Biometric of Intent: A New Approach Identifying Potential Threat in Highly Secured Facilities

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***Abstract*—Biometric of Intent (BoI) is a Computer Vision (CV) automation, using Artificial Intelligence (AI) techniques, which presents a new approach that extends the reach of the classic biometric identification process. It provides an efficient mechanism which deters the threats raised by unknown individuals who have deceitful intentions and who aim to deploy unlawful operations such as terrorist attacks. In this context, our proposed BoI model is based on a framework constructed upon an automated machine learning facial expression analysis system which can assist law enforcement agencies who intend to deploy a systematic preventive security approach that aims to reduce the risk of potential unlawful attacks by rogue individuals through the evaluation of their emotional state in relation to their malicious intent.**

Keywords—behavioral biometric, biometric of intent, FACS, facial expressions analysis, basic emotions

I. Introduction

The rise of terrorist threats, following the 9/11 attacks, have been a major drive for public and private investment in biometric technologies due to their efficient means in detecting Subjects of Interest (SoI) through their multi-modal biometric credentials (fingerprint, face, iris, …). Even though these technologies proved to be of value in identifying suspected individuals, still, they seem to lack the real efficiency of detecting unknown individuals who present imminent threats. As such, behavioral science provides an interesting answer to fill the above-mentioned security gap. The use of behavioral sciences for threat deterrence is already in operation in US airports by the Transport Security Administration (TSA) through the deployment of "Behavioral Detection Officers" in the context of the SPOT program (Screening Passengers by Observational Techniques). Our objective, therefore, is to take the biometric landscape to new heights by leveraging facial behavioral analysis used in SPOT to implement an Automated Biometric of Intent Identification System (ABoIIS) with the aim of scanning and detecting individuals' malicious intents. Moreover, the purpose of this paper is to present the founding principles of Artificial Intelligence (AI) algorithms and Computer Vision (CV) which underpin our BoI system by providing an insight to the initial results which are related to the emotion detection training method.

II. Philosophical Background

A. *Disentangling the face*

Faces are portraits that reveal our inner traits which are characterized by emotional performances. *The Picture of Dorian Gray* uncovers the capacities that emotions are able to stimulate within us, as Dorian tells Basil (the painter of his portrait): "A man who is master of himself can end a sorrow as easily as he can invent a pleasure. I don't want to be at the mercy of my emotions. I want to use them, to enjoy them, and to dominate them."

So, how agreeable it would be for a person to be able to be master of his/her own emotions by being able to manipulate his/her facial expressions, leading people to diverged assumptions. This is a notable skill, or one might even say a

real talent that can only be mastered by a genuine capacity of mind. It is all through the face where the technicality of its performances projects the emotional substance of the inner self as Wittgenstein (1980) suggests: "The content of an emotion – here one imagines something like a picture. The human face might be called such a picture [1]" If we are to remain on the reasoning that all of human attributes are but the set-up of a 'picture' ascribed to the face, solely, then we might as well forget about the in-depth of such a 'picture' by remaining at the surface of its morphology. But, what about the state of mind, what about the consciousness or unconsciousness of the bearer of this picture (face)? Does a simple face, any simple face, classified as picture/mask, does it hold no veins, no nerves, no liveliness? Is it only a moveable mask which is dictated in action through mimicry? If so, then what does this mask mimic? Here, we enter into the dilemma of the self and its consciousness to the other self(ves) where pluralistic intersubjective commonness revives a non-subjective phenomenon. Therefore, the Cartesian reliability on the 'I', merely, pertains to the exclusion of the other selves that are theoretically legitimate in correspondence to the 'I'. Kant, accordingly, "…contest[s] this solipsism by showing that self-consciousness could not be apart from consciousness of objects in space [2]." So, the mimicry reproduced by the facial exterior (the facial mask) – which beholds facial networks that operate through the functioning of the muscles which are concealed underneath soft-tissues and are set to divulge "…meanings [that] are interconnected in the ever changing web of language…wherein no concepts or principles have any necessity and where knowledge claims are justified with conventional standards as contingent and variable as the rules of any game [2](,)" – is manifested by whatever is established as self-knowledge and conceived through the common perception of an interconnected knowledge. Self-knowledge, therefore, is but a fabrication of assembled communal/societal self-recognized and self-authorized beliefs and thoughts that stretch out to the senses to materialize through body language and in consequence, facial articulations.

