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Real-Time Liveness Detection Algorithm Based on Eyes Detection and Utilize Age Estimation Technique to Build a Controllable Environment

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الملخص

نظرا للتقنية المستخدمة وانتشار استخدام الانترنت في مجالات واسعة وحاجة الإباء لمراقبة أبنائهم او التحكم في استخدام البرامج على اجهزتهم، ركز الكثير من البحاث في تقديم البيئة المناسبة لتمكن الإباء من التحكم في البرامج. هناك العديد من بالحوث لغرض تقدير العمر والتأكد من ان الحركة لمستخدمين الأجهزة الإلكترونية. ورغم الأبحاث التي لا تزال مستمرة في تقدير العمر والتأكد من حياة المستخدم إلا انه لا تزال هناك بعض الصعوبات والقيود في تقدير العمر ومنها ان الكثير من البحاث ركزت ابحاثهم عن الصورة وجودتها، الحركة وسرعتها وتعبيرات الوجه. بالإضافة الي ذلك هناك أبحاث ركزت أكثر على اكتشاف ان المستخدم حياً لغرض منع الهجمات الالكترونية او لتقدير عمر المستخدم عن طريق اليات تصنيف وجوه المستخدمين. في هذا البحث الطريقة ركزت عن تقدير العمر وكتشاف ان المستخدم حياً بالاعتماد على الكاميرات ذات الدقة المنخفضة من اجل بناء بيئة تمكن الآباء من السيطرة على استخدام أجهزة الكمبيوتر من قبل الأطفال الصغار. تعتمد الفكرة على الجمع بين تقنيات الكشف عن الحياة وتقدير العمر بحيث يقوم البرنامج المقترح بالكشف عن الحركة أولا ثم تحدد الطريقة ما إذا كان المستخدم شخصا حيا أم لا لاتخاذ قرار في الخطوة التالية بعد تقدير عمر المستخدم لتسمح له بالدخول الى النظام

او لا. النتائج المتحصل عليها أظهرت قدرة النظام المقترح في تحقيق الأهداف المقصودة حيث يمكن استخدام هذه الخوارزميات لبناء بيئة يمكن التحكم فيها حيث تمكن البرنامج من الوصول إلى Internet Explorer أو تقييد الوصول وذلك بعد تحديد الفئة العمرية المسموح لها بالوصول الي متصفح الانترنت.

الكلمات المفتاحية: تقدير العمر، الكشف، الحياة، العيون، صور الوجه

ABSTRACT

Detecting liveness and age estimation have many applications and attract many researchers. There are many approaches for detecting liveness and estimating age, still some limitations can be addressed such as they are focusing on image quality, eyelid motion, and facial expression to analyze spoof images. In addition, existing methods proposed for either detecting liveness with the aim of preventing spoof attack, or for estimating age with the aim of grouping facial images or classifying them. In this research, a method for liveness detection and age estimation based on low camera resolution is proposed for the aim of building controllable environment that allow parents from dominating the usage of computers by young children. The idea is based on combining liveness detection techniques with age estimation. Firstly, the method detecting the movements in the eye region and weighing these movements from number of selected frames from the recorded video. Then the method determines whether the user is live person or no to take a decision in next step after estimating user age. The obtained results show that, the method was able to accurately determine the liveness as well as take a decision based on the recorded video using low resolution camera. Furthermore, due to the nature of the data employed in this study, the researchers generated some data for the real users using low resolution building webcam device by recording video of users' face images on mobile device. With that, number of different videos had been used to detect the liveness. The results also show the ability of the proposed algorithms in achieving the intended objectives whereby these algorithms can be used to

build a controllable environment in which the specific age can access or restricted from accessing internet explorer as example.

Keywords: Age Estimation, Detection, Liveness, Eyes, Facial Images

Introduction

In recent years, a continuous increase of accessing the internet at home. The proportion of children having access of internet at home is about 92.8% and their age ranged between 12 and 18 years old. Previously this observation is also confirmed by [2]. They notice that 56% of the teenagers between 12 and 18 years old use the computer in a separate room such as a study or bedroom, without parent supervision. Furthermore, the authors in [3] show that in only 41% of the cases a computer with Internet access is placed in the living room. Mostly young children accessing internet for entertainment, education, edutainment, e-commerce, flowing advertising or gaming. However, the differences in the internet usage are totally depend on age of users and gender. The cyberspace environment allows constructing a personal social space online and the growth of web applications such as MySpace and Facebook, the sharing of pictures, videos and the use of webcams, have affected the types of popular internet applications. That is, most of these applications have negative influence on young children. Thus, it is an important to be vigilant about Internet use of youngsters. Therefore, important measurements at a certain moment in time should be taken when old applications are no longer adequate for protection.

