Capabilities of automatic and manual face morphing

Jannis Priesnitz[1], Julian Thomae[2]

Abstract: In a common scenario one passport including its biometric features belongs to one person. This and only this person *should be* successfully matched to the biometric picture which is in the persons passport in the situation of an Automatic Border Control (ABC). But what if two or more persons are successfully matched to one passport? With the procedure of morphing faces, it is possible to get a promising acceptance rate for both persons. This work compares an automatic with a manual approach for creating morphed faces. In addition the region, in which an sufficient match rate for both persons is reached, is determined to hide the second face as good as possible from manual inspection.

Keywords: Face morphing; face detection; automatic border controls

1 Introduction

Face recognition systems have become one of the most popular biometric authentication methods in the last years. It is based on the fairly unique biometric characteristic of a human face. One of their advantages are the property of a contactless capturing the face images with help of an arbitrary high resolution camera system which highly accepted by the data subjects. In addition to this, the capability of a visual inspection instead of an automatic process is one of the reasons why face recognition is selected as authentication method for biometric passports. The basic idea is simply to observe certain properties of the human face, such as the shape of the head or wrinkles and furrows, and place landmarks on characterizing points.

Hier könnte noch kurz aging und posing rein.

Since 2002 face recognition is used as identity confirmation in the electronic Machine Readable Travel Document (eMRTD) by the International Civil Aviation Organisation (ICAO). This means every eMRTD issued by an governmental organisation contains an facial image which has to follow certain properties in order to support the machine based automatic verification.

? cite

cite / improove

In several countries, such as , it is possible to provide own printed pictures to the issuing

... Spain?

[1] University of Applied Sciences Darmstadt, Department of Computer Science, Schöfferstraße 3, 64295 Darmstadt
jannis.priesnitz@stud.h-da.de
[2] University of Applied Sciences Darmstadt, Department of Computer Science, Schöfferstraße 3, 64295 Darmstadt
jueliant@gmail.com

organisation. This practise leads to the possibility of processing on the photo and therefore altering the biometric data set stored in the eMRTD. Of course these alterations form a potential attack vector on the Automatic Border Control systems (ABC) . A feasible attack would be an alteration in the way that another individual than the one which the passport is issued to is recognized by the ABC or both individuals are recognized as the same person.

introduce earlier

To achieve this the face of the issuing individual and an attacker has to be morphed together. The goal onthis process is to provide a morphed photo to the issuing instance which visually nearly identical with the issuer but automatically accepts both, the issuer and the attacker. Having reached this both, the issuer and the attacker are able to show up at the ABC system and both will be accepted.

whitin?

What are we doing on the topic?

OPT: erweitern welche Ansätze von face detectoin gibt es grundsätzlich?

Outline

label + ref

The rest of this paper is organized as follows: In ... we provide some details on the topic of face detection followed by describing the procedure of morphing faces. ... deal with the selected detection algorithm and gives some details on our test setup. Finally in ... the result of test subjects are discussed followed by a conclusion in ... .

2 Database and selection of test subjects

how many?

number

As test sample a data set of XXXICAO compliant pictures were given. In order to get promising morph results, a subset of XX pairs of photos were selected for manual morphing 3.3 where as the automatic morphing algorithm 3.2 was applied on all data sets. For manual morphing only pairs with a visually high coincidence are considered because the aceptance rate of the comparison algorithem is expected to be higher. In summation XX manual and XXX automatic morphs are issued in this paper.

ICAO conformance beschrieben

FaceDB

3 Morphing of Faces

The main task during the morphing of two pictures is to detect characteristics and place landmarks as an advince for the algorithm. This can be done completely automatic or with support of an user. In this paper both way are discussed.

