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Facial Recognition and Its Applications in Distance Learning Environment

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Abstract

As cameras have become an integral component in modern computers and mobile devices, and the capability of these cameras in computers and mobile devices are ever increasing, facial recognition is becoming an easily accessible functionality for many computer applications. Another area that has benefited from the fast advancement of technology, including capabilities of computers as well as the speed and bandwidth of the Internet, is distance learning. Online education and training are nowadays an emerging and prosperous area of business. More and more traditional higher educational institutes are offering online classes, joining their pure online counterparts and competitors. In this paper, we first discuss common algorithms and methods used in facial recognition. We then present approaches to integrating facial recognition into Web applications and explore how facial recognition may be employed in distance learning environment to improve the effectiveness and efficiency of distance learning. At last we describe practical methods to integrate facial recognition modules into contemporary learning management systems.

Keywords: Facial Recognition, Biometrics, Distance Learning, Learning Management Systems

I. Introduction

Facial recognition is becoming a more and more popular and accessible biometric method to enhance computer applications.

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Government agencies and banks have been actively integrating facial recognition into their systems. The TSA is working on a Registered Traveler program using biometrics in order to conduct security screenings in a quicker fashion [1]. Several banks nationwide are looking for ways to implement facial recognition into ATMs [2].

Another area that has been through a fast growing due to advancement in technologies is distance learning. According to the 13th annual report of the state of online learning in US Higher education, an online report titled Tracking Online Education in the United States, there were in total of 5.8 million distance learning students in the US in Fall 2014, among which 2.85 million were taking all courses online and the other 2.97 million were taking part of their course load online [3].

In this paper, we strive to research and explore methodologies to implement facial recognition systems and examine how to effectively deploy facial recognition in a distance learning environment or learning management systems. We first investigate how facial recognition is implemented, in theory and in practice. Then we focus on Web applications and explore how contemporary Web technologies have evolved to enable the integration of facial recognition into modern Web applications. At last we describe several facial recognition components that could be used in distance learning environment, and discuss practical methods to integrate facial recognition modules into popular learning management systems.

2. Methods of Facial Recognition

There are essentially four main facial recognition methods in use today: feature analysis, neural network, eigenfaces and automatic face processing [4]. In the first method, feature analysis, each individual has unique facial characteristics that can be measured.

These characteristics include, but not be limited to, shape, spacing, texture, length and width. Each human face has approximately 80+ of these unique features named nodal points. These nodal points create a numerical code called a face print. The Face print can be used to extract a matching image template from a database [5].

The second method, the neural network based method, works in a similar fashion to the way neurons work in the brain. The neural network is broken down into input and output nodes, with nodes in between allowing for paths of communication. A particular node path is chosen based on an algorithm. The neural network is deployed in facial recognition through the use of the whole facial region. This contrasts with feature analysis that only uses nodal points. The neural network uses two techniques to recognize a facial image. First, all faces have differing shapes, features and dimensions.

Principle component analysis narrows the range of images a face will be compared against by ruling out a particular group of images due to differing features or dimensions. In the second phase, Back Propagation Neural Network will perform the actual recognition of an image to the face [6].

The third facial recognition method in use is eigenfaces. The advantage of the eigenface method over other methods is its speed in the facial recognition process. Eigenfaces can be simply described as a blurred facial image. The blurred image still allows for the recognition of prominent facial features. These features include the nose, eyes and mouth. Eigenfaces are generated mathematically through probability theory using matrices and vectors. The disadvantage of this method is its dependency on the same lighting and level views in order to recognize faces against images accurately. The use of Eigenfeatures has been developed to overcome this disadvantage.

Eigenfeatures measure the distance between facial features, and then compare distances against one another [7].

The fourth facial recognition method is automatic facial processing. This method, like Eigenfaces, is dependent on the same lighting and facial positions. However, this issue can be remedied as well, making automatic facial recognition highly accurate. A set of images for one individual is stored within the system. These sets of images differ in facial expression, direction and position of the face, lighting and so on. Each individual image is called a probe image. From here, each probe image is molded together to create an average image. The average image is used for the facial comparison and can therefore increase accuracy by nearly fifty percent [8].