Research Background

In recent years, age estimation for human from their facial images has a wide range of real-world applications based on computer interaction. In addition, there is some existing work on the facial aging progress, originating from psychological and biological studies. Despite that some existing works provide accurate method for estimating people age, however age estimation methods can be divided into two categories; classification based [4-8] and regression-based [9-11]. In addition, to the best of our knowledge

most of age estimation methods are used or tested on facial image that existing or predefined in well-known dataset such as FG-NET database or MORPH, in which most of these facial images are captured with high performance camera. Thus, applying existing methods on facial image that captured by low quality camera such as laptop camera or smart phone camera makes these methods gave different results. Furthermore, existing age estimation methods are proposed to classify age or grouped age whereby they have not tested for building controllable environment. By other words, these methods have not been integrated with some other algorithms to build a controllable environment such as allow access or deny access based on aging results. Although, in recent years important research efforts have been directed to use human biometrics data for authentication purposes, however many of these studies are vulnerable to direct attacks to the sensor of biometric systems such as spoofing attack. In this type of attack, the attackers show a spoof image (printed image) into the sensor to bypass the authentication system [12, 13]. Finding an effective countermeasure against this type of attacking type is the main problem addressed in most articles [14-19] that proposed new or enhanced method for liveness detection. Despite whether they proposed new or enhanced method for liveness detection, most of them are tested for detection spoofing attack. In addition, to the best of our knowledge none of existing liveness detection methods were integrated with age estimation to provide controllable system such as allowing the access or denying the access if the detectable facial image does not indicate to a live person.

Although, some of liveness detection could accurately detect the liveness and detect spoof face, but applying such methods in controllable environment is infeasible unless further studies should be conducted and tested. For example, the authors in [20] were able to accurately detect face liveness and detect spoof face. However, their method required two sensors for capture users' face since they use camera and flash which make this method applicable for specific device such as smart phone only. Also, in another recent example, [21] provides a secure face authentication based on liveness detection. However, this method is applicable for mobile devices in

which it could not be used directly on different platform such as windows. Moreover, this method uses a third party for authentication through a server. To conclude, most of existing methods are either proposed for liveness detection only or for age estimation only. Therefore, providing a new method for an automatic real liveness detection and age estimation is an important to build controllable environment in the usage of the personal computer. In addition, it could help parents in controlling the usage of the internet by their children without the need of knowledge of changing router setting or creating accounts on their computer.

Design and Implementation

This section shows a general overview on the design and implementation for the proposed algorithms, as shown in Figure 1 The main process started by the liveness detection steps, then eye area detection, after that the algorithm estimates the user age. Finally, the decision is taken to allow the user to access some applications or denying the user from the accessing. According to [22], there are two different datasets include Real-Time dataset and standard benchmarked dataset for implementing iris liveness detection. In this research, the standard dataset was used for testing and implementation.

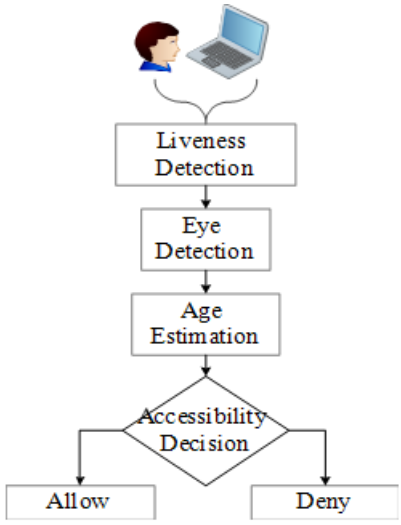

Figure 1. Structural overview on the design and implementation

Liveness Detection Stage

The eye blinking approach was used. The goal of face liveness detection method is to resist the spoofing attack in non-intrusive manner without any external hardware except a generic camera. According to [15], eyes' blinking rate of human being is around 15 to 30 eye blinks per minute, which is human blinks once after every 2 to 3 seconds and blink time is about 205 milliseconds'. Consequently, generic camera can easily capture face video with more than 15 frames per second, thus interval between frames is not more than 70 milliseconds. Then camera can capture two or more frames at the time of face in looking in camera. Based on this analysis, using laptop camera enable the proposed algorithm from detect face spoofing. The work flow of the proposed liveness detection framework is presented in figure .2.

