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Thermal Facial Screening for Deception Detection

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***Abstract*- Our group has been conducting advanced research in Deception Detection (DD) for the last three years. The conclusion from our effort is that facial thermal screening is a very promising method for DD. It can be used as an additional information channel to enhance traditional polygraph examination for investigative purposes. Because of the unique advantages of the method (non-invasive, real-time, and highly automated), it can also be used for mass screening in airport, border, and other critical checkpoints. Checkpoint agents are already asking travelers certain questions. A familiar example is the question: "Did you pack your own bags?" The difference under our proposal is that these questions will become much more meaningful and both an agent and a machine will evaluate the travelers' responses. The machine's recommendation will serve as an additional data point to the traveler's on-line record. Its weight will be commensurate with how well the machine proves itself in actual practice.**

I. INTRODUCTION

After recent global events, there is an urgent and immediate need to develop technologies that can be used to detect an individual's intent to carry out malicious acts. Currently, authorities validate a traveler's ID at airport and border control checkpoints primarily through manual inspection. Manual inspection is prone to evasion if false ID documents are used. This situation may soon change with the introduction of some standard biometric methods like face and fingerprint recognition. Another advancement that is already in place is a ***T***raveler ***O***n-***L***ine ***I***nformation ***S***ystem (***TOLIS***). ***TOLIS*** takes into account certain data regarding each traveler to determine the level of threat he/she may pose. For example, ***TOLIS*** may weigh, among other pieces of information, the method of payment for an air ticket. An air ticket bought in cash may contribute a substantial number of "threat points" to the traveler's record.

The combined ***TOLIS***-biometrics solution will be a substantial improvement compared to manual inspection methods. Nevertheless, it will fall short of providing effective security because it will still leave a serious loophole: ***the case of seemingly legitimate and normal travelers with bad intentions.*** The fact that these travelers do not have a criminal or terrorist record makes them immune to traditional biometric methods such as face recognition. The fact that they follow standard western travel patterns (e.g., buy an air ticket on credit) makes them less vulnerable to ***TOLIS***.

The only line of defense in such cases is to develop a method and system that detects deceit. Such a ***D***eception ***D***etection (***DD***) system will be successful in a traveler screening application only if it satisfies the following requirements:

1. The ***DD*** system should be an integrated part of a multi-layered security system. Specifically, the ***DD*** result should be weighted in the overall ***TOLIS*** scheme. In turn, ***TOLIS*** should be complemented with traditional biometrics and baggage screen aids.
2. The ***DD*** system should have sufficient sensitivity and specificity.
3. The ***DD*** system should be fast. The objective is to enhance security without hindering air travel or border traffic.
4. The ***DD*** system should be non-invasive. The social acceptability of a system that will require strapping of the subject in any sort of device is very doubtful. Also, invasive means of measurement will be awkward and increase the discomfort of the traveler, thus increasing the possibility of false positives.
5. The ***DD*** system should be highly automated and operate in the absence of highly skilled personnel.
6. The ***DD*** system should be readily movable so that it can be re-deployed within the site. For example, at a moment's notice it may need to be transferred from the ticket checkpoint to the gate checkpoint.

We define a system that satisfies the above six requirements as a system performing ***deception detection on the fly***. Over the last three years, our team has developed technology that is capable of ***deception detection on the fly*** and therefore suitable for mass screening applications. This breakthrough technology is based on a discovery/invention combination:

1. **The discovery**: There is an instantaneous increase of blood flow around the eyes of a subject in response to a stress stimulus.
2. **The invention**: Blood flow rate data can be extracted from raw thermal data by modeling the heat transfer mechanism at the surface of the human body.

The discovery is a physiological finding and a direct result of the well-known startle experiments our team performed in late 1999 [1] [2] [3]. The invention is an algorithmic methodology we developed to monitor non-invasively facial physiology [4] [5].

II. PHYSIOLOGY

It has been known in physiology for a long time that human beings and other primate animals exhibit the "fight or flight" syndrome when they feel threatened [6]. In those situations, blood is redistributed across the body toward skeletal muscles (see Figure 1). This is in anticipation of the subject either fleeing or engaging in a fight. In civilized human societies, people can feel threatened in much less physical scenarios, for example, when there is a possibility of being caught telling a lie.