3.1 Basic idea

For every morph there were 15 images created from 0% of Subject 1 to 100%, respectively the remaining % of Person 2. So the are images combined of:

- 1. Picture: Person 1 100% - Person 2 0%
- 2. Picture: Person 1 92,86% - Person 2 7,14%
- 3. Picture: Person 1 85,71% - Person 2 14,29%
- 4. Picture: Person 1 78,57% - Person 2 21,43%
- 5. Picture: Person 1 71,43% - Person 2 28,57%
- 6. Picture: Person 1 64,29% - Person 2 35,71%
- 7. Picture: Person 1 57,14% - Person 2 42,86%
- 8. Picture: Person 1 50,00% - Person 2 50,00%
- 9. Picture: Person 1 42,86% - Person 2 57,14%
- 10. Picture: Person 1 35,71% - Person 2 64,29%
- 11. Picture: Person 1 28,57% - Person 2 71,43%
- 12. Picture: Person 1 21,43% - Person 2 78,57%
- 13. Picture: Person 1 14,29% - Person 2 85,71%
- 14. Picture: Person 1 7,14% - Person 2 92,86%
- 15. Picture: Person 1 0% - Person 2 100%

say something on this + make tabular

3.2 Automatic morphing

3.3 Manual morphing

In contrast to the automatic face morphing approach, manual morphing is discussed in this section.

To achieve morphes, the open source software GNU Image Manipulation Software (GIMP) (Version 2.8.16) with the GIMP Animation Package (GAP) (Version 2.6) was selected for this process. Morphing with GAP follows the simple approach of manually placing connected landmarks at characterizing points in both faces. In 1 two pictures with a setup of landmarks are shown. It can be observed, that the landmarks are placed at characterizing points in both faces, e.g. at the eye browns, lips and nose. The general shape of the face as well as the shape of the head including the hair is also respected. In the example the facial landmarks are close to each other whereas the landmarks describing the shape of the hair are farer apart.

The selection of characterizing points is based on *erkenntnissen* from earlier works on the topic of automatic face detection, to achieve an optimal morphing result in these sections and .

regions?

cite handbook of bio p.60

[VP05]

cite these fancy mp4 thingy

The algorithm shifts the landmarks from face one to face two. In addition to this the color of the skin is transmitted.

For the test samples 100 - 125 landmarks were placed, depending on the face characteristics. The output contains a sequence of 30 photos which show different stages of the morphing procedure. In figure 2 a two subjects and three morphing stages (5, 15 and 25) are shown. The visual inspection of **??** shows biometric features of both subjects whereas **??** and **??** has more similarity to the closer subject but also covers features of the other subject. A manual post production of the morphs is not necessary because potential revealing details, like the interference of the clothes, glasses or hair is not considered as characteri

?

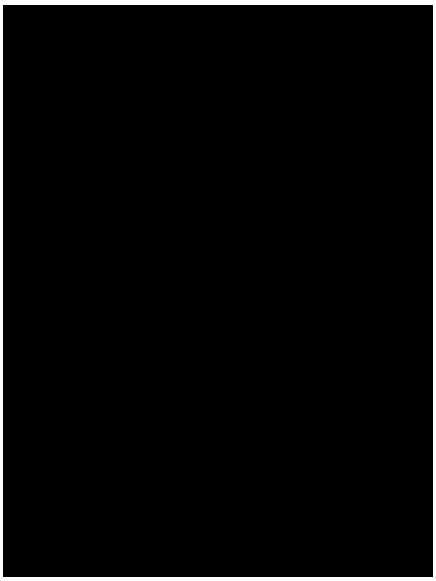
Results

compare to automatic results when there.

