

Capabilities of automatic and manual face morphing

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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. Beside the issues of the naturally aging of the face, posing, a external influences like lightning or camera properties, intentionally alterations on the picture could be done, to reduce or improve the acceptance level of the recognition system.

DONE Hier könnte noch kurz aging und posing rein.

Since 2002 [Ri16] 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 [dI].

DONE cite / improve

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In several countries, it is possible to provide own printed pictures to the issuing organisation. This practise leads to the possibility of processing on the photo and therefore altering the biometric data set stored in the eMRTD. A feasible attack would also be an alteration in the way that another individual, than the one which the passport is issued to, is morphed into the photo. Of course these alterations form a potential attack vector on the Automated Border Control systems (ABC) . Automated border controls are automated self-service barriers which compare the photo stored in a biometric passport to a just in time taken photo or video. This process was selected by the ICAO as standard process for automated immigration checks which mainly takes place as airports [Ri16].

OBSOLETE introduce earlier

Especially morphing the biometric data from two subjects into one photo is feasible alteration. If the alteration was successful, are recognized as the same person by the ABC.

in / whitin?

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 are able to show up at the ABC system and both will be accepted.

Morphing can be either done by an algorithm which is completely automatic or by manually setting the landmarks and perform the morphing automatical. In this work, we will compare both processes with respect to the acceptance rate of a face detection algorithm.

DONE What are we doing on the topic?

OPT erweitern welche Ansätze von face detectoin gibt es grundsätzlich?

1.1 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 acceptance

rate of the comparison algorithm is expected to be higher. In summation XX manual and XXX automatic morphs are issued in this paper.

how many men women?

2.1 ICAO compliance

To fulfil ICAO compliance, a picture has to meet several properties. The whole face should be shown as well as the right and left half. The face, without the hair, should cover 70 - 80 % of the photo and should be in a centered position without any rotations. The photo has to be sharp, clear and contrasty in all sections and should be enlightened homogeneously in all passages without reflexions. As background and single collared contrasty surface without shadows should be selected. The subject has to look into the camera directly. Especially if the subject wears glasses, reflections should be avoided and the eyes must not be covered by parts of the glasses. The pose should be neutral and the mouth has to be closed. The wearing of headpieces is omitted but can be permitted e.g. because of religious reasons or long lasting head injuries[dl].

All photos used in this work are ICAO compliant or nearly ICAO compliant, with respect to the above criteria. Some of the pictures had the wrong format (the subject was too close to camera). These photos were reformatted to meet the standard with digital post production. It can be ruled out that the post production has any effect on recognition algorithm.

DONE 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 advance 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 brows, 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.

regions? The selection of characterizing points is based on *erkenntnissen* from earlier works on

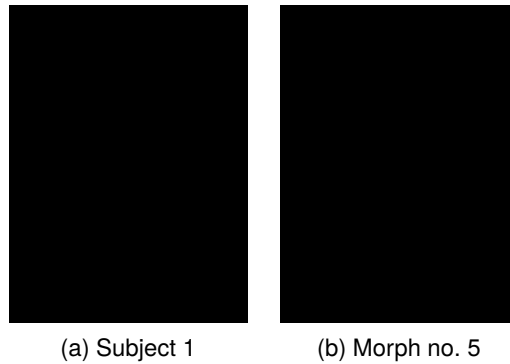


Fig. 1: Example of two ICAO compliant photos (1a and 1e) and morphs at stage 5 (1b), 15 (1c) and 25 (1d)

the topic of automatic face recognition, to achieve an optimal morphing result compared with own estimation based on the individual appearance of the subjects. .

[VP05]

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. 2e

Results

In figure 2 a two subjects and three morphing stages (5, 15 and 25) are shown. The visual inspection of 2a shows biometric features of both subjects whereas (e) and 2d 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 by the algorithm.

Detailed description of the morphs

cite handbook of bio
p.60

cite these fancy mp4
thingy

compare to automatic
results when there.

?

