Abstract dei progetti FIS

Optimally designed haPtic systEms foR multi-Cue sEnsing and delIVery: foundatIons and techNoloGies

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Starting Grant

PE

As of today, we are far from having images for the hands close to the richness of their visual counterpart, and haptic systems - mechatronic devices for delivering and sensing tactile cues - still struggle to enter everyday life.

Furthermore, while effective devices for seeing through in augmented reality (AR) exist, the feeling through paradigm is unsatisfactory. Current limitations in haptic systems are mainly related to human touch complexity, hard to model and even harder to artificially reproduce. PERCEVING proposes to design a revolutionary hand wearable haptic system and an innovative hand sensing tool, which can effectively render and sense, respectively, all main tactile and proprioceptive cues, minimizing resource usage. For the design of the former, I will prioritize the usage of soft-deformable materials (e.g. fabrics) to superpose artificially rendered tactile cues while minimally affecting natural perception, for an effective tactile AR. I will move from the observation that humans organize tactile information into low-dimensional percepts, relying on physical measurable quantities, i. e. invariants or Haptic Descriptors HDs, used to discriminate given tactile properties, such as finger contact area growth for softness. To completely decipher the HD alphabet, I will perform extensive finite element simulations of hand-object interaction to identify all the physical variables that could be artificially measured and serve as HDs in different exploratory tasks. These HDs will form a prior dataset that can be organized in a basis of correlation schemes, whose elements can be combined (also with proprioceptive and motion information) to encode most of object tactile attributes. The stimuli related to this basis elements and their combinations will be delivered via the hand wearable haptic system and drive the choice and optimal placement of sensors of the sensing device - to maximize the information uptake, and tested in virtual/AR and telerobotics tasks

Mining Interpretable Models explOiting Sophisticated Algorithms

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Recent advances in research in Artificial Intelligence (AI) are leading to the adoption of more and more effective but complex models in AI-based decision-making systems. A widely recognized obstacle in accepting such systems is the lack of interpretability. The cause for this lack is that the most effective complex models are blackbox, i.e., it is humanly impossible to understand the decision process adopted. On the other hand, an AI system based on an inherently interpretable model would be trusted and accepted more easily than one using a blackbox, also because ethical properties can be easily checked on it. Leveraging the state of the art of AI and thanks to my strong background in eXplainable AI (XAI) maturated since 2018, I propose to mine sophisticated algorithms to infer interpretable models that guarantee also desired ethical and functional properties such as privacy, fairness, causality, and verifiability. The objective is to exploit sophisticated algorithms such as deep learning, quantum computing, evolutionary algorithms, etc., to obtain inherently transparent models by breaking the typical algorithmic symmetry present in the procedures adopted in the learning and prediction phases. From another perspective, the idea is to turn traditional data mining processes into “model mining” procedures, where the knowledge must be extracted from sophisticated models instead of from the data. Hence, in applicative scenarios, the models used by AI systems would be interpretable, while the algorithms employed to retrieve them can be arbitrarily complex. The aim is to

mine interpretable models for different problems on relational data, images, time series, and text. I want to experiment with the extracted interpretable models on real case studies of decision-making such as credit scoring and medical diagnosis. This high-risk project has a high potential impact on balancing the asymmetry between AI systems and their users, empowering transparency and trustworthiness.