Rapportage about testing of the 3D motion correction

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I. Introduction

The 3D motion correction algorithm that is created in the earlier report only had the option to be corrected with a reference face from the same constructed scan .abs file. But for a fully working correction the correction has to be done on an average face, such that it is applicable for every face that is being scanned. Which will need another method to evaluate the 3D motion correction algorithm.

This report describes the method that is used for testing and evaluating the 3D motion correction that has been created to correct for 3D motion. The report has to conclude if the 3D motion correction is an option of correcting for movements during 3D scans. So the goal is to find out the performance of the 3D motion correction algorithm.

II. Method

The old method that is being used to determine the movements inside the .abs files uses the same .abs files to correct for the movements. This can only be done for the same .abs file as every new 3D face recording differs a bit due to the placement and orientation of the face. The face can be a bit rotated or moved when comparing it to the same face measured at another 3D face scan. This is also the reason that a .abs average face is not a possibility for correcting movements by comparison. First the faces have to be registered on the same point system. For the new method, which is listed below, a register program is used to conclude whether movements can be detected inside the .abs files.

1) Generate a distorted face (Ft)
2) Generate an average face in .sfi file (Sav)
3) pick timeline i in Ft and generate n variations Ft(x,y)
4) register all variations Ft(x,y)
5) interchange .sfi files to txt files Si(x,y)
6) in matlab store n times abs(Si(x,y)-Sav)
7) Txy(i) = argmin(abs(Si(x,y)-Sav))
8) repeat this for every timeline i

III. Data

As test data one .abs face is used for every test situation. The .abs face has to have a movement shift inside the region of its eyebrows downwards till the mouth. Because the other parts of the face are being removed by the register program. This .abs face will be shifted with one extreme shift movement with a sine wave inside and a really small movement that only consists of four small movements of a pixel row. Both situations will be compared to their actual face and the average reference face. These .abs movements are chosen to check whether some single movements or extreme movements can be deduced from the actual and average face.

IV. Measurements

It is expected that the maximal movements inside a .abs file can be up to a shift of one pixel. So the maximal shifts that are able to appear if only the x,y planes are considered will be according the matrix below. The numbers represent the order they will be plotted. Do note that this matrix is the representation to what the best option is for fitting. Which means that the opposites are the actual movements that the face has made.

$$\begin{vmatrix} -\Delta x, +\Delta y(1) & 0, +\Delta y(2) & +\Delta x, +\Delta y(3) \\ -\Delta x, 0(4) & 0, 0(5) & +\Delta x, 0(6) \\ -\Delta x, -\Delta y(7) & 0, -\Delta y(8) & +\Delta x, -\Delta y(9) \end{vmatrix}$$

The measurements would have a perfect outcome if the movements are detected with the average face as a reference. It would be unacceptable if none of the movements are recognized.

The face that is being used as a test face for the motion correction consists of i = 480 y-lines. The lines from the range i = 85 till i = 323 are to be found inside the registered picture. So only movements between that range have a purpose, as this range of registration is also used for 3D face recognition. Because forehead lines do often look like each other there will be less difference by shifting the y- line than at the positions around the nose. To test the motion correction the start position is chosen to be at i = 172, which is the start of the nose bone. The test .abs file with the small movements has the following movements on i = 172 to i = 175

- i = 172 has a movement in the +x - direction
- i = 173 has a movement in the -x - direction
- i = 174 has a movement in the +y - direction
- i = 175 has a movement in the +x and +y - direction

The extreme movements has a sine wave in the face and several height shifts. But it has the following movements in the tested range of i = 172 to i = 177

- i = 172 has no movement
- i = 173 has a movement in the +y - direction
- i = 174 has no movement
- i = 175 has a movement in the +x - direction
- i = 176 has a movement in the +x - direction
- i = 177 has a movement in the +x and +y - direction

V. Results

The plot results of the small movements .abs file can be shown below. The plots made from the extreme movements are placed inside the Appendix, as there are a lot of plots and the results are largely the same. The x-axis represents the movement that is tested. The movements are numbered at the matrix from the Measurements header. The y-axis represents the absolute difference between the derived .sfi files and the average .sfi (or FRGC face .sfi). If for example the absolute error of the -x-y moved line .sfi is the lowest, there will be a minimum at (7) on the x-axis. Which stands for that (7) is the best option, to move the line with -x and -y direction, but the distorted face had a shift to +x and +y direction. Every line from 172 to 175 is plotted and checked if their movement can be corrected for. Every step the FRGC face is used to determine if the right movements can be detected. The average face is used to determine if these movements can also be detected if it is not corrected for at the same facial structure.

The distorted face is being transformed with the results that are deduced from the motion correction on the average face. So if the motion correction results in the lowest absolute difference at (5), there will be no movement for this line. If the lowest absolute difference is at (8) there will be a -y direction shift.