B. The face: a visual pattern for expressed emotions

Messages that are emitted by the face are set to reveal whatever lies within the impulses of emotions that can uncover the intentions of human opinions and beliefs by bringing about an insight into a person's intentions [3][4]. Emotions which are displayed on the face give information of what is going on inside a person through means of excavating whatever is found within the "…individual's emotional repertoire… [5]." The face "…thereby reflects the mind by betraying the impulses that prompt thoughts of actions. It is, therefore, the servant of conscious activities [4] (,)" which seem to be disclosed in terms of "…momentary mental states… [3] These mental states are uncovered through their disclosure of emotional reactions that are shown rapidly and on the spot on any viewed face – at the direct moment of their divulgence [5]. Their detection, however, relies on the means of their unravelling as their reactions take form through momentary snapshots which become more apprehensible with the help of computer assistance.

At another angle, it is pertinent to understand that the functionality of the face is, somehow, considered in being able to knock-down barriers that are constructed by the layouts of neutrality. Neutrality, therefore, has no clear terminology in the glossary of facial interpretation. Why? Simply because neutral face traits are depicted by computer systems to have structural matches to emotional expressions. More specifically, emotional expressions cannot but be inscribed through their behavioral patterns on neutral face traits [13]. Ultimately, faces are not supposed to be labeled as mere "blank canvases" awaiting an order from a premeditated movement awareness system which is thought to dictate their emotional states and messages [6]. Facial expressions are much more complicated than that. Although their assessment and interpretation are considered in being well understood universally – especially the six basic facial expressions which are introduced by Ekman [6] – still, there are some perplexities with regards to how they are assessed, that is, whether facial emotions are perceived in terms of the physical aspects which are based on age, gender and ethnicity [3][6] or in terms of social or emotional aspects [6] [7]. Of course, logically, facial emotions should be the outcome of a mélange of all the previously mentioned disciplines, however, it would be more pertinent to take into consideration the importance or even the effect of the physical aspect with regards to facial evaluation as mentioned in the study of Hess et al. [6]:

> *In a recent study, we showed participants photos of individuals from four different age groups (18-29-30-49-50-69 and 70+) and asked them to indicate how likely they thought that the person shown in the photo would express each of four emotions (happiness, sadness, anger and fear) in everyday life. The responses differed with regard to both sex and age. Thus, as they get older, men were perceived to be less likely to show anger, whereas the reverse was the case for women. Men were also perceived as more likely to show sadness as they grow older (Hess at al., 2009: 3499).*

III. BIOMETRIC OF INTENT(BOI)

A. Definition

Biometric of Intent aims to scan the invisible mental processes of individuals' emotions, intents and beliefs through the usage of external behavioral indicators such as facial expressions. BoI is based on the hypothesis that individuals "who intent to do harm will be concealing this fact, thereby expressing deceitful behaviors – and that deceitful behavior cues are founded in stress, which in turn are displayed in emotions" [15]. As such, we propose to detect such harmful intents through the identification of stressful emotions displayed through facial cues.

