systems and will become an ordinary part of today's student life. Thus, it is obvious that machine learning should be part of today's student's curriculum. Unfortunately, machine learning seldomly is implemented into the curriculum in a substantial or linking manner, but rather offered as an elective course. This chapter provides an analysis of how machine learning can be integrated as a mandatory part of the curriculum of mechatronic degree courses. It is considered what the required minimal changes in fundamental courses should be and how traditional subjects like robotics, automation, and automotive engineering can profit most of this approach. As a case study, this chapter utilizes an existing German mechatronic degree course specialized on information technology, which covers most of the discussed aspects.

INTRODUCTION

Mechatronics is a multidisciplinary field that includes mechanical engineering, electronics, and computer engineering. Typical application areas are industrial automation, robotics, and automotive engineering. Especially for the latter two, control theory has become an important topic.

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Within mechatronic systems, software and intelligent systems play a crucial role as they are the key drivers for innovation and added value of modern mechatronic systems. Nowadays, also machine learning is a new major factor in this field, and very often it interacts closely with control theory. Some techniques will be or are already integrated into modern mechatronic systems as standard components, like e.g. image and speech recognition. Usually, these components are simply licensed and integrated from suppliers. Nevertheless, in many cases the integration of machine learning requires a deep understanding of the technical behavior of a mechatronic system. Therefore, engineers should have a basic understanding of common machine learning approaches. This is especially true for the field of robotics, flexible manufacturing, vehicles and logistics.

This demand in mechatronic engineering practice has a strong impact on mechatronics and computer science engineering curricula at universities: While machine learning is increasingly important for the mechatronic systems, the mechatronic degree courses at universities often lack integration of this subject, and usually the different curricula are not ready to integrate this subject into fundamental courses of a degree curriculum. We will show, that with minor changes in the curriculum, seamless integration of machine learning contents is achievable. In that way, a university can enhance the attractiveness of a degree course without additional expenses.

In the following sections of this paper, we analyze the requirements for integrating machine learning into mechatronic degree courses based on an existing (example) degree course. In order to be able to choose a proper approach to integrate machine learning, it is essential to understand, which part of machine learning offers the strongest connections to the courses under discussion and therefore candidates are to be integrated into the courses. Next, the interaction to control theory and simulation will be highlighted; both topics have already (classically) a big influence on mechatronic degree courses. The subsequent section will show, which new requirements for degree courses have to be considered, and which already established approaches and topics can be utilized for this purpose by slight re-arrangements, e.g. in control theory.

AN OVERVIEW ON MACHINE LEARNING

Which aspects of machine learning are now the most important ones for mechatronics? One taxonomy for machine learning approach divides them into

- Supervised,
- Unsupervised
- And reinforcement methods.

Supervised methods can be broadly divided into two groups of tasks: regression and classification. Regression is about estimating or predicting a continuous quantity, like e.g. the probability of failure. Classification deals with assigning a given set of features into discrete categories, like e.g. categorizing objects into animal or furniture. Both techniques are important when it comes to mechatronics with a wide field of applications like Predictive Maintenance, see e.g. (Ahmad et al 2012), automated/autonomous driving (Vallon et al 2017) and Convolutional Neural Networks and Deep Learning are more and more used in medical systems see e.g. (Lee et al 2017) and healthcare, see e.g. (Esteva et al 2019). Beyond the technical application areas, it becomes more important in production planning, logistics and cost