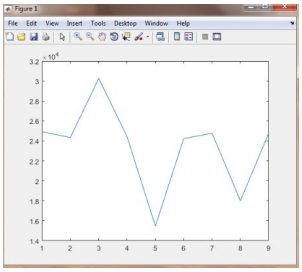

Fig. 1: The FRGC face with shifted line 172

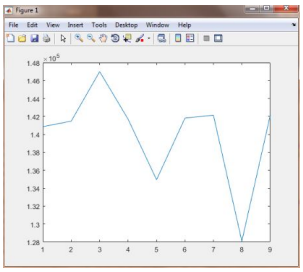

Fig. 2: The average face with shifted line 172

The FRGC face has its best placement on the starting position (5), while the average face sees a movement in the -y - direction (8).

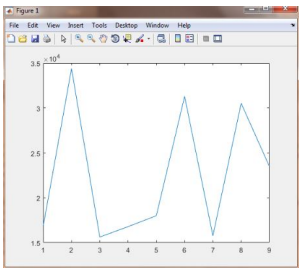

Fig. 3: The FRGC face with shifted line 173

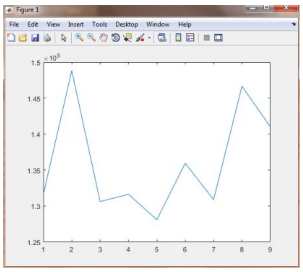

Fig. 4: The average face with shifted line 173

The FRGC face sees a movement in the +y and +x direction(3) and also a peak which has a higher absolute difference at -y and -x direction(7). While the average face has its best placement on the starting position (5).

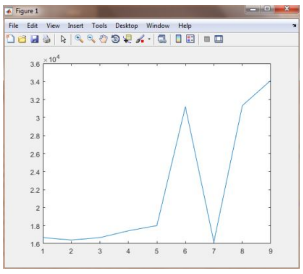

Fig. 5: The FRGC face with shifted line 174

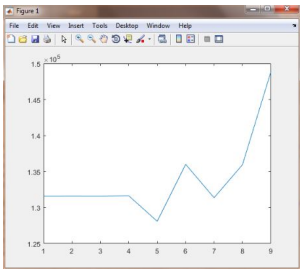

Fig. 6: The average face with shifted line 174

The FRGC face sees a movement in the -y and -x direction(7), but also has low values around the +y directions (1,2,3) and -x (4). While the average face has its best placement on the starting position (5).

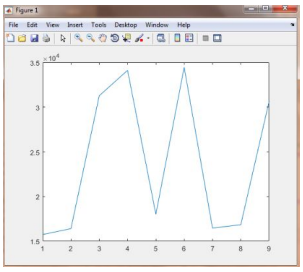

Fig. 7: The FRGC face with shifted line 175

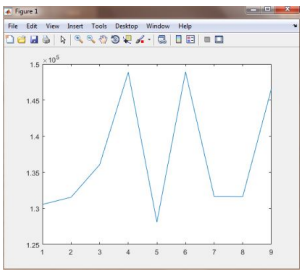

Fig. 8: The average face with shifted line 175

The FRGC face sees a movement in the +y,-x and +y directions(1,2), but also has low values around the -y,-x and -y directions (7,8). While the average face has its best placement on the starting position (5).

The plot results of the .abs file with the extreme movements are placed in the Appendix. Due to the extreme movements inside the .abs the registered .sfi picture is skewed. This results in all the plots being the best possibility at the original picture. So no movement is seen, when looking at the plots from the average face and the original FRGC face. While the FRGC face and average do not have the same plots at the small movements, the plots of the extreme movements have the same behavior for the average face and the FRGC face.

VI. Analysis

When comparing the .abs files of the minimally distorted face and the original, the movements are directly derived from the motion correction. As a check this also should be able to be derived with the help of the .sfi files.

- i = 172 There are no movements found, while there was a +x movement.
- i = 173 The -x movement is found, as the +x has a lower absolute difference. The +y has a lower absolute difference again, which recognizes that the actual shift is used from line i = 172 on the average face. So the line is recognized correctly.

- i = 174 The +y movement is found, as the -y has a lower absolute difference. The -x that is recognized is not inside the actual distorted face, so this is wrongly found. But there are many values at the plot which considers that a -y movement is inside the distorted face.
- i = 175 The +x movement is found, as the -x has a lower absolute difference. The +y that is recognized is wrongly found, as there is a +y movement, which has to recognize a -y at the matrix for correction.

The actual motion correction program has to be able to derive the movements from the test face by fitting the distorted face on an average face. Where the following corrections were done for every i-line.

- i = 172 A -y movement is found, while a +x movement was done. This -y movement can be due to having more spacing between eyebrows and the nose bone.
- i = 173 There are no movements found, while there was a x - movement. But it is not recognized.
- i = 174 There are no movements found, but a low absolute difference line is recognized at +y movement. Which recognizes that the line is moved by -y. While the line was moved by a +y movement.
- i = 175 There are no movements found, so the face is not changed.

When comparing the extremely distorted face with the original .abs face file the outcome results in no movements that are detected at all. When placing lines on the several matrix places it results in a higher absolute difference. As can be seen from the plots inside the appendix, there are no movements found. This is probably due to that the face when registered is rotated because of a extremely distorted nose. This extrema of movements has no recognizable corrections when comparing the original and the average face.