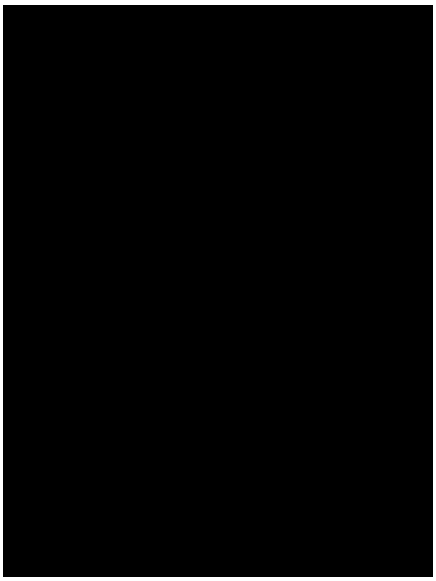
Detailed description of the morphs

(a) Subject 1 (b) Morph no. 5

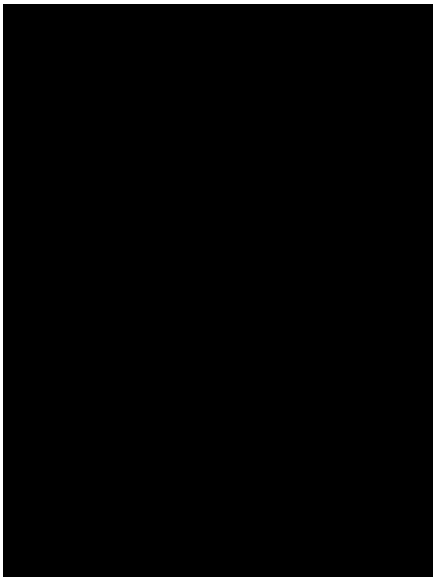
Fig. 1: Example of two ICAO compliant photos (1a and 1e) and morphs at stage 5 (1b), 15 (1c) and 25 (1d)



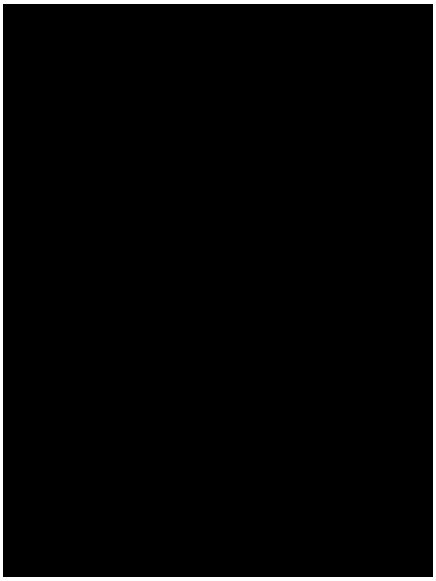
(a) Subject 1



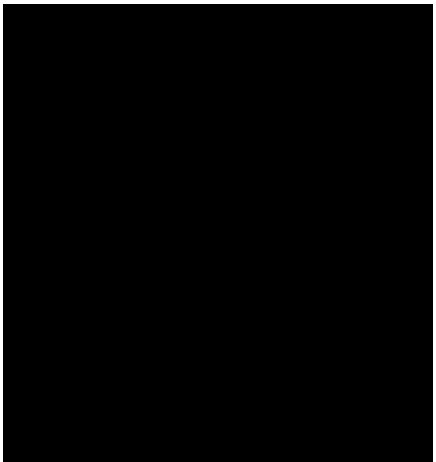
(b) Morph no. 5



(c) Morph no. 15



(d) Morph no. 25



4 Face detection

Detection algorithm

As face detection algorithm the open source software OpenFace was selected. OpenFace is based on a neural network with is fully trained and has high confidence rates in the shipped version. Because OpenFaces main goal is to detect faces on arbitrary photos, the accuracy level is expected to be higher if it works on ICAO compliant data sets.

Process of work

Both of the two source photos and the sequence of 30 morphs is given as input to the OpenFace comparison algorithm. OpenFace computes the match rate of every morph to both of the two photos. The expected outcome of comparison algorithm is an almost equal match rate for morph no. 15, where both pictures are represented to 50%. The closer the morph gets to one of the original pictures the higher the match rate and the lower to the other picture.

mention match rates of sample pictures in fig 1

hier distances abstrakt beschreiben

beschreiben welcher thershold gewählt wurd und warum

5 Results

Resulting from the work are the squared l2distances calculated with the program openface.

rename

The distance shows the similiarity to the given subjects. A lower distance means the compared two persons are more equal, when the distance is under a given threshold, these two persons are accepted to be the same person and so access is given. The resulting morphed photos were compared to diffrent photos of both subjects, to get a independend distance. 3.1

5.1 Distances

manual machen und von automatisch abgrenzen

5.1.1 Subset of 5 morph sets (from subjects also used by Budrhani)

All resulting squared l2 distances for the morphed photos of subjects 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23

to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 compared to the corresponding compare images are way too many data. So there is as an example the morphed photo 01-m-002-27 to 01-m-003-24:

Picture	01-m-002-28.jpg	01-m-002-29.jpg	01-m-002-30.jpg	01-m-003-25.jpg	01-m-003-26.jpg	01-m-00
1	0.11916	0.07499	0.19188	1.30874	1.16709	
2	0.13701	0.06885	0.18756	1.25716	1.10248	
3	0.17384	0.06523	0.19060	1.17656	1.01354	
4	0.22901	0.07982	0.21253	1.08009	0.90457	
5	0.31766	0.12439	0.24763	0.89989	0.70834	
6	0.39700	0.16766	0.30990	0.83492	0.62518	
7	0.50975	0.24823	0.40167	0.72848	0.51501	
8	0.67400	0.39087	0.53792	0.60985	0.39251	
9	0.74737	0.46525	0.58010	0.52552	0.32146	
10	0.94108	0.62628	0.74969	0.40924	0.21060	
11	1.05918	0.76321	0.86483	0.32472	0.13804	
12	1.21209	0.90143	0.99503	0.25177	0.08833	
13	1.25246	0.97993	1.05583	0.19876	0.05832	
14	1.34758	1.07654	1.14637	0.19252	0.04679	
15	1.37122	1.13813	1.18339	0.14941	0.05522	

Also shown in figure 3.

The results of the 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23 to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 morphs are shown in figure 4.

For better recognizability the mean value of all the diffrent squared l2 distances is calculated for Person 1 and Person 2. The result is shwon in figure 5.

As visible the lowest distance to both persons is at Picture 9 (Person 1 42,86% - Person 2 57,14%) wtih a minimal distance of **0.485**.

Openface uses normally a threshold of **0.99**, which allows nearly all morphs from Picture 5 to 10 to be successfull acknowledged as shown in figure 4. Only in 3 cases there is the distance way too high to work properly. The compared photos are 01-m-016-24.jpg, 01-m-016-25.jpg and 01-m-016-26.jpg from the same person, so this morph is not working. As a result in 4 out of 5 cases it is possible to morph two subjects to be successfull acknowledged, this makes a sucess chance of 80%.

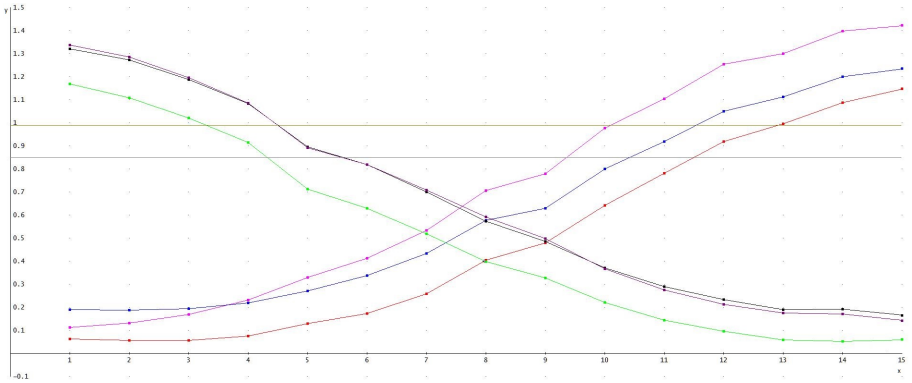


Fig. 3: Squared l2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24 (with 15 steps ont he x axis) comparing to 01-m-002-28.jpg, 01-m-002-29.jpg, 01-m-002-30.jpg, 01-m-003-25.jpg, 01-m-003-26.jpg and 01-m-003-27.jpg