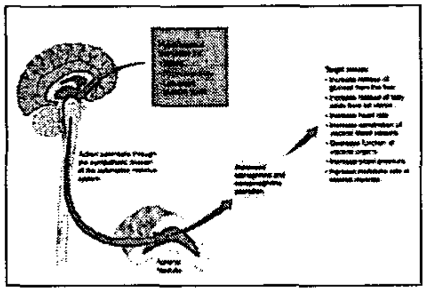

Figure 1: The physiological mechanism that responds to stressful situations [6]. The sympathetic division of the autonomic nervous system instructs the adrenal medulla to increase the secretion of epinephrine (adrenaline), which in turn redistributes blood locally. More blood is funneled temporarily in systems that appear to need it most.

The "fight or flight" syndrome has been primarily associated with parts of the human body having an abundance of skeletal muscles. In contrast, we have observed a manifestation of the "fight or flight" syndrome in the face. Our research objective was to identify any possible facial thermal patterns associated with stressful situations. To this end, we were conditioning subjects in a quiet, dimly lit room to a baseline relaxed status. Then, without warning, we were producing a very loud, instantaneous noise (startle stimulus). We were imaging the subjects with a thermal camera system just before and just after the startle stimulus. The startle stimulus was serving as our experimental device to momentarily invoke feelings of anxiety in the subject.

Comparative analysis of facial temperatures before and after the startle showed consistently in all subjects a measurable increase in the temperature around the eyes (periorbital area). The thermal signatures of other facial areas (forehead, nose, and chin) appeared to remain unchanged (see Figure 2). The temperature change in the periorbital area was very fast (within 300 msec of the startle stimulus), and it faded rather quickly (within 10 to 30 sec). Since we controlled all experimental parameters that could affect skin temperature (e.g., room temperature and airflow), the observed periorbital temperature change could only be ascribed to increased blood circulation in the eye musculature. In addition, because the reaction was so fast, it appeared that this was a sympathetically driven response and therefore difficult to be consciously controlled.

Figure 3 shows the artery network of the head and neck [6]. By mapping the end of the facial artery to the warming locality in Figure 2 (b) we gain an insight to the underlying physiological mechanism. The intent of the facial "fight or flight" syndrome is to facilitate rapid eye movement through increased blood flow in the eye musculature.

Our physiology research has demonstrated that there is a dramatic manifestation of the "fight or flight" syndrome in the human face during stressful states. It has also demonstrated that if the stimulus is strong enough the ensuing localized skin warming is immediately apparent in the raw thermal data sensed by a thermal camera system. The next step we had to take was to investigate the validity of our finding for a particular kind of stress stimuli, that is questions relevant to an investigation. In other words, if a subject is deceptive in his/her answer does that trigger the same facial "fight or flight" response we observed in the startle experiments? Our research has positively answered this question [7].

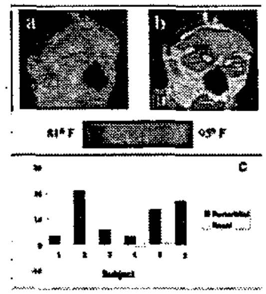

Figure 2: Thermal images of the face for a subject (a) before and (b) 300 msec after an instantaneous startle. Arrows indicate local warming in the periorbital area. The color bar depicts the false coloring scheme from the lowest (81° F) to the highest (91° F) temperature. (c) Changes of the average pixel value in the periorbital and nasal areas with auditory startle. The changes are depicted for each subject (n= 6 subjects). Positive deviation represents local warming and negative deviation, cooling.

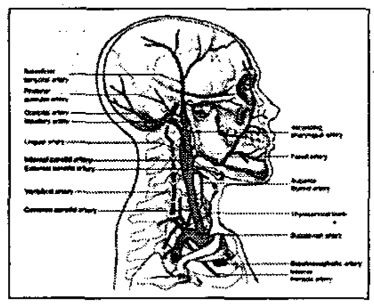

Figure 3: Arteries of the head and neck [6]. Of primary interest is the facial artery that appears to be the conduit of blood redistribution during stressful states.

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