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Research paper

Student Attendance Recording Using Smart Camera Sensor

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Abstract

Recently, studies about face detection technology has been already reach its advanced state. In computer vision field of study, face detection technology is often used to identify someone by imitating how human eye works. Generally speaking, researches on face detection technology utilize regular camera which is embedded with image processing algorithm for image sequence. The approach is different when depth camera is used in face detection study. The process of detection using depth camera is also aided by infrared sensor which provides distance (depth) information and three-dimensional imaging of the object. The purpose of this paper is to design and develop a prototype of student attendance record application. Depth camera is used as an input tool to facilitate the face detection process. The resulting images from depth camera will be processes further in order to recognize student's facial shape. To be able to identify student identity, the face detection process is done using facial geometric approach. This paper will address few issues regarding person identification such as the variation of human face condition (adjustment to the pattern) and variation of the camera position relative to the identify subject. The accuracy of the detection process is calculated to measure overall system success rate. This paper proposes the utilization of depth camera and implements it in a prototype of student attendance record application. Our proposed prototype can accelerate student attendance recording process compared to manual attendance recording process using paper. During several tests, our prototype also shows that it can successfully identify student face both in multi-view and multi-person scenarios.

Keywords: *face detection, face recognition, depth camera, and geometric model.*

1. Introduction

Tracking and identifying human face is one research field area in computer vision. There are many implementations of this study as commercial or noncommercial product for human face recognition. As the development of the implementation technology, researches of human face detection and recognition is very well known in the field of visual information. There are many techniques to capture human faces patterns, store them in a storage (as visual information), and use the stored information as a pattern to recognizing human face. But, this technique needs more space and resources to compute, as the visual information with many variant conditions takes large number of data, both to stored and processed.

In order to overcome this problem, many researchers using advanced technology such as depth camera. Using depth camera, researcher can optimize the computing process because this camera has more input parameter than ordinary camera. But, one of problem using depth camera is how to utilize and optimize depth camera ability to identify moving object with multi-view concept. This paper takes that problem as a main problem to yield a design application in student attendance record as a case of implementation. Besides, this paper is a starting point to build an efficient tool in facial recognition using smart (depth) camera. Smart Camera used in this research in Intel RealSense Technology. Using this camera, this research is built an application to increase facial recognition accuracy both in frontal and multi-view.

The paper result is a design model to use Intel RealSense 3D camera in student attendance case. There are several cases that used in this paper to implement it in the next step research. Design including data that stored, and type of testing that will be held in the next process.

2. Literature Review

Face recognition technology has been developed into mainly technique for biometric-based recognition system. There are several biometric-based recognition technologies such as fingerprint, finger geometry, hand geometry, iris, retina, voice and behavioral traits (such as signatures or gait). Especially for human facial recognition, this biometric-based recognition is widely used to perform verification (one-to-one matching) and identification (one-to-many matching). The difference of these two things is in the process of facial recognition whether it compared to an image or database image.

In several papers that study facial recognition, problem of the implementation's system is caused by the position of camera relative to subject. Frontal view is the ideal condition of facial recognition's system. It means, camera position should be perpendicular to identified subject. This condition should have met because capture image will be compared with image's data point of view (usually, comparing

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image taken in perpendicular view to camera). Unfortunately, this criterion rarely met because of several conditions in implementation such as camera's place or subject movement.

Besides, this frontal view condition is influenced by factors intrinsic and extrinsic factors. Extrinsic factors can be environmental conditions that affect indirectly in facial imaging process, such as illumination, pose, scale, noise, resolution. In other ase, intrinsic factors are caused by to the physical nature of the face and are independent of the observer. Intrinsic factors are divided into two categories: interpersonal and intrapersonal. These categories are affected by conditions in facial feature itself (race, gender, emotions, etc), and external factor as additional feature of the facial's feature (such as: glasses, haircut, and mustache, cosmetic). Zhao et al. explained about general facial recognition system. It can be pictured as the diagram below:

