Master thesis plan

Armand Moulis

January 28, 2016

Participants

Master thesis worker

Name	Role	Email	Abbreviation
Armand Moulis	Thesis worker	armand@moulis.se	AM

Experts and mentors

Name	Role	Email	Abbreviation
Niclas Appleby	Mentor at NFC	elisabet.leitet@polisen.se	NA
Elisabet Leitet	Mentor at NFC	niclas.appleby@polisen.se	EL
Lasse Alfredsson	Examiner	lasse.alfredsson@liu.se	LA
Martin Danelljan	Expert at LIU	martin.danelljan@liu.se	MD

Contents

Document history

Version	Date	Changes	Sign	Reviewed
0.1	January 28, 2016	First Draft	AM	

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 comparing visible features between suspect and perpetrator in order to determine whether it is the same person. This is done manually and is time consuming which is why there exist an interest in creating methods and standards which could do the comparison automatically. [1] To create automatic methods the facial features has 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 remains 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 can be observed without 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 do 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. [Källa NFC????]

This thesis work will focus on developing a 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 position of relatively permanent pigmented or vascular skin marks (RPPVSM)"

3 Problem specification

To generate statistical data of the presence of facial marks in specific regions in human faces it would be effective to do this automatically. Thus, is it possible to detect and locate facial marks and separate them into permanent respectively non-permanent marks automatically. Several different

segmentation and digital image processing algorithms will be explored to detect facial marks and divide the face into regions.

4 Boundary

When working with images, in general, the quality of the images are crucial for the results. Low resolution and badly illuminated images taken from different angles can cause analytical difficulties. This is why this thesis are only going to use 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 uses images from a database and since only the face is of interest the background has to be removed. This step is called face segmentation and the output is sent to the skin mark detector respectively the face region generator. When the RPPVSM are separated from the other skin marks and which 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.
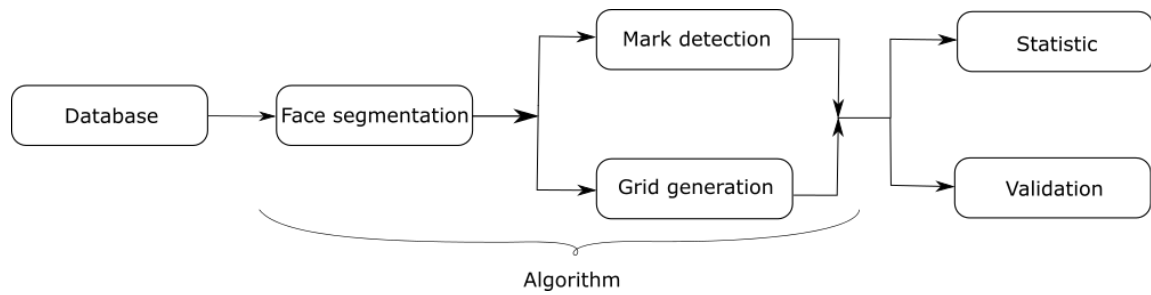
Figure 1: Work flow for the whole system

5.1 Face segmentation

The main idea for face segmentation is to use simple thresholds to create binary masks and also some use edge templates. [4] It would also be interesting to use the 11 most common colours in the English language as colour spaces when trying to segment out the face. [5]

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 cancelling the illumination variations and normalizing face by centring 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, grey and HSV. [5].

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. It would also be interesting to use the Fast Radial Symmetry Detector (FRSD) used by Nisha Srinivas et al. [2].