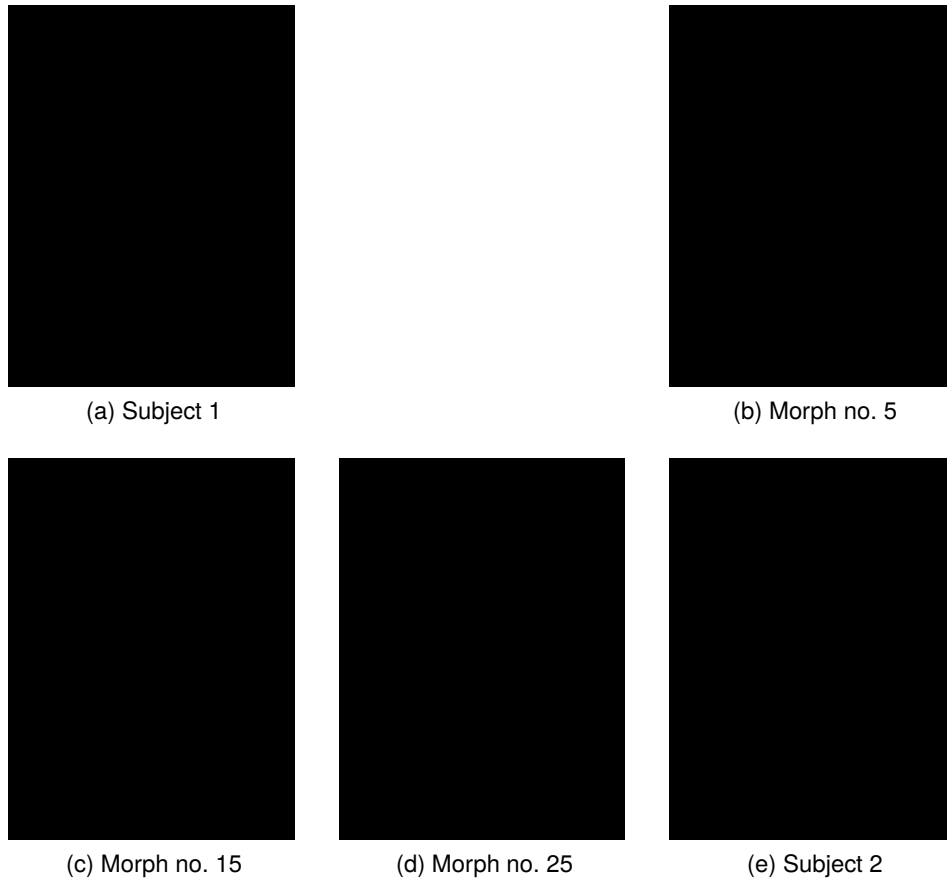


Fig. 2: Example of two ICAO compliant photos (1a and 1e) and morphs at stage 5 (1b), 15 (1c) and 25 (1d)

4 Face detection

Detection algorithm

As face detection algorithm the open source software OpenFace was selected. OpenFace is based on a neural network which is fully trained and has high confidence rates in the shipped version. Because OpenFace's 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 threshold gewählt wurde und warum

5 Results

Resulting from the work are the squared l2 distances calculated with the program openface. The distance shows the similarity 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 different photos of both subjects, to get an independent distance. 3.1

rename

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-003-27.jpg
1	0.11916	0.07499	0.19188	1.30874	1.16709	1.10248
2	0.13701	0.06885	0.18756	1.25716	1.10248	1.01354
3	0.17384	0.06523	0.19060	1.17656	1.01354	0.90457
4	0.22901	0.07982	0.21253	1.08009	0.90457	0.70834
5	0.31766	0.12439	0.24763	0.89989	0.70834	0.62518
6	0.39700	0.16766	0.30990	0.83492	0.62518	0.51501
7	0.50975	0.24823	0.40167	0.72848	0.51501	0.39251
8	0.67400	0.39087	0.53792	0.60985	0.39251	0.21060
9	0.74737	0.46525	0.58010	0.52552	0.21060	0.13804
10	0.94108	0.62628	0.74969	0.40924	0.13804	0.08833
11	1.05918	0.76321	0.86483	0.32472	0.08833	0.05832
12	1.21209	0.90143	0.99503	0.25177	0.05832	0.04679
13	1.25246	0.97993	1.05583	0.19876	0.04679	0.05522
14	1.34758	1.07654	1.14637	0.19252	0.05522	
15	1.37122	1.13813	1.18339	0.14941		

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 different squared l2 distances is calculated for Person 1 and Person 2. The result is shown in figure 5.

As visible the lowest distance to both persons is at Picture 9 (Person 1 42,86% - Person 2 57,14%) with 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 successfully 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 successfully acknowledged, this makes a success chance of 80%.