B. *Empirical studies supporting BoI validity*

In his written testimony [8] to the House of Representatives, Committee on Science, Space and Technology (CSST) with the regard to the evaluation of SPOT program, Paul Ekman presented two empirical studies supporting the above mentioned BoI hypothesis. By studying the high stake lies, he "…found that behavioral signs relevant to distinguishing lying and truthfulness are the same regardless of what a lie is about as long as there was a threat of severe punishment. The behavioral hot spots were the same regardless of whether the lie was about strongly felt unpleasant emotions, strongly held opinions or stealing money [8]". Based on this observation, two empirical studies were deployed. The first one consisted on detecting lies in a counter terrorism scenario through body language [8]. This study involved members of national security organizations with personal experience in dealing with terrorists along with research subject members of extremist groups in the U.S who believed that breaking the law is justifiable when needed to reach the goals of their groups. A group reward and punishment mechanism were put in place in the aim of deceiving an interrogator by convincing him that they are telling the truth. The results of the study provided a 75% and 78% accuracy for the facial analysis and symbolic gesture analysis respectively [8] leading to a strong evidence on the validity of the BoI hypothesis. The second study, where Ekman served as consultant, consisted of analyzing deceits about intentions in a security setting [8]. The operational scenario was based on simulating a situation which resembles an airport checkpoint where participants usually wait in queue behind security lines. Then (within the scenario) a uniformed police officer passes the queue and looks at each person. In this set-up, 11-44 second critical period 2 FACS (Facial Action Coding System) experts are looking for Action Units (AUs) associated with anger, contempt, disgust, fear, happiness and surprise. The study indicated that the presence of contempt, disgust and fear are present for the persons with deceitful intent at 85% accuracy [8].

Based on the above, we can safely forecast that it is possible to detect intentions from behavior and that facial AUs provide an interesting indicator which may help us fulfil our intention, that is, facial recognition.

IV. The Facial Action Coding (FACS)

A. *Discrete emotion theory*

Relying on the discrete emotion theory which assumes the existence of mutually exclusive basic emotions, each with different action programs, facial expressions, psychological processes and accompanying cognitions, Paul Ekman and Wallace V. Friesen propose six basic emotion modules [9]: joy, sadness, anger, disgust, fear and surprise. These cross-cultural emotions have the involuntary tendency to show a particular facial expression such as smiling in the case of joy. In this context, the detection of these basic emotions through their facial display can be used in apprehending more complex emotional states, thus, having a better insight of the associated internal mind state.

B. *Facial expression analysis technique: FACS*

In 1978, Ekman and Friesen developed one of the most influential methods to objectively code facial behavior [10] which was further fine tuned in 2002. FACS consists of a fully standardized classification system of facial expressions decomposed into elementary components called Actions Units (AUs). In this context, the AUs are considered in being the alphabet of the language of emotions and the basic emotions (joy, sadness, anger, disgust, fear and surprise) its words.

V. Automated Biometric of Intent Identification System (ABoIIS)

A. *Direction model*

To reach our objective in terms of identifying, in an accurate manner, the intent of deceit as depicted above, we propose to implement an ABoIIS with the following directing principles:

a) Emotional language of thoughts: On the basis of the AUs alphabet, we propose, through the usage of Artificial Intelligence (AI) to define a language of thoughts permitting us to decipher its words (basic emotions) and sentences (combined complex emotions).

b) Machine learning: The use of Machine Learning techniques to train an emotion detection engine in order to provide an accurate interpretation of the emotions conveyed by facial expressions.

c) Real time performance without any specialist hardware, through the leverage of state of art computer vision and machine learning algorithms.

B. *Conceptual Model*

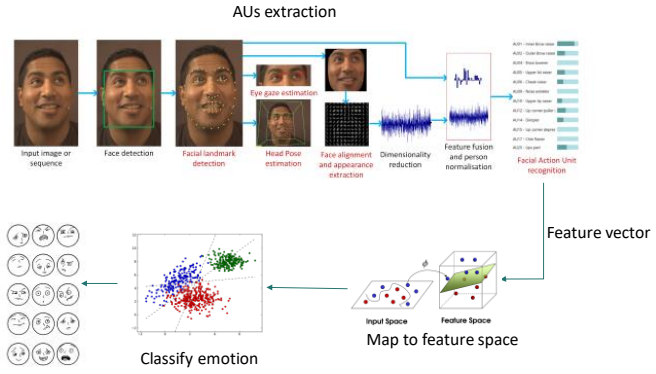

Fig. 1. ABoIIS Conceptual Model

The flow of information to estimate the basic emotions probabilities is composed of the following steps:

a) AUs extraction: through the use of Open Face [11] toolkit, AUs are extracted in terms of regressions and used to contruct a feature vector associated with a normalized face.

b) Emotion classification: the constructed feature vector is submitted to a multi-class Support Vector Machine (SVM)

that will permit us to estimate the probabilities for each of the six basic emotions.