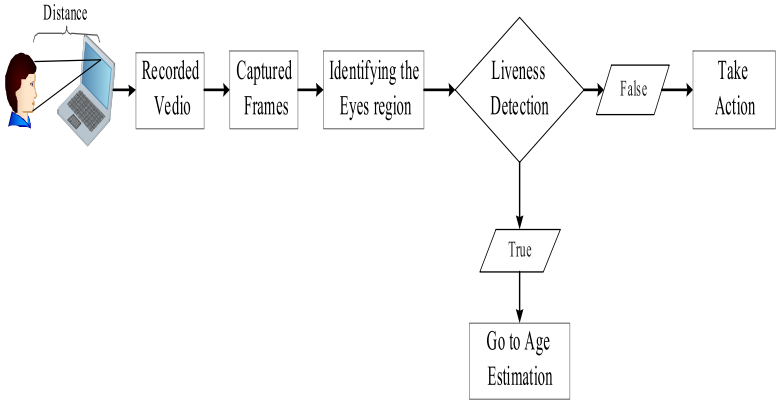

Figure 2. The work flow of the proposed liveness detection framework

When a person tries to use the system, he/she will do the access to some applications as well as may perform a login process. During that, the person's face video will be recorded and a face picture will be captured. Thus, in the first step the proposed liveness detection framework records a video for the current user. In the second step, the number of frames that will be used for identifying the eyes region are selected. Then at third step, the region of eyes is identified in order to determine the liveness.

Eyes Region Detection

In the proposed algorithm, for detecting the faces and facial features, we are using Human Face Fragmentation as devised by [17] and shown in figure 3. Therefore, the eyes region is determined bases on the Human Face Fragmentation. In this research, the eye region considered as the region of interest (ROI) which is a portion of an image that we want to filter or perform some other operation on it.

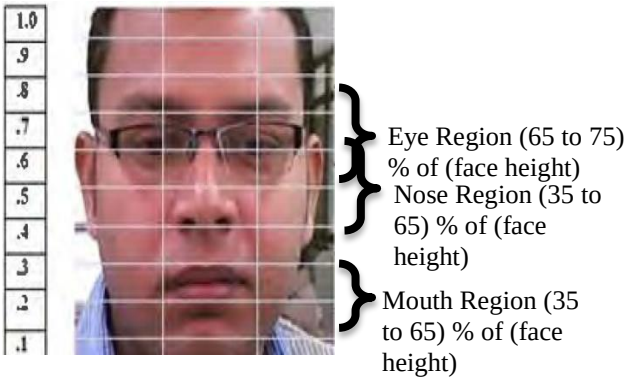

Figure 3. Human Face Fragmentation [1]

Generally, the eyes are located at the upper face and are also characterized by a strong variation of color, thus, the detection of the corner points (points characterized by a strong change in the image signal) in the upper face that allow to identify regions that can be eyes [1]. According to [23] the eye blinks detection technology is essential and has been applied in different fields such as the intercommunication between disabled people and computers. At this step, the corners points are detected by the Shi-Tomasi detector [24] that uses the smallest eigenvalue. After identifying the eyes region, we used the eye blinking approach to determine the liveness. It is feasible to adopt eye blink as a clue for anti-spoofing and for liveness detection [25]. In the liveness detection step we used eye blinking approach for two reasons; firstly, eye blinking approach can complete in a non-intrusive manner without user collaboration, no extra hardware is required, and the eye blink behavior is the prominently distinguishing character of a live face

