Abstract

The research activity discussed in the following manuscript is based on the design, implementation and testing of deep learning architectures for two different contexts: Industry and Healthcare.

In the first case, the research activity was carried out at the European Organization for Nuclear Research (CERN) with the aim to model the magnetic hysteresis in the context of electromagnets. The main goal of physicists and engineers working at CERN is the study of high-energy physics. In order to understand the fundamental structure of matter, the particles are made to collide together at a very high speed, close to the speed of light. At this aim, a chain of interconnected accelerators allows the acceleration of charged particles up to 6.5 TeV (Tera electron Volt) per beam in the Large Hadron Collider (LHC). In particle accelerators, the beam circulates in a ring of magnets and is accelerated by the radio frequency cavities. The magnets produce a bending magnetic field that rises in proportion to the beam momentum. Hence, a precise knowledge of magnetic field values is crucial for various subsystems, especially for beam control. Consequently, there is a strong motivation to investigate new models to complement or even replace measurements, when the latter is not available. At this aim, a deep neural network architecture has been proposed for predicting the magnetic field in iron-dominated magnets. According to the results, the proposed architecture is the one that fits the measured field most closely, with a percent error below 0.02 %. These outcomes outperform the current approaches present in the literature and are very encouraging for forthcoming real-time applications.

The second case study regards the healthcare context and it was carried out in collaboration with the University Hospital Federico II, which has provided the dataset consisting of 170 anonymized exams of patients with fracture and 38 anonymized exams of patients without fracture. The assessment of exams, consisting of computed tomography images in trauma patients, is fundamental to adopt the pertinent therapy and conduct them towards highly specialized centers. Often, patients are directed to the regional reference center specialized in maxillofacial trauma even if they do not need surgical treatment. This causes incongruous hospitalizations, leading patients to a condition of discomfort and stress. For this purpose, a deep neural network was designed to detect fractures in the maxillofacial region of injured patients. The tests show the network capability of distinguishing between fractured and normal bone with an accuracy of 80 %. Even if the automated detection system cannot replace medical staff, it can contribute to validate radiologists' doubts and decisions, representing a useful tool to prevent patient injury by minimizing diagnostic delays and incongruous hospitalization.