VII. Conclusion

The goal was to find out if the performance of the 3D motion correction is being able to find movements due to fitting on an average face, by checking correction on the .sfi files. This is done by using the method described and taking certain i-lines for which the movements are known. These movements can be compared to the movements which are corrected for.

The situation in which the original face .sfi is used to fit the distorted face does results in motion corrections. They are not all the right ones and it is not exactly the same result as with the .abs files.

The situation in which the average face .sfi is used to fit the distorted face does not show results in motion corrections. It does not respond to the test movements that are made to the distorted test .sfi. Only a -y - direction movement is seen, which can be due to a difference of length between the eyebrows and the nose bone.

As for the .sfi test with extreme movements inside there is totally no movement that has been found. The motion correction did not respond on the average face, but also not the original face. This can be due to the small range of i-lines that have been taken into consideration.

The 3D motion correction algorithm that is tested on the average face did not respond to the movements inside the test subjects tested range. So the performance is not as expected and thus also not applicable to improve 3D face recognition software.

Appendix

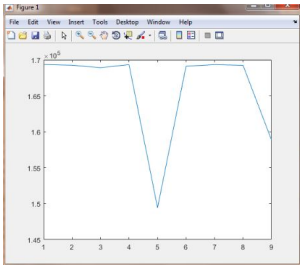

Fig. 9: The average face with shifted line 172

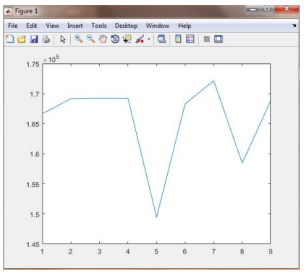

Fig. 10: The average face with shifted line 173

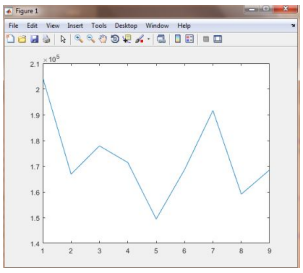

Fig. 11: The average face with shifted line 174

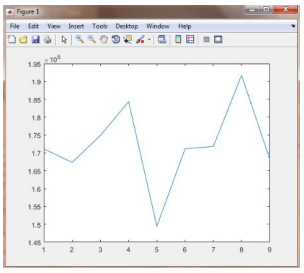

Fig. 12: The average face with shifted line 175

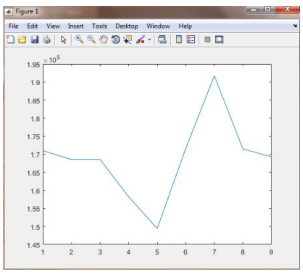

Fig. 13: The average face with shifted line 176

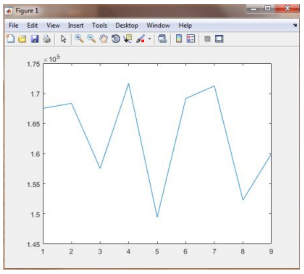

Fig. 14: The average face with shifted line 177

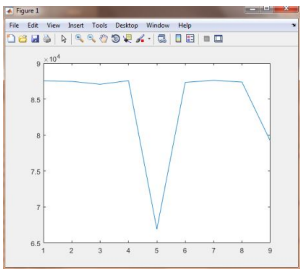

Fig. 15: The FRGC data face with shifted line 172

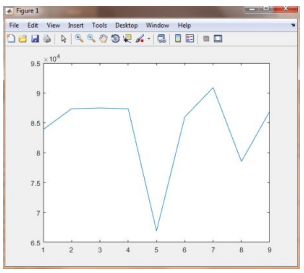

Fig. 16: The FRGC data face with shifted line 173

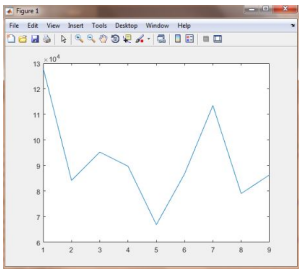

Fig. 17: The FRGC data face with shifted line 174

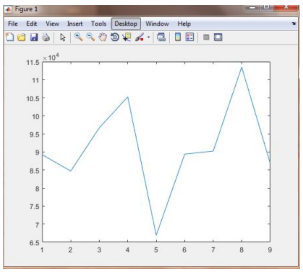

Fig. 18: The FRGC data face with shifted line 175

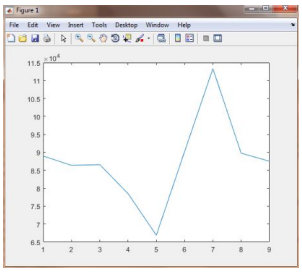

Fig. 19: The FRGC data face with shifted line 176

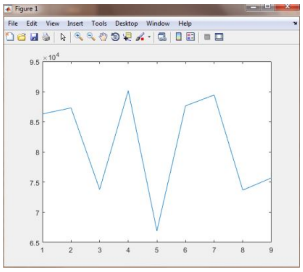

Fig. 20: The FRGC data face with shifted line 177