from a facial photo, which would be very helpful for liveness detection only from a generic camera. An eye blink movement can be represented by an image sequence S consisting of T images, where $S = [I_{(i)}, i = 1, ..., T]$. The typical eye states are opening and closing. In addition, there is an ambiguous state when blinking from open state to close or from close state to open. We define a three-state set for the eyes, $Q = [\alpha$: open, γ: close, $ß$: ambiguous$]$. Thus, a typical blink activity can be described as a state change pattern of $\alpha \rightarrow ß \rightarrow \gamma \rightarrow ß \rightarrow \alpha$. From the theoretical view, for a live person how stand in front of camera the sequence of captured frames would has different values for α, γ and $ß$. For each natural blink activity, both left and right eyes will blink. We can determine a live face if we correctly detect the blink of either left or right eye for each blink activity [26]. Thus, *two-eye detection rate* is defined for this case as the ratio of number of correctly detected blink activities to the total blink activities in test data, where the simultaneous blinks of two eyes are accounted for one blink activity. Therefore, in the proposed framework, the liveness detection is based on the values of α, γ and $ß$.

Age Estimation

The age estimation process starts once the previous stage detects a live person in front of the laptop camera. Thus, this section illustrates the main algorithms that are performed for estimating the person's age. The steps include *preprocessing*, *facial component localization*, *feature extraction*, and *hierarchical age estimation***.** It is very natural; the recoded video has different and several frames thus it is a significant to preprocessing these frames in order to use them for estimating the age of the current user. The typical workflow of functions that simplifying the sequence of the above-mentioned steps is explained as following:

1- Read the recoded video using *aviread* function

2- Determine the number of frames that are required by the index and store them in I

3- Convert the frames into gray images using rgb2gray(I) which converts the true color image to the grayscale intensity image and display the image as shown in Figure 4 a.

4- Locate the whole face region and label it by a rectangle as shown in Figure 4 b and then locate the face components as shown Figure 4 c

5- Crop the face area using *imcrop* function as shown in Figure 4 d.

6- From the cropped face locate the face components using the idea of Human face fragmentation as following:

a. Detect face region using *FaceDetector* function
b. Detect eye region using Eye_Detrct function
c. Detect mouth region using Mouth_Detector function
d. Detect nose region using Nose_Detect function
e. Detect left eye using LEye_Detector function
f. Detect right eye using REye_Detector function
g. Detect right eyebrow using REB_Detector
h. Detect left eyebrow using *LEB_Detector*

7- Extracted features from the face components as shown in Figure 4 f and store them for later use.

8- Estimate age, here the extracted features are used for estimating the current users age using function named *predict_age*.

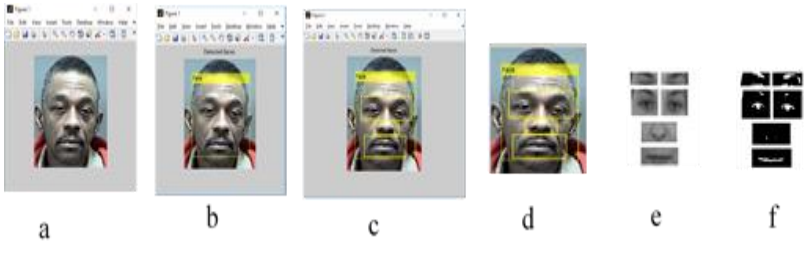

Figure 4. Procedure of algorithm: (a) Convert the frame into gray images, (b) Detected and cropped the face, (c) Face is divided into three vertical parts, which are indicated eyebrows, eyes, nose and mouth areas, (d) Six ROIs show the exact right-eyebrow, right-eye, left-eyebrow, left-eye, nose and mouth regions, (e) face components

The function works to calculate the distance between different key points to determine the age. For example, we utilized the y coordinate distance of point 9 to 7 as the height of left corner regions and one-third of the x axis distance of point 8 to 6 as the width of left corner region to locate the feature regions as shown in figure 4.
b. The main steps of estimating age are.
a. Estimate the geometric transformation between the old points and the new points to find the distances between the points
b. Apply the transformation to the bounding box and convert the box corners into a single array for easy comparison
c. Compare the results with the predefined database and estimating age. In Txia and Huang [27], the authors divided age into four age groups as ranged: 20~30, 31~40, 41~50, 51~60. However, we divided the age into 2 groups A and B only where group A includes all ages greater than 20 and B grouped all users ranged less than 20. The main reason for divided the ages into two groups is to simplify the estimation and to make the decision easier.
d. Determine the accuracy of aging estimation using confusion matrix.
e. Go to accessibility decision.

Accessibility Decision

The output produced by previous stage is used here for taking the decision. If the system categories user under group A, then the user is allowed to access the applications without any restriction. Otherwise, the system will deny the user from accessing some applications.