Newer facial recognition methods have also has been made available in recent years. In the past, facial recognition methods were limited to 2D images, which were sensitive to insufficient data points due to low lighting, partial images, indirect images etc..Newer methods have been introduced based on 3-dimensional images to address these issues and provide better accuracy. Another progress in facial recognition algorithm and techniques is from deep learning. According to [19], the recent progress in facial recognition is mainly due to two factors: 1). end to end learning using CNN (Convolutional Neural Networks); 2). large scale of training datasets available now due to the increasing use of facial recognition based applications. Recent complete survey on facial recognition methods can be seen in [9][10][11][19][20].

3. Acquiring the Facial Images

No matter what facial recognition method is used in your application, the face images have to be acquired through a type of cameras. Fortunately, digital cameras have become widely accessible due to advancement in technology and, especially, mobile computing.

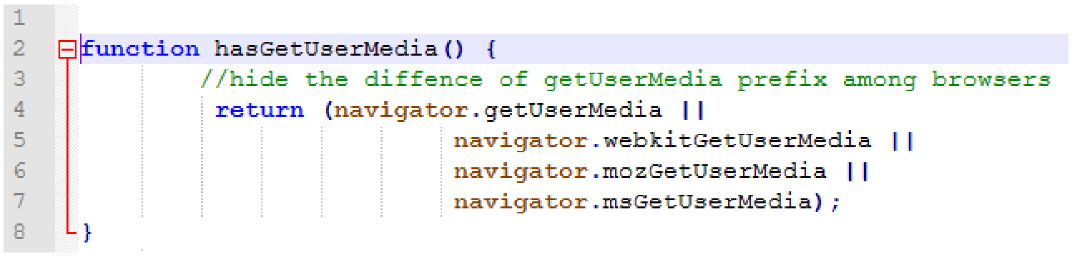
In the circumstance of distance learning, the focus is how live face images may be acquired through Web browsers, or in other words that are more concerned for Web developers, how to acquire face images through Web APIs. In history, the techniques to obtain the face images through Web technologies have varied. A common approach would have been using web based plug-in like Flash or Silver light in order to obtain the face images and then perform face detection, comparison and recognition. Fortunately, the situation has changed and the techniques have been through standardization due to HTML5. With HTML5 and JavaScript, developers can obtain face images with pure web code without any plug-in. This provides less dependency and better integration with other technologies such as facial recognition for Web application development.

One method to achieve a screenshot from the web camera in HTML is through a modified input element. The syntax for this input tag may look like below.

<input type="file" accept="image/*; capture=camera">.

The above input element will tie an image screenshot from your web camera into a file input tag to be uploaded to the Web server site. Support for this method is currently mobile centric and all mobile browsers have certain amounts of support for this method. However, only Chrome having support for it on desktop, which makes this method unsuitable for a typical distance learning environment as desktop computers are very common in distance learning environment. The more suitable approach, and the one used in our applications is using the get User Media () API built into JavaScript. The advantage of this approach, as well as the previous approach when supported, is that it does not require a plug-in to be used so anyone with a modern browser will be able to use your Web application and perform facial recognition easily.

