Master thesis plan

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Participants

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Document history

Version	Date	Changes	Sign	Reviewed
0.1	January 29, 2016	First Draft	AM	MD, EL
0.2	February 5, 2016	Minor changes after comments from MD and EL, added section data generation	AM	MD
0.3	February 8, 2016	Changes to the problem specification	AM	LA
0.4	February 17, 2016	Grammatical corrections and clarification of method, date of half time	AM	LA
1.0	April 5, 2016	Approved by LA	AM	LA

1 Introduction

The amount of technical tools available for forensic analysis in law enforcement increases rapidly and today there exist millions of devises capable of taking relatively sharp images. Video surveillance cameras, security cameras and cellphone cameras can all be used to catch perpetrators in the act. The videos and still images can be used as evidence for identification during trails which means that forensic technicians need tools to evaluate if the suspect is the same person as the one caught on camera.

Forensic technicians use still images to compare visible features between suspect a and a perpetrator in order to determine whether it is the same person. This is done manually and is time consuming which is why there is an interest in creating methods and standards which could do the comparison automatically [1]. To create automatic methods the facial features have to be detected, classified, and located. The most common facial marks are moles, pockmarks, freckles, scars, and acne. Some of these marks are not permanent, e.g. acne usually heals without leaving any marks, while scares and moles remain the whole life [2]. Skin marks which can be used for identification are called "Relatively Permanent Pigmented or Vascular Skin Marks" (RPPVSM) and they have to be relatively permanent, common and also be observable without any special equipment. [3]

When the pattern of facial marks has been determined and compared with a suspect, the forensic technicians give a specialist report to he court. The report states how probable it is that the suspect is the perpetrator. In order to give this statement they need to know the probability that two persons can have the same facial mark pattern. To know this there is a need of statical information about the occurrence and position of facial marks within the population [4].

This thesis work will focus on developing an automatic system which can automatically detect and position RPPVSM in human faces, in order to get reliable statistics about facial marks in the population.

2 Title suggestion

This thesis will result in a thesis report which must have a appropriate title. The first suggestion is:

> "Automatic detection and localization of relatively permanent pigmented or vascular skin marks"

3 Problem specification

The aim of this thesis is to examine the possibilities of automatically detecting and locating facial marks and classifying them as permanent or non-permanent marks. Several different segmentation and digital image processing algorithms for detecting facial marks will be explored. The thesis will also investigate how to create a facial grid from facial landmarks, in order to give the facial marks a position.

4 Boundary

In general, when working with image, the quality of the images are crucial for the results. Low resolution and badly illuminated images taken from different angles can cause analytical difficulties. Therefore, in this thesis we are only going to us images which:

- Have a high resolution
- Are well illuminated
- Are taken en face
- Are in RGB-colours

5 Method

A functional automatic system for facial mark detection should consist of several smaller subsystems, see fig. 1. All these subsystems require images from a database and since only faces are of interest, the background has to be removed in every examined image. This step is called face segmentation and the output is sent to the skin mark detector and the face region generator. When the RPPVSM are separated from other skin marks and the region they belong to, a validation of the algorithm is performed. If the results from the validation are satisfying, the algorithm can be used on a larger database to generate statistical information about the occurrence and location of RPPVSM.