These detection methods result in mark candidates and among them there will surely be some false positive detections. The false detections will be excluded by removing candidates within regions with a lot of hair and candidates which 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.
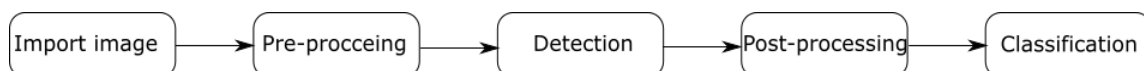

Figure 2: Work flow for the detection of the facial marks

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. [6, 7] 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.
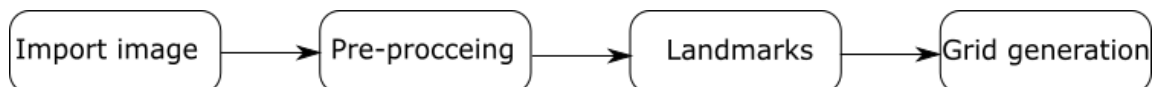

Figure 3: Work flow for the generation of region in the faces

3

5.4 Validation

Validation of the algorithm will be done by comparing the output with the ground truth on a couple of images. The data used for this will consist of 100 images and 75% of them will be uses as training data and the remaining 25% as test data. To get a average it will perform a cross validation which means that the training data and test data will alternate.

The measurement for validation will mainly be the accuracy of the confusion matrix but also the precision and recall will be used for the validation. Since algorithm will use fixed thresholds and parameters it would be of interest to display the validation results for different parameter settings in a Receiver Operating Characteristic (ROC) graph.

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 ration between the intersection area and union area of the detected and true skin marks. When the ratio is greater than this ration, e.g. 50%, it counts as a true detection, otherwise it is a false detection.

5.5 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 Reference 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" [4] looks promising and it is new publication. For landmark detections there are several algorithms but the one from "Detector of Facial Landmarks Learned by the Structured Output SVM" [6] 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" [5] 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.

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	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	97.5	Summation of the time

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)	Thesis plan approved	Thesis plan has been approved by LA
6 (12/2)		
7 (19/2)	Facial Grid	The face region generator works
8 (26/2)		
9 (4/3)		
10 (11/3)		
11 (18/3)	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
12 (25/3)		
13 (1/4)		
14 (8/4)		
15 (15/4)		
16 (22/4)	Algorithm functional	The algorithm function and may need fine tuning
17 (29/4)		
18 (6/5)		
19 (13/5)	Results and validation	
20 (20/5)	First complete draft of thesis report	Thesis report has been sent to MD
21 (27/5)	Final version of thesis report	Thesis report has been approved by LA
22 (3/6)		
23 (10/6)	Thesis presentation 10/6	

In table 2, the time is divided into weeks and the date in brackets represents Friday in the corresponding week.

Table 3: Important dates

Date	Description

8 Expected results for half time presentation

References

[1] Bruegge R.W.V. Spaun N.A. Forensic identification of people from images and video. In *Biometrics: Theory, Applications and Systems.*

[2] Richard W. Vorder Bruegge Ph.D. Nisha Srinivas M.Sc., Patrick J. Flynn Ph.D. Human identification using automatic and semi-automatically detected facial marks. *Journal of Forensic Sciences*, 61(S1):117–130, September 2015.

[3] Siu-Yeung Cho Craft N. Nurhudatiana A., Matinpour K. Fundamental statistics of relatively permanent pigmented or vascular skin marks for criminal and victim identification. In *Biometrics (IJCB)s.*

[4] Soumyadeep Halder Debasish Kundu Sudipta Ghosh Sauvik Das Gupta Partha Das, Anirban Sarkar. A novel approach towards detecting faces and gender using skin segmentation and template matching. In *Signal Processing and Integrated Networks (SPIN).*

[5] Jakob Verbeek Diane Larlus Joost van de Weijer, Cordelia Schmid. Learning color names for real-world applications. *IEEE Transactions on Image Processing*, 18(7):1512–1523, July 2009.

[6] Michal Uřičář, Vojtěch Franc, and Václav Hlaváč. Detector of facial landmarks learned by the structured output SVM. In Gabriela Csurka and José Braz, editors, *VISAPP '12: Proceedings of the 7th International Conference on Computer Vision Theory and Applications*, volume 1, pages 547–556, Portugal, February 2012. SciTePress — Science and Technology Publications.

[7] Ramanan D. Xiangxin Zhu. Face detection, pose estimation, and landmark localization in the wild. In *IEEE Computer Society Country of Publication:.*