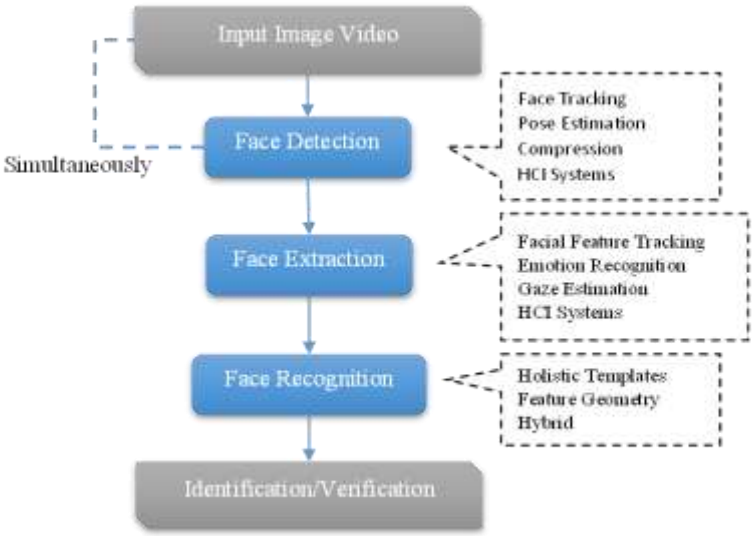


Fig 1: Generic Facial Recognition (Zhao)

Diagram above shows that whole facial recognition is divided into several phase that conducted into specific field of study. First phase is face detection which detect facial feature that determine whether input is a face or not depend the pose of subject, or other parameter. Second phase is face extraction, and lastly there are face recognition itself such as feature geometry, holistic templates, and hybrid method (holistic & feature) (Zhao et al., 2003).

In face detection study, there are 3 categories of method that commonly used: (1) face detection using intensity image, (2) video sequence processing, and (3) sensory data. In intensity image category, it used statistical approach, which analyzes the pixel of image data. The most common method in this approach is LDA. Beside statistical approach, it used neural network approach. (Zhao et al., 2003). In video sequence, analysis of face detection on moving object, segmentation in facial area, and matching pattern of facial feature is basic technique that are done. This process happens in the alteration image of each frame in video sequence. Sensory data is used 3D data of facial image feature with additional tools such as infrared sensor. Using this sensory data, depth point of facial feature, frontal-view image, and 3D model can be a processed input in this stage.

There are many researches that study computer vision with student attendance recording as a case that have to be implemented. Nita Thakare et al. proposed a framework for students that take participation in classroom lecture. In their paper which title Face Detection and Recognition for Automatic Attendance System, they explained that the record of student attendance is utilizing a camera in front of classroom which catching student's picture continuously. System will detect human facial feature in captured image, and mark the attendance of students. Besides, they audit paper with similar case study. There are 4 phases that used in this paper: (1) image acquisition, (2) face detection, (3) feature extraction, and (4) face recognition. Screenshot of their proposed system is pictured in figure below (Thakare et al., 2016).

3. System Overview

Our prototype objective is to verify student's presence using face detection technology. The prototype works through 3 stages. First phase is the construction of master data containing all student's facial feature data. Second phase is student identification using face detection. Finally, third phase is verification of student's presence using the result of second phase (see figure 3 below).

The facial feature data registration is done by capturing and extracting facial feature images from front angle. The extracted images then stored in a student database. After the registration process is successful the system will be able to process student attendance recording. Depth camera is used as capturing device located above entrance door or parallel with student's position. The camera is in active state and immediately detect object movement as soon as student passes through entrance door. System will try to detect face, track its position, followed by rendering a 3D images of student's face. The resulting 3D image will be compared with stored images in order to identify student's identity. If matches were found between 3D images and stored images, then student's identity is identified and student's presence is verified.

Fig 2: 3D Rendering of Face Image

Our prototype is built using Visual C# and utilize depth camera using Intel RealSense SDK. Employing face recognition algorithm, the prototype is able to recognize students both in standard frontal view and multi-view scenario.