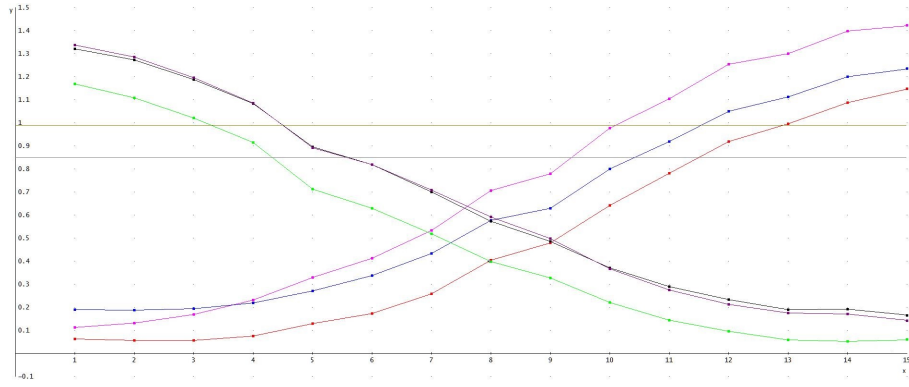


Fig. 3: Squared L2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24 (with 15 steps on the x axis) comparing to 01-m-002-28.jpg, 01-m-002-29.jpg, 01-m-002-30.jpg, 01-m-003-25.jpg, 01-m-003-26.jpg and 01-m-003-27.jpg

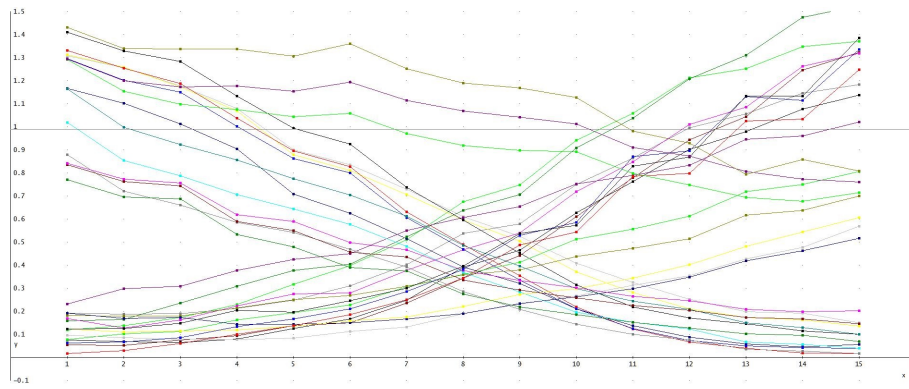


Fig. 4: Squared L2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23 to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 (with 15 steps on the x axis) comparing to the corresponding compare photos

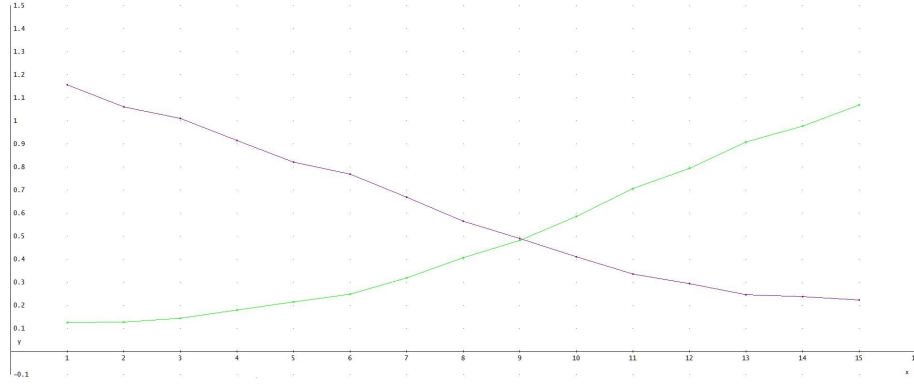


Fig. 5: Mean squared l2 distances (y axis) of morphs from 01-m-002-27 to 01-m-003-24, 01-m-003-24 to 01-m-005-23, 01-m-004-23 to 01-m-005-23, 01-m-010-23 to 01-m-013-23 and 01-m-014-23 to 01-m-016-23 (with 15 steps on the x axis) comparing to the corresponding compare photos

