Deep Adversarial Frameworks for Visually Interpretable Periocular Recognition

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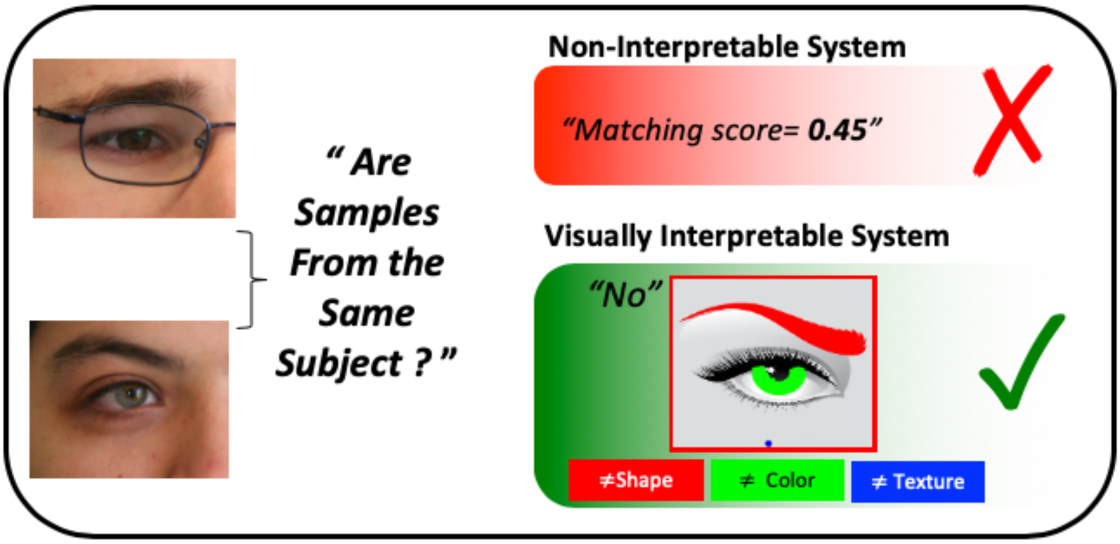

Figure 1: Illustration of the "interpretability" problem that hinders the application of biometrics-based solutions to forensics applications: the state-of-the-art periocular recognition systems work in a "black-box" paradigm, and do not provide the *reasons* behind a match/non-match observation

This proposal is rooted in a popular adage that states that "a picture is worth more than 1,000 words".

Complex ideas are known to be conveyed in a more effective way by a single still image than by a verbal description. Among the many examples in the literature supporting this idea, we highlight Leonardo da Vinci's, who wrote that a poet would be "*overcome by sleep and hunger before being able to describe with words what a painter is able to depict in an instant*" or Napoleon Bonaparte, who is supposed to have said that "*un bon croquis vaut mieux qu'un long discours*".

According to the above, this work aims at the development of methods to simultaneously (and jointly) "recognize" objects in images and "interpret" their decisions. In particular, we consider the biometric (periocular) recognition problem [1]-[10].

In practice, the goal is to obtain classification models that not only infer class (ID) information , but also provide local and global visualizations of the data that justified the decision (e.g., by providing synthetic representations of the input data, that - in a human understandable way - justify why a pair of samples is/is not from the same person, as illustrated in Fig_1).

By using the traditional black-box machine learning models, such as multilayer perceptron neural networks (MLP) and gradient boosting machines (GBMs), human-understandable explanations are currently obtained only from post-hoc processes, i.e., using explanation techniques only after model inference. At first, this kind of interpretable solutions is known to obtain explanations that yield more from data artefacts than from actual knowledge inferred by the model. Second, it happens that such black box machine learning models are exactly the solutions that have been advancing the classification state-of-the-art close to (and even beyond) human level performance, not only in biometric recognition but in many more applications.

From the conceptual perspective, the main innovation is the research about integrated deep learning frameworks (based in MLP and GBMs) that intrinsically provide visually interpretable results, while keeping state-of-the-art recognition performance. We plan to develop disruptive learning frameworks composed of both generative and discriminative modules that interact in an adversarial way (as in the Generative Adversarial Networks (GAN) paradigm), but where the inferred components – upon convergence – can be used simultaneously to "recognize" and "interpret". The main goal is to obtain human understandable descriptions of the components in the periocular region, namely: 1) the eyebrows (shape); 2) the eyelids (shape); 3) the iris (color); and 4) the skin (color and texture).

The workplan comprises the study of the recently published and highly popular generative deep learning architectures (such as "*StyleGAN*", "*AttributeGAN*" or based in Variational Auto-encoders) that have two key features: 1) ability to infer disentangled representations of the input data; and 2) ability to perform multi-attribute transfer via such disentangled representations.

Considering also the roots behind dense semantic segmentation models, an interesting possibility will be to fuse such disentangled representations with conceptually (biologically) coherent regions-of-interest, to be used as input of the generative modules to obtain synthetic representations of the input data that provide an intuitive interpretation why a pair of samples are/are not from the same subject (i.e., recognition).

Obtaining such kind of visually interpretable recognizers would be interesting for various purposes, such as: 1) support human-decision processes in domains such as forensics, where the results of one analysis should be communicated in a human-understandable way to a jury or a judge; 2) improve biometrics feature engineering, by providing cues about the features that are of most interest to provide good decisions; 3) drive future data collection protocols, by providing a good understanding of the value of each data segment privileged by the recognition system; and 4) augment trust, by showing insights that fit the usual human understanding of the recognition problem, even for people with no knowledge in data science.

Prerequisites

- Basic skills in English writing/reading;
- Good programming skills, preferably in *Python*, *Keras* and *TensorFlow* languages.
- Previous knowledge about Machine Learning and Artificial Intelligence.

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