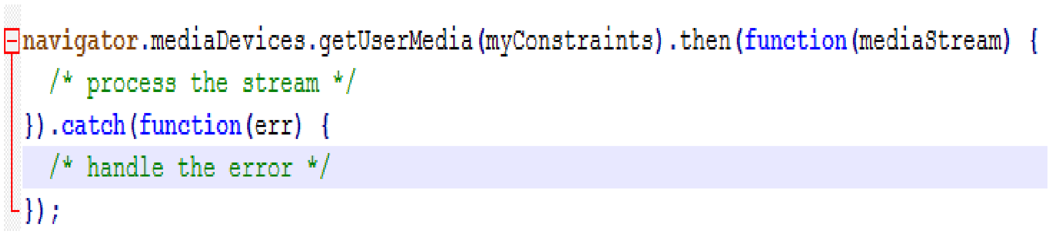
Using this approach, the Web application will first do a feature check to see if get User Media () API is available to the browser environment. In the first release of get User Media () API, the get User Media () method belongs to JavaScript object window. Navigator. The JavaScript code for doing this checking would be similar to the code below.



```
function hasGetUserMedia() {
        //hide the diffence of getUserMedia prefix among browsers
         return (navigator.getUserMedia ||
                        navigator.webkitGetUserMedia ||
                        navigator.mozGetUserMedia ||
                        navigator.msGetUserMedia);
}
```

Figure 1: Check *gets User Media* Support with *window. Navigator* Object

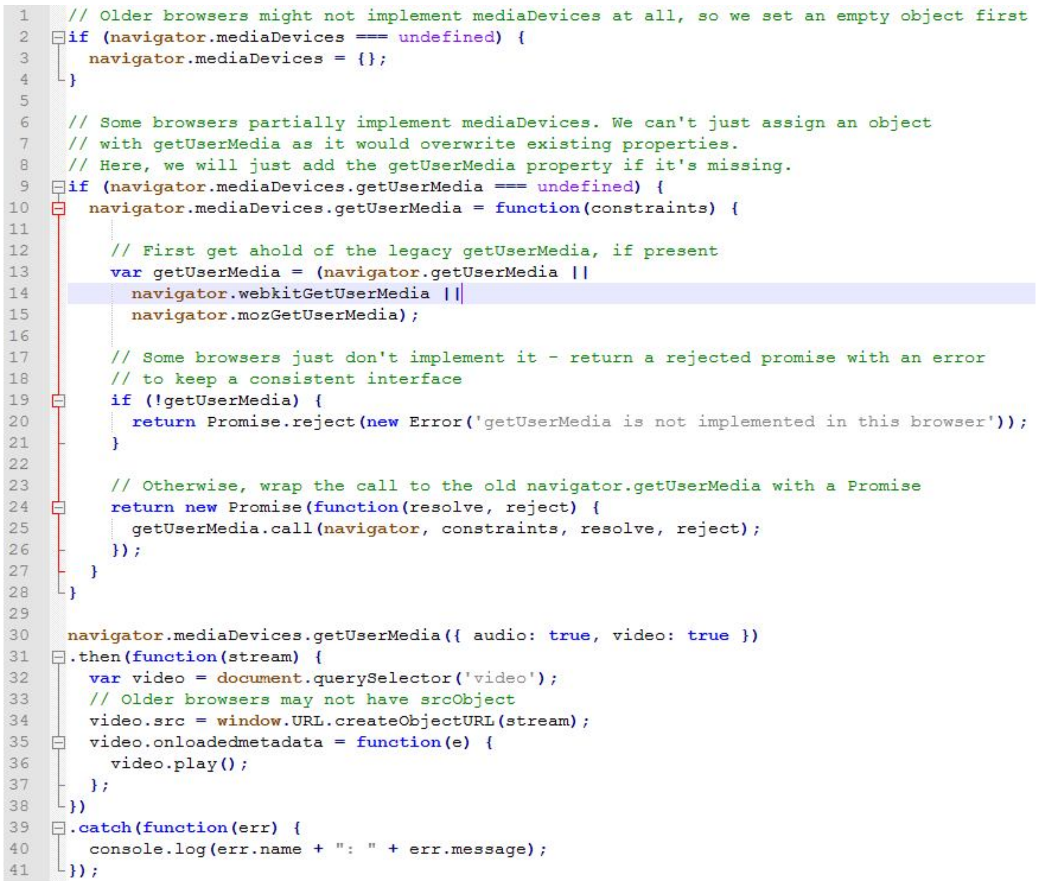
The revised get User Media() API makes use of navigator. Media Devices object [12]. When invoked, the *Media Devices. Get User Media ()* method would prompt user for permission to use video and/or audio devices. A **Promise** object may be returned depending on the user's response. The JavaScript code may look like below in which *my Constraints* is a **Media Stream Constraints** object in get User Media () API. This object specifies the types of media of request and requirements for each type.



```
navigator.mediaDevices.getUserMedia(myConstraints).then(function(mediaStream) {
  /* process the stream */
}).catch(function(err) {
  /* handle the error */
});
```

