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A STUDY OF IRIS RECOGNITION SYSTEM IN THE CONTEXT OF ALCOHOL CONSUMPTION

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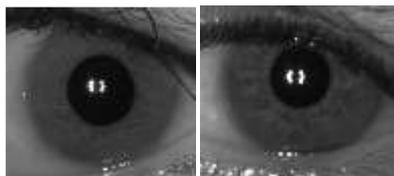
ABSTRACT

Iris recognition is one of the important methods used to recognize cooperative subjects in controlled environments. With the advent in the technology & low cost iris scanners, this biometric method is being used in varied application areas and also poses new challenges. This paper investigates one of such challenges, namely matching iris images captured before and after alcohol consumption. Due to alcohol consumption, the pupil dilates/constricts which causes deformation in iris pattern, possibly affecting iris recognition performance. The experiments performed on some standard databases show that in matching pre and post alcohol consumption images, the overlap between genuine and impostor match score distributions increases by approximately 20%. This suggests that about one in five subjects under alcohol influence may be able to evade identification by iris recognition.

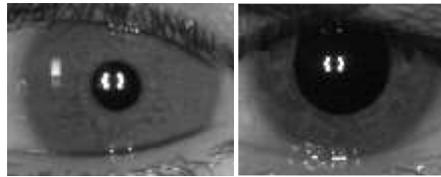
Keywords: Iris, Biometric, Pupil, Dilation.

I. INTRODUCTION

Among various biometric modalities, iris, arguably, is one of the most reliable, universal, measurable, accurate and inimitable[1]. Iris recognition was first proposed by Flom and Safir [2]. Daugman proposed an iris recognition algorithm representing iris image as a mathematical function [3]. After that Wildes [4], Boles [5], Ma[6], and several other researchers proposed different recognition algorithms. Over the years, it has been established that every iris is unique, particularly in the detailed structure of the front or anterior layer. Not only are the irides of identical twins different, but the iris of the two eyes of the same person are also different. Although specific details of the appearance of an iris vary depending on the level and direction of illumination, it has been claimed that the basic and significant features of iris remain stable and do not change over a long time. These properties have led to the use of iris in several large-scale civilian applications such as the NEXUS pass program [7], UK IRIS program [8], and India's UID program [9] for authentication/ identification purposes. Generally, covariates in iris recognition are image quality (i.e. noise, blur), illumination (specular reflection), offangle, occlusion, and resolution [10]. In recent years, several approaches have been developed to advance the state-of-art in iris recognition and address these covariates [11]. However, there can be potentially many other covariates in iris recognition which have not yet been identified. In our opinion, iris recognition under the influence of alcohol is one such covariate. Usually, it is presumed that pupil dilates after alcohol consumption [12] whereas some other research suggests that alcohol consumption does not affect iris recognition [13], [14]. Similarly, Brown *et al.* [15] suggest that *alcohol produces no effect on pupil size* whereas Richman *et al.* [16] suggest that drug recognition experts use pupil size for detecting subjects under alcohol/drug influence. On the other hand, medical literature suggests that, the pupil dilates up to a certain limit of alcohol consumption and thereafter it starts constricting. The limits of dilation and constriction are not the same for all subjects; rather they depend on the individual's anatomy and other medical conditions.



(a) Pupil constriction & dilation pre-alcohol consumption



(b)Pupil constriction & dilation post-alcohol consumption

Figure 1. Examples illustrating constriction and dilation in pupils due to alcohol consumption

Figure 1 shows some examples of pupil dilation and constriction after alcohol consumption[1]. Let us assume that one image (pre-alcohol) is used as the gallery and the other image (post-alcohol) is used as the probe. Due to large dilation/constriction, there is a change in iris information content and therefore, iris recognition algorithms may not be able to correctly match them. To the best of our knowledge, there has not been any study that has carefully evaluated iris recognition performance under alcohol influence. We conjecture that this problem has not received adequate attention for the following reasons:

- Minor dilation and constriction₁ of the iris can be addressed with polar coordinate transformation.
- It is assumed that the subjects are cooperative and not under the alcohol influence.
- Lack of a database and challenges in collecting such as database to analyze the effect of alcohol on iris recognition.

In this paper, we introduce *alcohol influence* as one of the covariates in iris recognition. Major contributions of this work are: (a) collect the Iris Under Alcohol Influence (IUAI) database with 110 unique irises, (b) illustrate that large pupil dilation and constriction due to alcohol influence affects iris recognition, and (c) a simple approach to measure dilation and constriction in pupil and iris boundaries.

II. DATABASE

Collecting a database that contains iris images captured before and after alcohol consumption is a challenging task. To the best of our knowledge, there are some databases like IIITD Iris under Alcohol Influence (IUAI) database that contain such variations for multiple subjects. The subjects consumed about 200 ml of alcohol (with 42% concentration level) in approximately 15 minutes and the images were captured 15-20 minutes after alcohol consumption. In this process, room temperature, lighting and other factors were kept constant so that the only varying parameter was alcohol consumption.

The database contains pre alcohol and post alcohol images obtained from various subjects. Assuming the iris patterns of two eyes of a person to be independent.