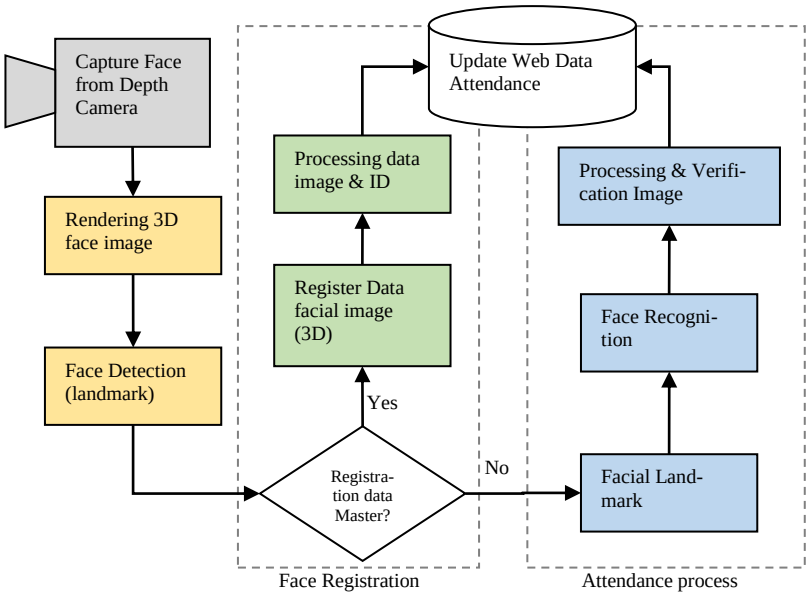


Fig 3: Student Attendance Recording using Depth Camera

Our prototype is also integrated with web-based student attendance system. This web based system stores students image data that are used in order to both identify and verify student's presence using depth camera. After identification and verification has successful, this web-based system also updates student's attendance data.

4. Design & Result

This system will be divided into 2 main processes: facial image registration and student attendance recording process. Detailed descriptions of these processes are explained in Table 1.

Table 1: Design Application of Student Attendance System

Phase	Sub-Phase	Description
Facial Image Registration	Start	System is started
	Camera Shooting	Student face is ready in front of smart camera
	Face Detection	System will detect facial contour and read the pattern of student facial feature
	Face Pattern Registration	Operator save the feature or pattern from previous process
	Manual Input of Label	Operator give id into feature/facial pattern that save from the previous process
Student Attend-ance Recording	Start	System is started
	Camera Shooting	Student face is ready in front of smart camera
	Face Detection	System will detect facial contour and read the pattern of student facial feature
	Face Recognition	Based on the facial feature from previous process, facial is compared to the system data stored.
	Attendance Recording	If facial feature/pattern is recognized, system will write the student attendance into data-base of academic purpose

In this paper, we explained several libraries (process) that will be used in the next process.

a. Library Main Screen

This library is a main screen that shows human face in the screen. It can be more than one face in the screen, but this library will adjust to read the first human facial feature that captured by camera.

b. Library Face Tracking Indicator

By default, this library process shows human face tracking indicator. Tracking rectangle adjust its size depend on user's face. If subject moving forward or backward, tracking rectangle will grow or shrink depend on the subject's facial feature's size. Markers face will dis-appear, and the border surrounding the Image control will turn red, when the user moves out of range of the camera.

c. Library Registering a User

This library process will register user information into system. Request of registering data will be held by clicking "Register User" button.

d. Library Unregistering a User

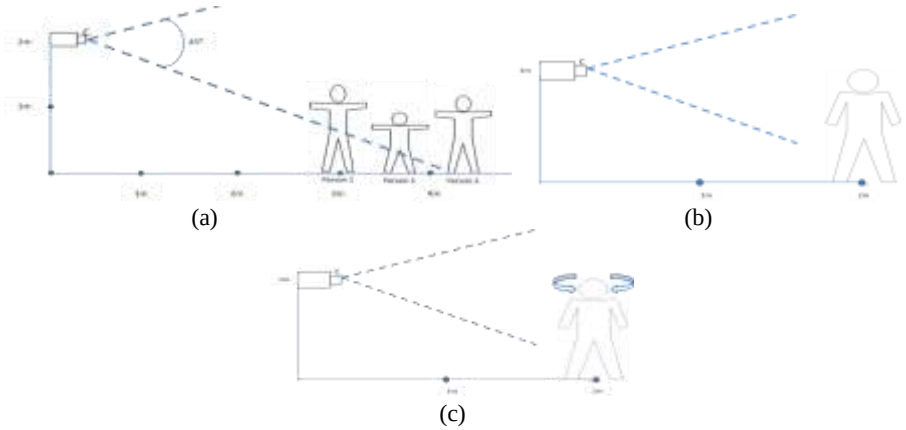
This library has contradiction functionality with previous library process. Registered subject can be removed from the system data stored. Request of this action will be implementing with "Unregister User" button.