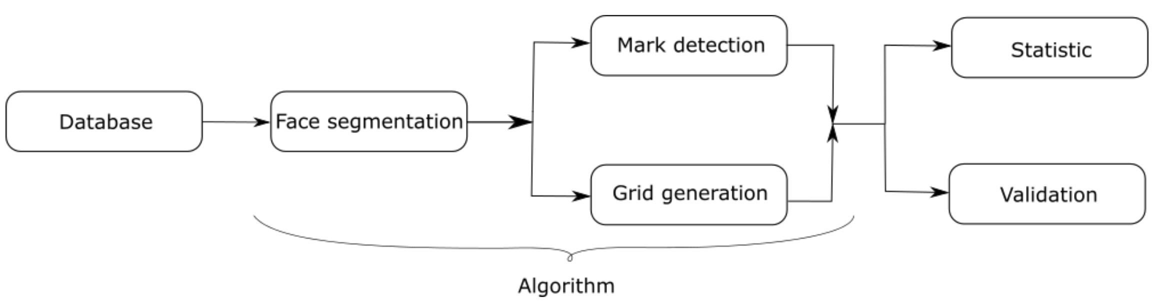

Figure 1: Work flow for the whole system

5.1 Face segmentation

The main idea of face segmentation is to use simple threshold methods to create binary masks and also use edge templates. [5] To facilitate the segmentation I will use the Color Names descriptor [6], which is based on the 11 most common colours in the English language. The segmentation can also be done by finding the contour of the faces, if time allows it.

5.2 Skin mark detection

The skin mark detector consist of smaller parts, fig. 2. When the image is imported, it has to be pre-processed by canceling the illumination variations, and face normalizing by centering the eyes and setting the interpupillary distance to a specific pixel distance. [2]. To visualize certain colours better the RGB-image can be transformed into other colour spaces, such as pink and grey. [6].

With the pre-processed image, the detection of marks can begin. The detection can be done with edge detection and segmentation algorithms such as watershed [7, 8]. The Fast Radial Symmetry Detector (FRSD) used by Nisha Srinivas et al. [2] will be investigated if time allows it.

These detection methods result in mark candidates and among them there will surely be some false positive detections. The false detections will be excluded if they are located in regions with a lot of hair and do not have a blob shape. This is the post-processing step. [2]

When there only remains true facial marks, they have to be separated into RPPVSM and transient marks. The classification step is done by training a radial kernel Support Vector Machine (SVM) and using it to classify the detected marks.

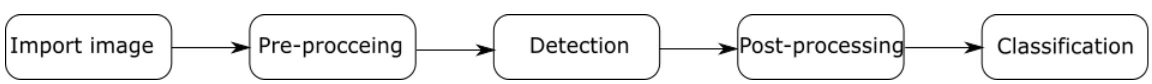

Figure 2: Work flow for the detection of the facial marks

5.3 Face region generation

The face region generator, fig. 3, will be based on landmark detection and then the facial grid is generated by drawing straight lines between the landmark points. [9, 10] The number of regions and the shape of them is decided by the customers since they have a insight how they want the statistic to look like.

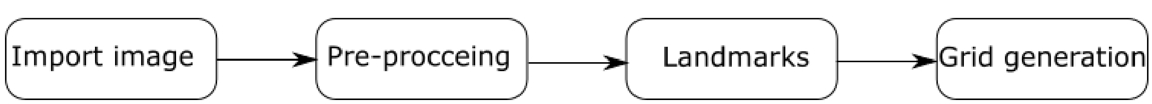

Figure 3: Work flow for the generation of region in the faces

5.4 Data generation

In order to validate the algorithm a set of training and test data has to be generated. To get the required data set, a simple GUI will be created where the mentors from NFC can set bounding boxes over facial marks. The marks are labeled permanent respectively non-permanent. The mentors will also provide facial images which will be labeled.

5.5 Validation

Validation of the algorithm will be done by comparing the output with the ground truth on a number of images. The data used for this will consist of 100 images at first since the generation of training and test data is quite laborious. The number of images can of course be increased if needed. 75% of the images will be used as training data and the remaining 25% as test data. To get an average, the data will be cross validated which means that the training data and test data is alternated.

The measurement for validation will be the accuracy of the confusion matrix, but also the precision and recall will be used for the validation. Since the algorithm will use fixed thresholds and parameters the validation results for different parameter settings will be displayed in Receiver Operating Characteristic (ROC) graphs.

Since it is facial marks which will be detected there has to be a definition of what counts as a true respectively false detection. The most natural way to do this is to determine the ratio between the intersection area and union area of the detected and true skin marks. When the ratio is greater than a specified amount, e.g. 50%, it counts as a true detection, otherwise it is a false detection.