Testing and evaluation

We divided tests into two parts: at first part, we tested the ability of the Liveness and Eye Detection in detecting and identifying the whole face correctly, the components of the face include eye region, mouth, nose, left eye, right eye and left and eyebrow. The main aim of doing these tests is to make sure the Liveness and Eye Detection deliver its intended objectives. During this test, we captured videos from different persons under different age group (below 20 years old and above 20 years old). Some videos are captured by having a real person or a printed photo trying to access a laptop through a

webcam. In the second test, we tested whether the age estimation algorithm can estimate age and classify ages into two groups as mentioned previously. At the last test, we tested the accessibility decision functionality in order to make sure that the algorithm can take a decision.

Result and discussion

This section shows the obtained results and discussion for the liveness detection steps, eye area detection, age estimation and finally, the accessibility decision.

Liveness Detection

In this section, the algorithm is tested against the ability of determining whether the person who setting in front of Laptop's camera is a live person or no (printed pictures or recorded video). The eyes region is used for detecting the eyes' blinking. The result of eye region subtraction for a sample recoded video of child as a sample is shown in figure 5.

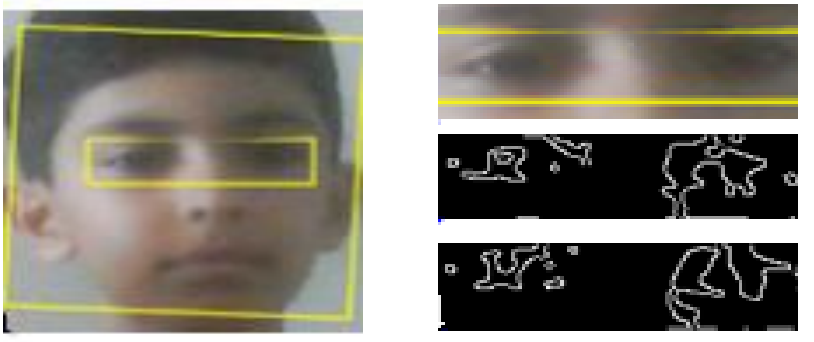

Figure 5. (a) captured frame from Real live video. (b) Segmented eyes region. (c) LBP for the eye region of first frame. (d) LBP for the eye region of next frame.

The results are obtained after a pixel-to-pixel comparison made for the boundary of eye region for each two sequenced frames, which

resulted in 0, 1, and -1. Zero represents no change in feature (no movement), while 1 and -1 refer to movement in features. The results described in figure 6 demonstrates the difference between the subtraction of eye region for real users (live) figure (a) whereas figure (b) demonstrates the difference between the subtraction of eye region for a fake user (printed picture)

The results of the average of the calculated standard deviation for the real user and fake users are presented in a column chart as shown in figure 6.

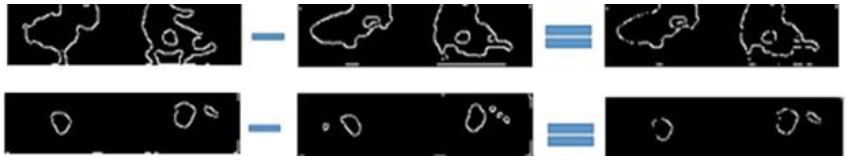

Figure 6. The results of eye region subtraction. (a) real user. (b) spoof image.

The average of the calculated standard deviation for the real user and fake users can be used to differentiate between fake user and real user a

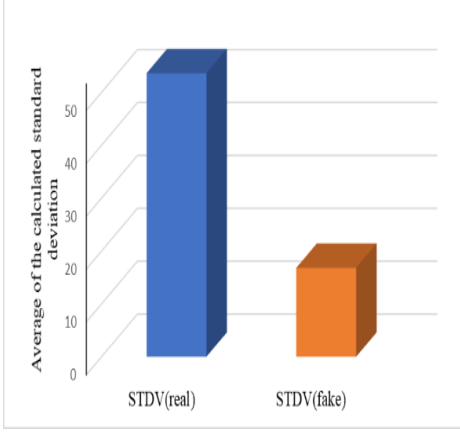

Figure 7. The average of the standard deviation for the real user and fake users

as shown in figure 7. The obtained results of STD by the proposed algorithm shows the highest STD reflecting a real user or a live user whereas the lowest STD reflecting fake user. therefore, it is clear that the algorithm can differentiate between real user and fake user based on STD results.

