

Summer Internship Final Report

Report Title:

Face Detection and Tracking

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Summary

For this summer internship, my project title was Face Detection and Tracking. When I met with my advisor Dr. Yan Meng, she told my group members and I the topic. She then gave us an overview of the project. I informed her that I had never taken any Image Processing courses before, so she provided me with some resources which would give me a background for the project. She informed me that it must be written in C++, which is a programming language that I had studied before. My first thought on this project was it would not take the entire group to complete this project entirely all summer. After a couple of weeks from studying about face detection and tracking, the group decided to begin programming. While programming, I came across many obstacles. As many people probably have experienced, programming can cause hours of frustration and many headaches. The thing which really hurt was when my computer crashed and my work was gone. But I bounced back from that and started to backup my files. During my coding I commented it thoroughly, which would make it easily to read and understand for the years to come.

Introduction

Face detection is the foundation of a facial recognition system. Face detection, detects a person's face by either facial features or from using skin color. I know there are many pros and cons for both cases. For instance, people facial features differ in many aspects, and of course there are many different skin colors. But for this project, I think I wanted to go through by using facial features.

Background

Binary Image Processing

Because processing and thresholding do not usually provide an entirely satisfactory segmentation of the image into features and background, editing or processing of the binary image is also an important step. The black and white or binary image is easy to perform operations on, and so these processes are often quite fast. There are two basic types of operations - morphological operations that add or remove pixels based on the pattern of neighboring pixels, and Boolean operations that combine several binary images using logical operations on each pixel.

A binary image is a digital image that only has two only two possible values for each pixels. Binary images are also called bi-level or two-level. (The names black-and-white, B&W, monochrome or monochromatic are often used for this concept, but may also designate any images that have only one sample per pixel, such as grayscale images.) Binary images often arise in digital image processing as masks or the result of certain operation such as segmentation, thresholding, and dithering. A binary image is usually stored in memory as a bitmap.

Initial Assignments

Face Tracking

Face tracking was researched by Coney Dorsey, but for the first week or so, I did some research on about the topic. Face tracking in this project would be able to draw box around the face and track the image until it was out of the vision of the camera. The faces should have been tracked in real times (thirty frames per second). Dr. Meng realized that the face detection portion was to enormous for one person to complete so I teamed up with James Ashenhurst.

Face Detection

Face detection is the foundation of a facial recognition system.. The purpose of face detection is to identify and locate human faces in an image regardless of the position, scale, in-plane rotation, pose (out-of-plane

rotation) and illumination. Have you wondered why face detection is so important? The reason is face detection is the first step in a facial recognition system and usually is the first step in many surveillance systems. Face recognition is biometric identification by scanning a person's face and matching it against a library of known faces. Face detection, detects a person's face by either facial features or from using skin color. Trying to detect a person's facial features usually means that the person would be facing the camera. Many face detection programs have been completed, but some of them already have a database which has the images stored and it goes through the database to search for the image that is close to the image which it has received. The reason why this is not good for this project because for this project the program must be able to detect faces in real-time.

Detecting faces using skin color seemed that it might have been easier. It is common to think that different people have skin-colors which differ significantly from each other due to the existence of different races. However, what really occurs is a larger difference in brightness / intensity and not in color. The goal of skin detection is to group pixels to form possible face candidate regions and then use connected components analysis for pixels grouping. In order to detect the facial feature in scale invariant, the possible face candidate regions will be normalized, and then texture

information in these regions will be segmented by means of mean and variance of face region.

While researching face detection, the group came across a Reading People Tracker. We thought that maybe we could use this as example and improve the algorithm. But we realized that this program detected motions in an empty room first, and then detect the motion afterwards. We could not use this because in the future it is maybe used on mobile cameras.

Conclusion

In conclusion, being here at Stevens Institute of Technology this summer has been a really good learning experience. Before I came to Stevens, I did not know anything about Image Processing. I really didn't give face detection and tracking any consideration before now. After being here for twelve weeks, I have expanded my knowledge. I have learned the basic concepts of face detection and tracking. I realized that even though a project has been complete it can always be ways to improve the project. I had especially learned that you should always make a back up copy of any work you are doing. I think that Stevens Institute of Technology has a wonderful Electrical and Computer Engineering Department. I would like to thank Stevens Institute of Technology for giving me the opportunity to study here and do my best to improve my project.

References

Group Members

<http://cldorsey0.tripod.com/>

<http://cs.oberlin.edu/Members/jashenhu/REU/>

Reading People Tracker

http://www.siebel-research.de/people_tracking/reading_people_tracker/

Face Detection

<http://vision.ai.uiuc.edu/mhyang/face-detection-survey.html>

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http://www.stanford.edu/class/ee368/Project_03/Project/reports/ee368group08.pdf

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Binary Image Processing

http://www.absoluteastronomy.com/encyclopedia/b/bi/binary_image.htm

<http://www.reindeergraphics.com/tutorial/chap6/binary01.html>

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Appendix

Week 1

The first week here at Stevens Institute of Technology, I meet my advisor, which is Dr. Yan Meng. She gave the group a topic on Face Detection and Motion and Tracking. She gave me Motion and Tracking. After receiving the topic, she told me that Coney Dorsey and I will work on this project together. Also we must conduct a C++ program that would detect an image once it is in the range of the camera. Now I am doing research on the actually process on how we should go by making the program. I have researched different websites and read several handouts given to us by Dr. Meng.

