Hysteresis compensation by deep learning algorithms

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Hysteresis is a Complex Phenomenon described for long time through specific and well-known mathematical tools. The availability of high performances computers allows the handling of huge amount of data and complex computational algorithms. Therefore, simulation of complex phenomena as systems with hysteresis has become an affordable task by the Deep Learning (DL) paradigm.

A nontrivial task in handling hysteresis operators is the design of suitable algorithms for hysteresis compensation, such as in control tasks, when smart materials are employed, [1]. Such tasks have usually been carried out through standard hysteresis operators as the Preisach model, which, as well known, fulfills the congruency property, i.e. minor loop congruency by vertical translation (shaded loops in Figure 1-Left). Conversely, the inverse should fulfill a congruency for horizontal translation of the loops (white loops in Figure 1-Left). This leads to the impossibility to exploit a standard Preisach algorithm for its description[2].

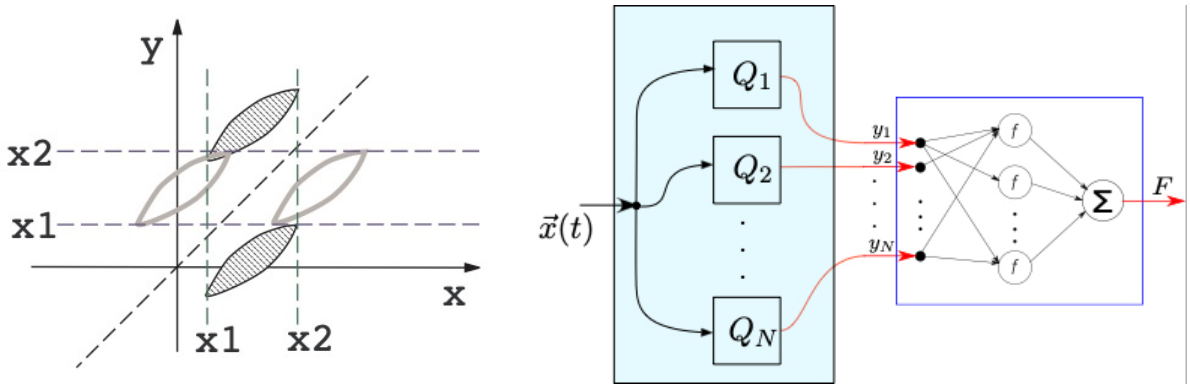

Figure 1: Left: Description of vertical and horizontal congruency. Right: Block scheme of the proposed DL-based hysteresis operator

The proposed contribution presents a DL algorithm (sketch in Figure 1-Right) to describe rate-independent memory phenomena, [3], with feature extraction implemented through the operators Q_k, which represent operator of play or stop type, [4]. While plays present counter-clockwise loops, the latter, showing clockwise cycles are well behaved to describe the inverse operator. Despite standard approaches, a DL algorithm doesn't constraints minor loops, i.e. no congruency property is a-priori imposed, which allows the DL approach being fruitfully exploited for the inverse implementation in complex control or Finite Element algorithms.

References

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