5.6 Statistic

To document the occurrence and location of RPPVSM the algorithm will be used on a larger database. Which database that should be used will be decided later.

6 Literature base

Several references has been mentioned in section 5 and most of them are of real interest. The main article which is covering the problem formulation well is "Human Identification Using Automatic and Semi-Automatically Detected Facial Marks" [2]. It covers some pre-processing and post-processing methods and also the facial mark detection which makes it a good reference. It is a new and reliable source since Richard W. Vorder Bruegge is known by the costumers.

The face segmentation form "A novel approach towards detecting faces and gender using skin segmentation and template matching" [5] looks promising and it is a new publication. For landmark detections there are several algorithms but the one from "Detector of Facial Landmarks Learned by the Structured Output SVM" [9] has implemented algorithm in C++ which is useful for this thesis work.

The use of other colour spaces has proven useful in earlier works done by the thesis worker. By using the colour spaced described in "Learning Color Names for Real-World Applications" [6] it can facilitate the detection algorithm.

7 Time plan

This section describes how the time will be distributed between different tasks and parts during the thesis work. The time given for this thesis work is 800 hours and a working day (d) is usually 8 hours. This means that the time resources is 100 work days for this thesis work. The time is distributed between the different task in table 1.

Table 1: Time consumption for different tasks, time is counted in number of work days (d).

Task	**Time (d)**	**Description**
Thesis plan	12	Writing a plan for the thesis work
Data generation	7.5	Create training and test data for validation and classifier
Face segmentation	3	Implement face detection and segmentation
Landmarks	3	Implement facial landmark detection
Grid	5	Implement face region
Pre-processing (Detector)	8	Implement pre-processing algorithms for the detector
Detection (Detector)	12	Implement detector algorithms for the detector
Post-processing (Detector)	12	Implement post-processing algorithms for the detector
Classification	6	Implement a SVM classifier
GUI	4	Create a graphical user interface
Validation	5	Generate results and validate the main algorithm
Thesis report	20	Writing the thesis work
Presentation	1	Presentation of master thesis
Opposition	1	Opposition of an other thesis work
Reflection	0.5	Writing reflection document
SUM	100	Summation of the time

Some relevant milestones are listed in table 2. These are just goals for the thesis work and the aim is to reach each milestone at the end of the week. The date in brackets represents Friday for each corresponding week.

Table 2: Milestones

Week (date)	**Description**	**Comment**
3 (22/1)		
4 (29/1)	First draft of thesis plan	Thesis plan has been sent to MD
5 (5/2)		
6 (12/2)	Thesis plan sent to LA	The thesis plan has been sent to LA
7 (19/2)	Thesis plan approved and data generator	Generation of training data is possible and thesis plan has been approved by LA
8 (26/2)	Facial Grid	The face region works generator
9 (4/3)		
10 (11/3)		
11 (18/3)		
12 (25/3)	Half time report + Rough detector	Present the progress and preliminary results to LA, MD, EL and NA The detector find all facial marks with no post-processing
13 (1/4)		
14 (8/4)		
15 (15/4)	Algorithm functional	The algorithm function and may need fine
16 (22/4)		tuning
17 (29/4)	Results and validation	
18 (6/5)	First complete draft of thesis report	Thesis report has been sent to MD
19 (13/5)		
20 (20/5)		
21 (27/5)	Final version of thesis report	Thesis report has been approved by LA
22 (3/6)		
23 (10/6)	Thesis presentation	

The most important date which are regarded as deadlines are listed in table 3.

Table 3: Important dates

Date	**Description**
23/3	Half time report
6/5	Thesis report has been sent to MD
27/5	Thesis report has been approved by LA
10/6	Thesis presentation

8 Expected results for half time presentation

For the half time report, it should be possible to present a results from a functional face region generator. There should also exist a rough facial mark detector which finds all candidates of facial marks but can't separate RPPVSM, transient mark and false detection, e.g. facial hair.

References

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