Week 2

The second week doing research was a quite fun. At the beginning of the week I search for related sites that had information on Motion and Tracking. I found website that had program functions that would be helpful for programming the C++ program. Basically, with the motion and tracking it takes the object and it has detected and tracks it movement. Dr. Meng informed us that our program should run in real-time. At the beginning of this week, I was instructed to help out on the face detection part of the

program. Face recognition is biometric identification by scanning a person's face and matching it against a library of known faces. But in our project faces will not be stored, faces will be recognized by our camera. Dr. Meng gave us a website which she thought that would be helpful. Now in my project I should try to detect a person's facial feature. I found in the website that she gave us different ways to detect the facial features. One way was to formulate as a problem to find the correct geometric arrangement of facial features. But Dr. Meng also gave us advice that maybe it would be a way to detect a person's skin, because the person may not always be facing the camera or some of their features are not visible.

Week 3

This week, I collaborated with my partner and we decided that we could come up with a General Image Process Library. I analyzed the documents that was present to me and determined which would be helpful for our project. I tried to understand the formula on detecting skin in the face detection problem. The goal of skin detection is to group pixels to form possible face candidate regions and then use connected components analysis for pixels grouping. In order to detect the facial feature in scale invariant, the possible face candidate regions will be normalized, and then texture

information in these regions will be segmented by means of mean and variance of face region. My partner and I reviewed some source code and tried to understand it. We later realized that this particular source code was not usable for our purpose. We then decided that it was a good guideline that we should follow. Then my partner and I went to http://www.siebel-research.de/people_tracking/reading_people_tracker/ and we saw how they had created a detecting program and thought that it was neat.

Week 4

Processing Color

Processing color is much faster than processing other facial features and, furthermore, color is orientation invariant under certain lighting conditions. It is common to think that different people have skin-colors which differ significantly from each other due to the existence of different races. However, what really occurs is a larger difference in brightness / intensity and not in color.

RGB

RGB is a colorspace originated from CRT (*cathode-ray tube*) display applications, when it was convenient to describe color as a combination of

three colored rays (red, green and blue). It is one of the most widely used colorspace for processing and storing of digital image data.

Skin Classifier

One method to build a skin classifier is to define explicitly (through a number of rules) the boundaries skin cluster in some colorspace.

Example:

(R,G,B) is classified as skin if:

$R > 95$ and $G > 40$ and $B > 20$ and

$\max\{R,G,B\} - \min\{R,G,B\} > 15$ and

$|R-G| > 15$ and $R > G$ and $R > B$

Three Types of Skin Modeling

Parametric- The parametric Gaussian models assume that skin colour distribution can be modeled by an elliptical Gaussian joint probability density function.

Nonparametric- Nonparametric skin modeling methods estimate skin colour distribution from the training data without deriving an explicit model of skin colour.

Explicit skin cluster- Classifier which expressly defines the boundaries of the skin cluster in certain colour spaces. The underlying hypothesis of methods based on explicit skin clustering is that skin pixels exhibit similar colour coordinates in a properly chosen colour space.

Week 5

At the beginning of week 5 we had a group meeting. During week 5, I explored websites and found some functions that was beneficial in my program. I also can up with some Use Cases and Scenarios. I also meet with a group member and looked at demos that he found on the computer which were similar to ours.

Functions

int RCobj_InitFaceDetect(int img_width, int img_height)

This function initialised the face detector with the given image dimensions.

int RCobj_detectfaces(SAFEARRAY **img)

Detects faces within the given bitmap array. Returns the number of faces detected.

void RCobj_getObject(int index, int &tx, int &ty, int &bx, int &by)

Given the index number of the detected face this function returns its bounding box within the bitmap image.

void CFacedetectApp::RCobj_getObject(int index, int &tx, int &ty, int &bx, int &by)

Return the position of a detected object

int CFacedetectApp::RCobj_detectfaces(SAFEARRAY **bmp)

Detect objects within the image

```
void CFacedetectApp::RCobj_detectfeatures(int index, int  
&lateral_symetry, int &lefteye_x, int &righteye_x, int &lefteye_y, int  
&righteye_y, int &mouth_y, int &mouth_width)
```

Detect facial features for the given face index

Week 6

During week 6, I began to start writing my program for the face detection. I used some of the functions that I found in my program. While I was program, I compiled my program to see if it had errors and if so I corrected them. My hard drive collaped and I can't get the program off of the computer yet. But I am in the process of trying to retrieve the information. Once the program is off the computer I will post the program on my website.

Week 7

For the first part of the week, I was still without a computer. I thought maybe I would have to purchase a new. Then Coney fixed it for me and all the programming which I had done was lost. So I began to start programming again. But this time I made a back file of them. I compiled the portion which I had done and had some errors. I then used **C++ How to Program 4th Edition** to help me debug my errors.

Week 8

During Week 8, I continued to program for the project. I came across some difficulties, which took a lot of research to overcome. But later on that week my computer crashed again. This makes the second time. But I had made a backup of most of the program and the portion which was deleted is trivial. So the next couple of weeks, I will continue to write my code and began on my final report.

Week 9

- Continued writing code for the program
- Tried to correct the errors in the program
- Collaborated with group member about our project
- Tried to fix my computer
- Began working on final report

Week 10

- Continued to program
- Tried to fix errors
- Worked on final report

Week 11

- Worked on errors to have program working.
- Finished final report