1 Motivation

The use of steel elements as a structural solution for buildings, intended for a wide range of purposes, has become a usual option for structural engineering practitioners worldwide. This can be seen as a result of the different advantages that steel can offer, such as its reduced production costs when compared to other construction materials, the speed of the construction process which enables globally more economical solutions, the high resistance of steel, leading to lighter and slender structural elements and thus to more aesthetically appealing solutions, the combination of steel with other materials such as concrete, leading to composite solutions which make use of the best mechanical characteristics of each material.

The design of steel structures leads, invariably, to the design of the respective joints, regardless of their configuration (welded or bolted connections). Nowadays, the design of steel joints constitutes a fairly simple process, owing to the introduction of the computer as an essential part of the process of structural design among practitioners. However, despite the exponential increase in computational power witnessed throughout the last few years and the accompanying evolution of steel design software with an analytical based approach or by means of the Finite Element Method (FEM), the steel connection design process still constitutes a time consuming task, one that is painstakingly repeated despite the existing similarities between the elements to be connected and the forces involved, leading to steel connections with similar geometrical configurations not only within the same project but also across different projects. The design of steel connections is therefore a process for which there is a large amount of previously existing and available data within organizations such as a structural engineering practitioner, data that is generated and validated numerous times following older engineering projects and that most of the times is not reused as a basis for the design of new steel joints. Thus, this design process presents itself as a possible candidate for the application of machine learning techniques that could potentially lead to a more expeditious procedure, leading to lower time consumptions during the steel connection design process throughout the different stages of a project, contributing for the reduction of the associated costs.

2 Contributions

The construction of an exhaustive database of unreinforced welded beam to column connections is a crucial contribution for the main objective of this work. This database is comprised of different pairs of standard commercial profiles, and in particular those used in Europe such as IPE, HEA and HEB, or profiles based upon the combination of these, and their respective dimensional variations usually measured. Once obtained, the complete database can then be split into training and testing sets, the former used to build the models by training a learning algorithm and the latter to evaluate and validate the said model.

3 Objectives

The main objective of this thesis is the application of different learning algorithms to data in order to solve two different problems. The first consists in building models that allow the prediction of the conditioning component of the steel connections, in what is known as a classification problem, while the second is the prediction of the corresponding design resistant bending moment by solving a regression task.

4 Thesis Organization

This document is divided into six chapters.

The first chapter contains a brief introduction in which some of the advantages for the use of steel as a construction material are laid out. Moreover, the mainstream approaches followed for the design of steel connections within a practitioner's environment are also presented.

The procedure followed by the European standard EN 1993-1-8, for the design of welded beam to column steel connections, known as the Component Method, is presented in detail throughout Chapter 2.

Chapter 3 begins with a short presentation of Artificial Intelligence (AI) in general and Machine Learning (ML) in particular. The general aspects, which are transversal to different algorithms, are also presented, including the different types of learning in which these algorithms are inserted, the different types of tasks, as well as the metrics usually used to evaluate an algorithm's performance. Chapter 3 ends with the presentation of the basic concepts underpinning the most relevant algorithms.

The definition of the problem being investigated, the proposed approach as well as the procedure followed to obtain the dataset are presented along Chapter 4, while the obtained results, for both the classification and regression tasks are presented and discussed throughout Chapter 5.

Chapter 6 contains the resulting conclusions as well as future developments that may be pursued based upon the current work.