Age Estimation.

The results for age estimation of original image, the estimated image and the MAE for 10 samples are shown in figure 8. The results clearly show the proposed algorithm can accurately estimates facial image with very low error rate ranged from 0 to 4 years as represented in figure 8. thus, the proposed algorithm can be used to estimate age with low error rate.

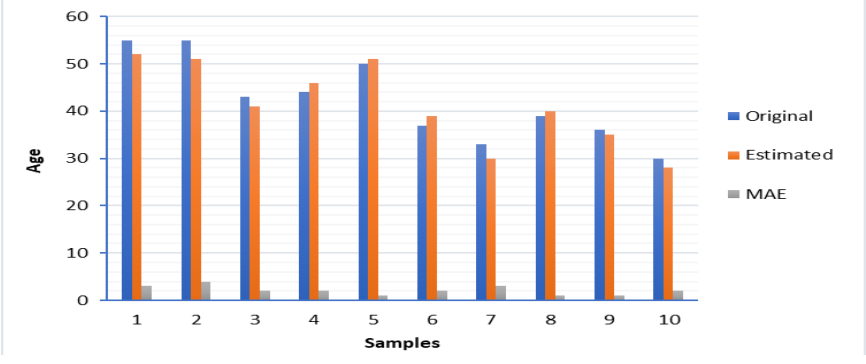

Figure 8. The results of original image, the estimated image

In addition, Figure 9 illustrates in column chart the result for six frames, which are captured from recorded videos for age estimation of original image, the estimated image and mean of the absolute difference. To conclude, the algorithm can estimate the age of the person who is using the laptop using his/her captured image. The algorithm successfully estimate age with an average of error reaches to 4 years.

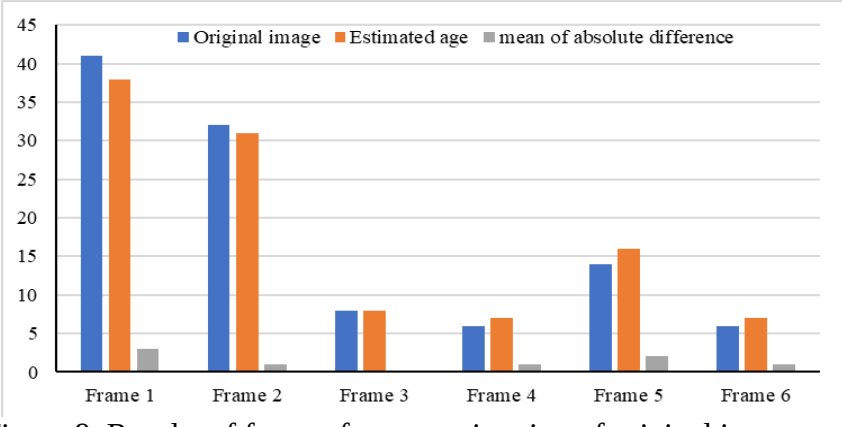

Figure 9. Results of frames for age estimation of original image

Conclusion

In this research, we addressed the issues using human biometric for building a controllable environment in windows platform. The method utilizes both, liveness detection technique and the age estimation technique. In addition, the method is based single build-in device (Laptop camera) to capture a video for the person who are using the laptop and then extract some features from the facial image of the captured frames. These features are used for both, detect liveness of the person and estimate age as well. The obtained results prove the ability of the proposed algorithms in detecting and localizing facial components include locating head, locating face, locating eyes as, locating nose and locating mouth. In addition, the results show the ability of the proposed algorithms in detecting and extracting features from different faces. The results also show the ability of the proposed algorithms in achieving the intended objectives whereby these algorithms can be used to build a controllable environment in which the specific age can access or restricted from accessing internet explorer as example. The analysis also found that the proposed algorithm offers a high accuracy in estimating the user age. The reason is that, in estimating the person age we utilize different facial features include the eyes region, mouth region, and nose region. Furthermore, the proposed

algorithms can accurately allow accessing or deny accessing for the users with a zero of relative error. However, the study is tested on windows platform using laptops. Still, there are numbers of further platforms using different devices such as smart phone in which further studies could be performed.

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