e. Recognition

Recognition process is a process that compares facial feature captured by camera with facial feature in system's database. If system recognizes the feature, next process is reading database of student academic record. This process will search for student id attendance schedule. There are several conditions that have met to make system write the presence of student.

f. Recognition Condition Case

In order to capture the data in frontal and multi-view condition, we decide several test case regarding camera angle, camera distance and face angle relative to camera.



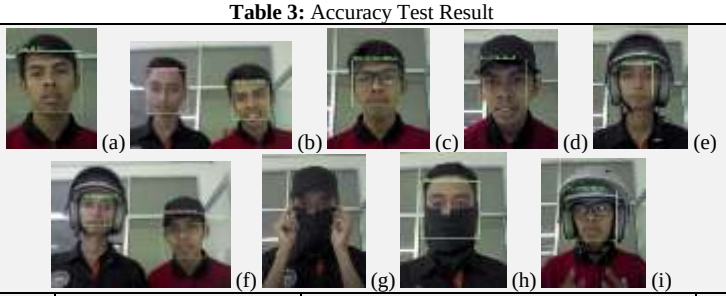
(a) (b)

(c)

Fig 4: Angle Test Condition (a), Distance Test (b), Face Angle Relative to Camera (c)

Furthermore, we experiment by adding more face(s) and adding noise objects that may interfere with face recognition process. Table 3 below shows that both number of face(s) and amount of noise objects play roles in face recognition accuracy.

Table 3: Accuracy Test Result



(a) (b) (c) (d) (e) (f) (g) (h) (i)

Condition	Number of face(s)	Amount of Noise object	Result
(a)	1	0%	Success
(b)	2	0%	Success
(c)	1	5% , (eyewear)	Success
(d)	1	10-15% , (cap)	Success
(e)	1	15-20% , (helmet)	Success
(f)	2	15-20% , (helmet and cap)	Success
(g)	1	60-70% , (cap and masker)	Failed
(h)	1	50% , (masker)	Success
(i)	1	40-50% , (helmet and eyewear)	Success

The test result justifies that our prototype still manages to accurately identify students despite of added noise object such as eyewear, helmet, cap and masker. Our prototype performs just fine up to 60% added noise, especially when certain facial features are covered, such as mouth, nose and forehead.

A test is also conducted to measure required time in both using conventional (paper) method compared to using our prototype. The manual conventional student attendance recording process takes 40-50 seconds in average while using our prototype the required time is shown in table below.

Table 3: Time Elapsed Test Result

N	Number of Face	Success (time)	Fail (%)	Mean time (second)
1	2	99	1 %	2.01
2	4	97	3 %	4.47
3	6	96	4 %	5.10

4	8	93	7 %	8.56
5	>8	90	10 %	9.16

The elapsed time required for face recognition process is highly depends on number of comparison data and hardware specification. The camera position and number of faces also takes into account as multi-view and multi-person scenarios tend to require more time and resulting in lower success rate. Overall, our prototype works just fine in multi-view, single person scenario.

5. Result and Discussion

Face recognition algorithm implementation using depth camera has successfully accelerated student attendance recording process. Student presence is successfully confirmed through frontal view facial detection within 2-5 seconds, far much faster compared to conventional student attendance recording that requires 40-50 seconds. Accuracy-wise, our prototype still need to be further improved and enhanced, especially in order to deal with change in either camera position or object angle in multi-view scenario.

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