Figure 2: Use of the Current get User Media () API

Since support for get User Media() varies from browser to browser, we adopt the JavaScript code as shown in [12] to provide flexibility so that both older and current browsers are supported. The JavaScript code as adopted from [12] is shown in Figure 3.



```
// Older browsers might not implement mediaDevices at all, so we set an empty object first
if (navigator.mediaDevices === undefined) {
  navigator.mediaDevices = {};
}

// Some browsers partially implement mediaDevices. We can't just assign an object
// with getUserMedia as it would overwrite existing properties.
// Here, we will just add the getUserMedia property if it's missing.
if (navigator.mediaDevices.getUserMedia === undefined) {
  navigator.mediaDevices.getUserMedia = function(constraints) {

    // First get ahold of the legacy getUserMedia, if present
    var getUserMedia = (navigator.getUserMedia ||
      navigator.webkitGetUserMedia ||
      navigator.mozGetUserMedia);

    // Some browsers just don't implement it - return a rejected promise with an error
    // to keep a consistent interface
    if (!getUserMedia) {
      return Promise.reject(new Error('getUserMedia is not implemented in this browser'));
    }

    // Otherwise, wrap the call to the old navigator.getUserMedia with a Promise
    return new Promise(function(resolve, reject) {
      getUserMedia.call(navigator, constraints, resolve, reject);
    });
  }
}

navigator.mediaDevices.getUserMedia({ audio: true, video: true })
.then(function(stream) {
  var video = document.querySelector('video');
  // Older browsers may not have srcObject
  video.src = window.URL.createObjectURL(stream);
  video.onloadedmetadata = function(e) {
    video.play();
  };
})
.catch(function(err) {
  console.log(err.name + ": " + err.message);
});
```

Figure 3: Resolving Cross-Browser Compatibility

In the HTML5 code, the *canvas* and *video* tags are used to display the feed of the web camera as well as to manipulate the images from the frames. To obtain the image we would put an empty image tag with a button below it that reads “Take Screenshot”. Thekey HTML components would be:

```
<video autoplay style="display: none"></video>
<canvas style="display: none;"></canvas>
<imgsrc="" id="screenshot" >
```