The constructed feature vector is based on the list AUs summarized in the following table.

TABLE I. FEATURES VECTOR

AU	Description
AU1	Inner brow raiser
AU2	Outer brow raiser
AU4	Brow lowerer
AU5	Upper lid raiser
AU6	Cheek raiser
AU7	Lid tightener
AU9	Nose wrinkler
AU10	Upper lip raiser
AU12	Lip corner puller
AU14	Dimpler
AU15	Lip corner depressor
AU17	Chin raiser
AU20	Lip stretched
AU23	Lip tightener
AU25	Lips part
AU26	Jaw drop
AU28	Lip suck
AU45	Blink

VI. SYSTEM INITIAL TESTING

A. Approach

In order to provide an initial validation for the previously described approach, we performed a testing campaign using the Warsaw set of emotional facial expressions [12]. This set is composed of 210 facial pictures classified by basic emotions, in addition to a neutral expression category. Each category consists of 30 pictures expressing multiple variations of a basic emotion. Using this set, we built a set of training data for each category which consists of 25 pictures with the presence of one basic emotion in relation with the category, and 175 pictures with no presence of the basic emotion in question. On the other hand, we built also a set of testing data which consists of 5 pictures with the presence of the basic emotion and 5 pictures with no presence.

B. Metrics

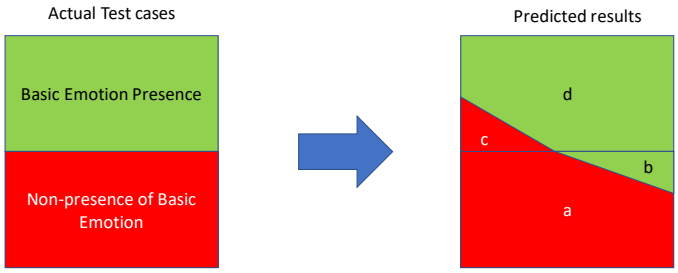

Fig. 2. Testing metric model

For the evaluation of the results of the testing campaign, we propose the following metric model summarized in fig.2:

a) Accuracy (AC): is the proportion of the total number of predictions that were correct. AC = (a+d)/(a+b+c+d).

b) Recall (R): is the proportion of positive cases that were correctly identified. R = d/(c+d).

c) Precision (P): is the proportion of positive cases that were correct. R = d/(b+d).

C. Results

TABLE II. TEST RESULTS

Basic Emotion	AC	P	R
Angry	100%	100%	100%
Disgust	100%	100%	100%
Fear	70%	75%	60%
Joy	100%	100%	100%
Neutral	90%	100%	80%
Sad	70%	100%	40%
Surprise	90%	83.33%	100%

The obtained results provide an initial indication of the potential validity of our proposed approach. Nevertheless, due to the limited size of the training and testing data, the obtained figures cannot be considered as statistically relevant.

VII. CONCLUSION

The first initial tests, which are composed of a training data set using the Warsaw set of emotional facial expressions [12], permitted us to establish a proof of concept which enabled us to validate feasibility in detecting basic emotions through our system in a lab-controlled environment. This has provided us with confidence on the reliability of our approach. Furthermore, our next step consists of building a more comprehensive training data set by taking into consideration the effects of ethnic diversity through the increase of the sampling frequency in the emotions' intensity spectrum which

may permit us to provide more reliable results in the context of a real-world scenario, such as threat deterrence within an international airport facility.

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