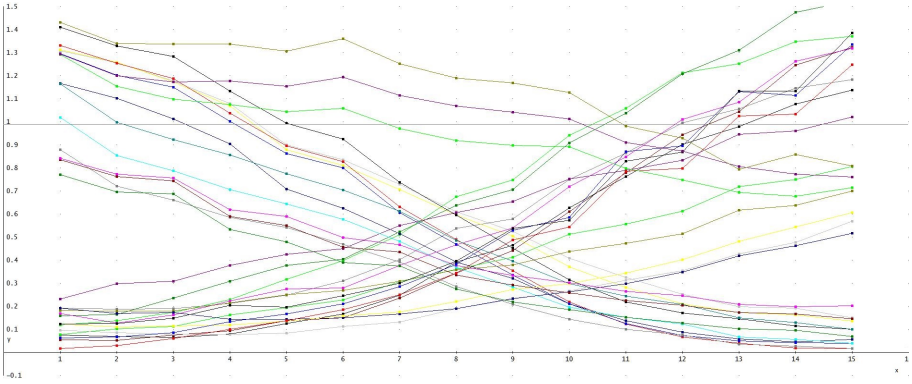


Fig. 4: Squared l2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23 to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 (with 15 steps on the x axis) comparing to the corresponding compare photos

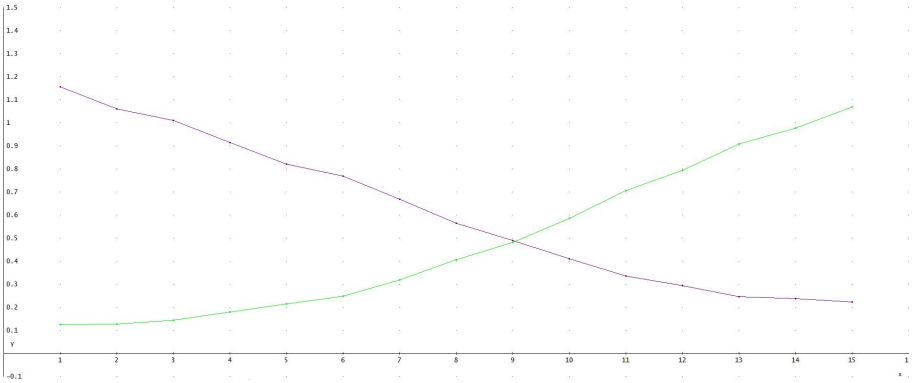


Fig. 5: Mean squared l2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23 to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 (with 15 steps on the x axis) comparing to the corresponding compare photos

5.1.2 Subset of 39 morph sets

Now 39 sets of morphed subjects were used. The used subjects are:

- 01-m-002 - 01-m-003
- 01-m-003 - 01-m-004
- 01-m-004 - 01-m-005
- 01-m-013 - 01-m-014
- 01-m-016 - 01-m-017
- 01-m-019 - 01-m-020
- 01-m-020 - 01-m-021
- 01-m-021 - 01-m-022
- 01-m-022 - 01-m-023
- 01-m-025 - 01-m-026
- 01-m-026 - 01-m-027
- 01-m-030 - 01-m-031
- 01-m-031 - 01-m-032
- 01-m-032 - 01-m-033
- 01-m-037 - 01-m-038
- 01-m-038 - 01-m-039
- 01-m-039 - 01-m-040
- 01-m-040 - 01-m-041
- 01-m-041 - 01-m-042
- 01-m-042 - 01-m-043
- 01-m-043 - 01-m-044
- 01-m-044 - 01-m-045
- 01-m-045 - 01-m-046
- 01-m-046 - 01-m-047
- 01-m-047 - 01-m-048
- 01-m-048 - 01-m-049
- 01-m-051 - 01-m-052
- 01-m-052 - 01-m-053
- 01-m-053 - 01-m-054
- 01-m-054 - 01-m-055
- 01-m-055 - 01-m-056
- 01-m-059 - 01-m-060
- 01-m-060 - 01-m-061
- 01-m-065 - 01-m-066
- 01-m-066 - 01-m-067
- 01-m-069 - 01-m-070
- 01-m-072 - 01-m-073
- 01-m-073 - 01-m-074
- 01-m-074 - 01-m-075

With these sets again the squared l2 distance is computed to the associated compare images

of the two subjects. The resulting distances are shown in figure 6. To decrease the amount of information the mean values for both subjects were computed and are shown in figure 7.