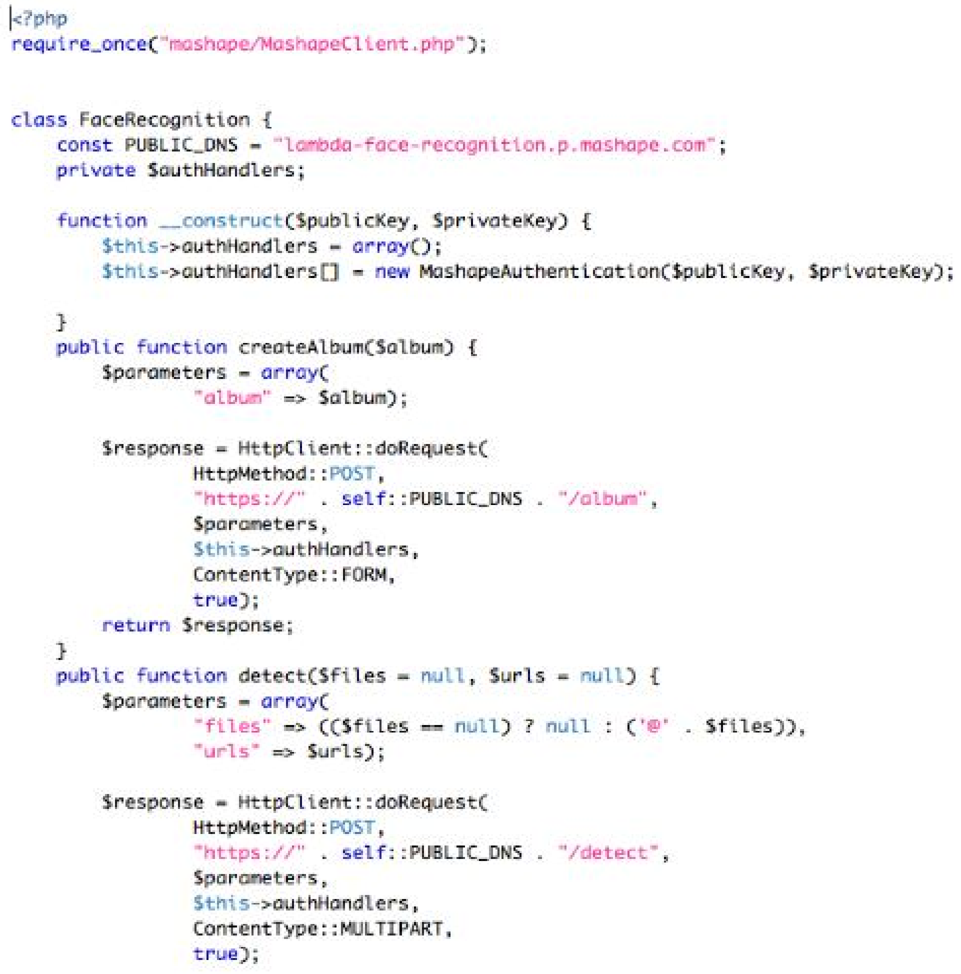
When the user clicks on the button, a hidden video tag will be activated based on JavaScript event listeners that are attached to the button to process this. The frames from this video tag will be passed to a canvas tag that can manipulate each frame as an image to add effects or to save the image and use it elsewhere on the page. In our application, the first frame is taken as a picture and passed from the *canvas* element to the *image* element. The user can then decide to use it for facial recognition or retake another screenshot. The selected picture would then be processed by the server to detect the face and to authenticate or deny the user.

4. Detecting and Recognizing Faces

The Facial Recognition API from Lambda Labs is used in our application for the facial identification and recognition component. This API may be used for free with a limitation number of detects and recognitions of face, which is appropriate for our prototype application modules. In addition to being able to perform face detection and recognition, this API may also perform facial feature extraction, (of the eyes, nose and mouth) and gender classification.

The downloaded client library can be used in languages such as Python, Objective C, PHP and Java. The API uses an album which can be filled with a limited number of pictures for recognition and another limited set of pictures for detection. The album has to be trained to recognize one label with multiple pictures associated to it. Pictures placed into the album can be either URLs or files. Each picture has to be tagged, labeling whom the image represents. The more pictures are in the album for each single individual, the more accurate detection and recognition it will have.

PHP was adopted as the programming language to develop our facial detection and recognition module, with Lambda Labs Face Recognition and Detection API as its supporting package. The facial recognition is used to verify that the picture the user uploads matches a person's stored template. Part of the PHP code is shown in Figure 4.



```php
<?php
require_once("mashape/MashapeClient.php");


class FaceRecognition {
    const PUBLIC_DNS = "lambda-face-recognition.p.mashape.com";
    private $authHandlers;

    function __construct($publicKey, $privateKey) {
        $this->authHandlers = array();
        $this->authHandlers[] = new MashapeAuthentication($publicKey, $privateKey);

    }
    public function createAlbum($album) {
        $parameters = array(
                "album" => $album);

        $response = HttpClient::doRequest(
                HttpMethod::POST,
                "https://" . self::PUBLIC_DNS . "/album",
                $parameters,
                $this->authHandlers,
                ContentType::FORM,
                true);
        return $response;
    }
    public function detect($files = null, $urls = null) {
        $parameters = array(
                "files" => (($files == null) ? null : ('@' . $files)),
                "urls" => $urls);

        $response = HttpClient::doRequest(
                HttpMethod::POST,
                "https://" . self::PUBLIC_DNS . "/detect",
                $parameters,
                $this->authHandlers,
                ContentType::MULTIPART,
                true);
```