III. MEASURING PUPIL DILATION OR CONTRACTION

For measuring the extent of pupil dilation or contraction (after alcohol consumption), we have designed a simple yet effective algorithm. Let I_{pre} the iris image of a subject 'S' taken before alcohol consumption and I_{post} the iris image of the same subject captured after alcohol consumption. The iris and pupil boundaries are assumed to be of elliptical shape, and the major and minor axis of each of the ellipses is computed. For pre-consumption image I_{pre} , let $LP_{major}(I_{pre})$ and $LP_{minor}(I_{pre})$ be the length of the major and minor axis of pupil boundaries, respectively. Similarly, let $LP_{major}(I_{pre})$ and $LP_{minor}(I_{pre})$ be the length of the major and minor axis of iris boundaries, respectively. $LP_{major}(I_{post})$, $LP_{minor}(I_{post})$, $LP_{major}(I_{post})$, and $LP_{minor}(I_{post})$ represent the length of major and minor axis of pupil and iris boundaries of post alcohol consumption image I_{post} , respectively. The area of inner ellipse or pupil boundary for both I_{pre} and I_{post} can be computed by:

$$A_{pupil}(I_{pre}) = \pi * \frac{LP_{major}(I_{pre})}{2} * \frac{LP_{minor}(I_{pre})}{2} \quad -(1)$$

$$A_{\text{pupil}}(I_{\text{post}}) = \pi * \frac{LP_{\text{major}}(I_{\text{post}})}{2} * \frac{LP_{\text{minor}}(I_{\text{post}})}{2}$$

Similarly, the area of the outer ellipse or the iris boundary can be computed using the following equation.

$$A_{\text{iris}}(I_{\text{pre}}) = \pi * \frac{L_{\text{major}}(I_{\text{pre}})}{2} * \frac{L_{\text{minor}}(I_{\text{pre}})}{2} \quad -(2)$$

$$A_{\text{iris}}(I_{\text{post}}) = \pi * \frac{L_{\text{major}}(I_{\text{post}})}{2} * \frac{L_{\text{minor}}(I_{\text{post}})}{2}$$

Let $M_{\text{iris}}(I_{\text{pre}})$ denote the mask area for the pre consumption image, i.e. the fraction of the iris area which is occluded by eyelids. Similarly, let $M_{\text{iris}}(I_{\text{post}})$ be the mask area for the post alcohol consumption image. The iris area which is not occluded in the pre and post alcohol consumption images, $UA_{\text{iris}}(I_{\text{pre}})$ and $UA_{\text{iris}}(I_{\text{post}})$, respectively, can be computed as;

$$UA_{\text{iris}}(I_{\text{pre}}) = (1 - M_{\text{iris}}(I_{\text{pre}})) * A_{\text{iris}}(I_{\text{pre}}) \quad -(3)$$

$$UA_{\text{iris}}(I_{\text{post}}) = (1 - M_{\text{iris}}(I_{\text{post}})) * A_{\text{iris}}(I_{\text{post}})$$

The usable area for iris recognition is then computed as follows.

$$R(I_{\text{pre}}) = UA_{\text{iris}}(I_{\text{pre}}) - A_{\text{pupil}}(I_{\text{pre}}) \quad -(4)$$

$$R(I_{\text{post}}) = UA_{\text{iris}}(I_{\text{post}}) - A_{\text{pupil}}(I_{\text{post}})$$

The final step involves taking the ratio of $R(I_{\text{pre}})$ & $R(I_{\text{post}})$. It is denoted as $E(S)$ i.e extent of change,

$$E(S) = \frac{R(I_{\text{pre}})}{R(I_{\text{post}})} \quad -(5)$$

If $E(S) > 1$ then dilation

If $E(S) < 1$ then constriction

Otherwise no change.

IV. RESULT & ANALYSIS

The effect of alcohol consumption on the subjects in database is studied using the approach discussed in Section 3. This section discusses the algorithms used to analyze the matching performance, experimental protocol, and analysis.

Algorithms and Experimental Protocol

For experiments and analysis, iris recognition algorithm are used:

(1) iris segmentation, feature extraction and matching algorithm by Vatsa *et al.* [17].

Three types of experiments were performed to understand the effect of alcohol consumption on the performance of iris recognition algorithms;

1. Matching two pre alcohol consumption iris images.
2. Matching two post alcohol consumption iris images.
3. Matching pre and post alcohol consumption iris images.

The first two experiments are conducted to establish the baseline performance on this database and the third experiment is conducted to analyze the effect of alcohol consumption.

Analysis

Key observations are summarized below.

- Using the *extent of change* algorithm described in Section 3, it is observed that among pre-post iris pair comparisons, the consumption of alcohol led to dilation in about 51% of the cases, whereas contraction is observed in the remaining 49% of the cases.
- This suggests that there is almost an equal chance of iris getting dilated or contracted under alcohol influence.
- There are significant changes in the pupil diameter also which results in large mismatch in identification.

The extent of change is observed to deviate from the standard value in around 30% of the cases and the accuracy of both the recognition algorithms goes down significantly for such cases. In other words, the database match scores of one in every five subjects differs significantly due to alcohol consumption.

V. CONCLUSION

There are several substances such as alcohol, LSD, MDMA, cocaine, and marijuana that affect iris property. Physiologically, these substances temporarily dilate or constrict pupil to a large extent. Iris recognition of a person under influence of these substances, therefore, can be viewed as a form of attack on the integrity of a biometric system. This paper shows that alcohol influence is a new covariate in iris recognition that affects the matching performance significantly. The experiments performed on the IIITD database suggest that after alcohol consumption, usable iris area changes due to deformation caused by dilation or constriction. This change is dynamic and varies from person to person. This is similar to disguise covariate in face recognition where the appearance can be changed provisionally. This covariate can be viewed as a vulnerability of iris recognition systems. It is our assertion that next generation iris recognition systems should consider this covariate and enhance their capabilities to address such challenges.

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