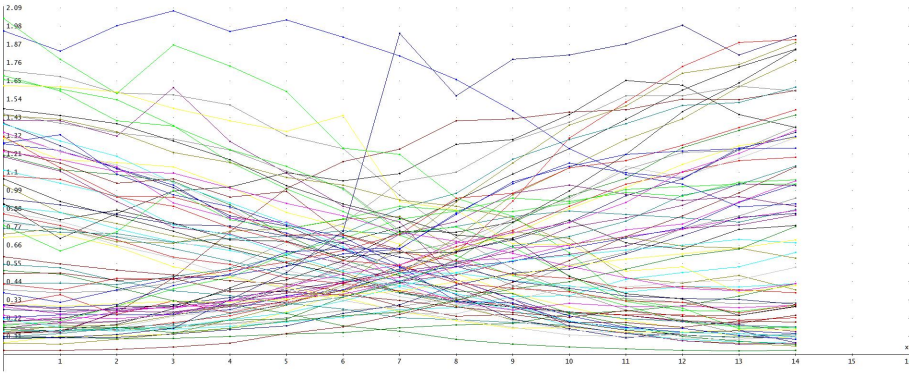


Fig. 6: Squared l2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) comparing to the corresponding compare photos

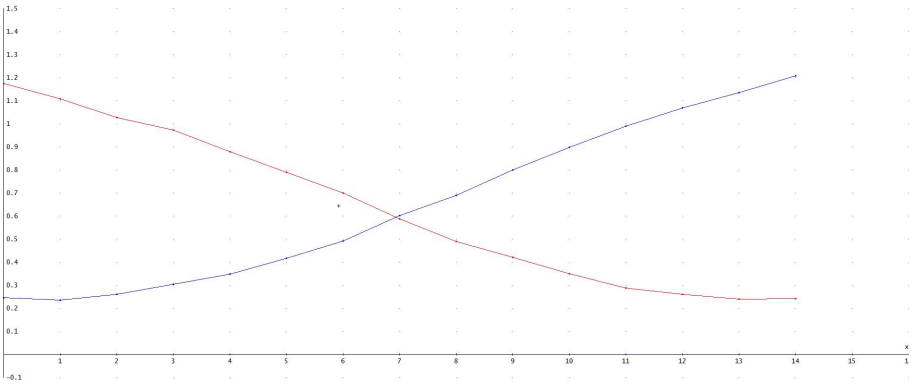


Fig. 7: Mean squared l2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) comparing to the corresponding compare photos

5.2 Threshold

richtige Bezeichnungen raussuchen

As a result a threshold is computed to get a 10% false accept and a 90% chance to right decline a morphed image.Used for the calculation is the subset and its distances of section 5.1.2. The resulting threshold for this subset is 0.78666402. In contrast to the distances it is shown in figure 8.

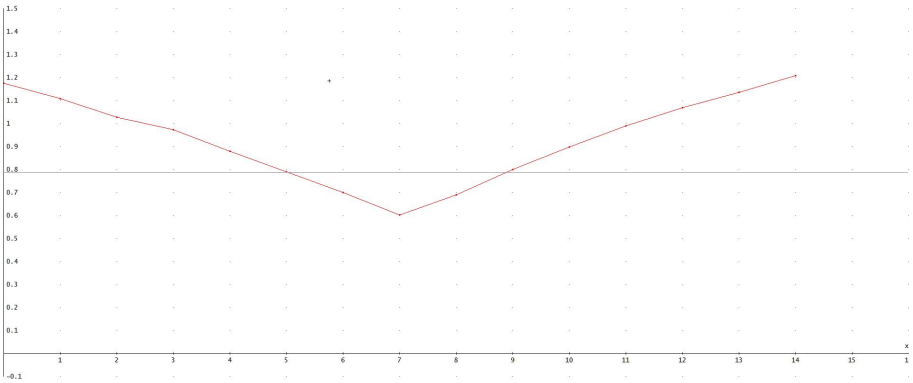


Fig. 8: Squared l2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) compared to the corresponding compare photos, in contrast to the calculated threshold of 0.78666402

manual machen und vergleichen

6 Conclusion

7 Further topics

ungemorpht vorvergleichen

Morphen von mehreren bildern

References

[VP05] Vukadinovic, Danijela; Pantic, Maja: Fully automatic facial feature point detection using gabor feature based boosted classifiers. In: Systems, Man and Cybernetics, 2005 IEEE International Conference on. volume 2. IEEE, pp. 1692–1698, 2005.