Figure 4: Implementing Facial Recognition in PHP

5. Facial Recognition and Distance Learning

In this section we present and describe how our facial recognition module is employed in distance learning and integrated into online learning management systems.

5.1. Using Facial Recognition in Distance Learning

The facial detection and recognition were used in two aspects of distance learning environment. The first one is face based remote-login Web app, in which a user can log in the distance learning based classroom using her/his face and a 4-digit pin code. The pin code greatly speeds up the login process because the facial recognition component now doesn't have to scan the entire face template database.

The second application is an online proctor application. Cheating has always been an issue in educational environment. An effective mechanism to ensure academic integrity in distance learning environment is even more challenging because it is commonly assumed that cheating over quizzes and tests is easier online than in a physical classroom [14]. We therefore developed a facial recognition based online proctor and auditing system that may be integrated into distance learning environment. The proctor and auditing system has the following features:

- The student, as the end user, will initially prompt a login system using her/his face and pin number.
- The verified student will be shown a message that the test is virtually proctored through a camera and remote monitor.
- The student will also be promoted that a randomly chosen image/video footprint may be recorded for auditing purpose.

- The proctor system can be configured to take pictures or video clips after fixed period of time or randomly from time to time. The teacher will be able to use these footprint photos or video clips as necessary.
- The student may put the system in Break Mode for emergency, and the proctor system will lock the screen and record the break information.

5.2. Facial Recognition in Learning Management Systems: An Ongoing Effort

Distance learning is normally managed by learning management systems (LMS). It is therefore highly beneficial and important to have a feasible method to integrate our facial recognition experimental systems into existing learning management systems. Our university is using Sakai [16] learning management system on daily basis. As a result, our ongoing investigation and experiments focus on Sakai.

As a Java based open source learning management system, Sakai provides a development environment that Java developers can be used to smoothly integratetheir Java programs into Sakai core systems. However, our facial recognition prototype was implemented in PHP. In our experiments, we therefore would have to adopt an alternative approach without rewriting our facial recognition modules in Java.

Fortunately, Sakai supports IMS Learning Tools Interoperability (LTI) (17), a standardized way to integrate learning management systems and other software utilities. Both LTI v1.0 and v2.0 are supported by the latest edition of Sakai. In our ongoing experiments, we wrapped our facial recognition code following LTI v1.0 specification because the Sakai system we have installed on our test server is an older edition.

In addition to Sakai, many other learning management systems are available and being used by schools, colleges and universities, such as Blackboard, Moodle, and Dokeos. There are different mechanisms to integrate external software modules into these learning management systems [18]. However, dominant learning management systems are more and more adopting LTI to allow integration with third party software modules. As a result, our ongoing facial recognition/LMS integration method shall work for other LTI-compatible learning management systems.

6. Conclusion

Face identification and recognition have become much more accessible application component as mobile devices and computers are equipped with cameras. It is becoming a natural and secure biometrics feature for user authentication. The new HTML5 and get User Media () API from W3 consortium have empowered Web applications to request permission from users and to use their Web cameras, which therefore can employ facial recognition based services.

In this paper, we first survey generic methods and algorithm for facial recognition. Then we describe our practice and experiments in integrating facial recognition service into a Web based distance learning environment, which make use of a combination of techniques such as HTML5 features, get User Media() JavaScript API, and Face Detection and Recognition API from Lambda Labs. We also describe how facial recognition modules and tools may be integrated into contemporary learning management systems using open and standardized programming paradigm and interfaces.

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