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

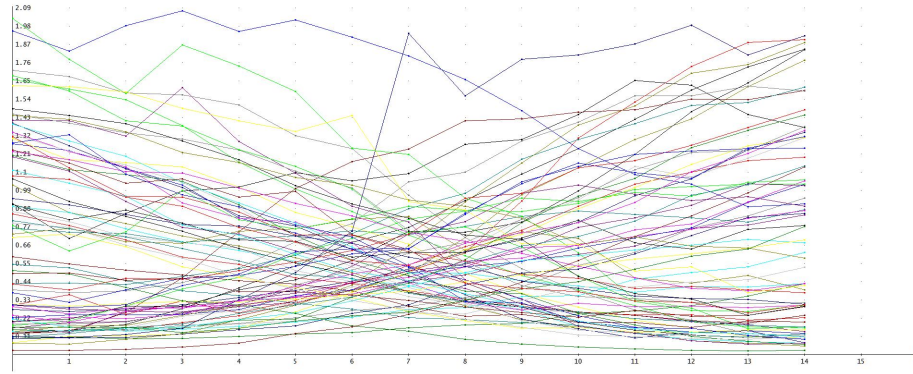


Fig. 6: Squared L2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) comparing to the corresponding compare photos

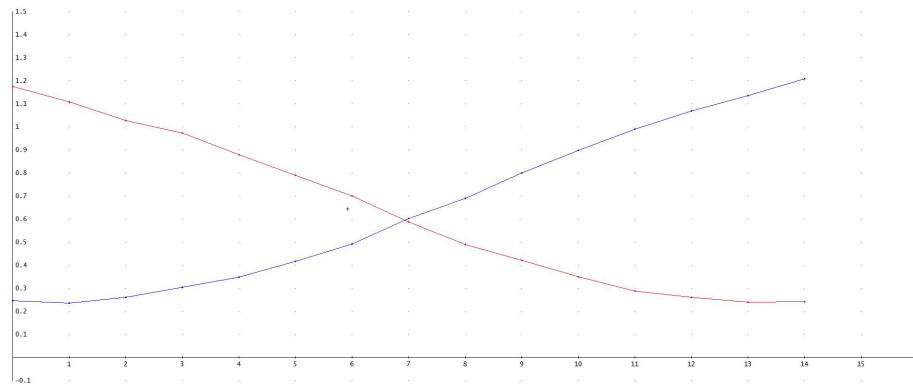


Fig. 7: Mean squared L2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) comparing to the corresponding compare photos

5.2 Threshold

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.

richtige Bezeichnungen
raussuchen

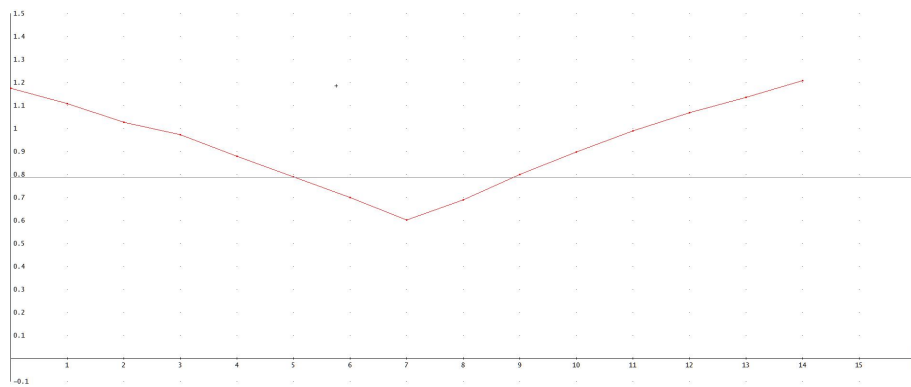


Fig. 8: Squared L2 distances (y axis) of the subset of 39 morphs (with 15 steps on the x axis) compared to the corresponding compare photos, in contrast to the calculated threshold of 0.78666402

manual machen und vergleichen

6 Conclusion

It takes about 40 minutes to achieve a high quality manual morph with GIMP GAP.

7 Further topics

ungemorphet vorvergleichen

Morphen von mehreren bildern

References

- [dI] des Innern, Bundesministerium: Verordnung über Personalausweise und den elektronischen Identitätsnachweis (Personalausweisverordnung - PAuswV).

- [Ri16] del Rio, Jose Sanchez; Moctezuma, Daniela; Conde, Cristina; de Diego, Isaac Martin; Cabello, Enrique: Automated border control e-gates and facial recognition systems. *computers & security*, 62:49–72, 2016.
- [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.