Inferring Human Body Parts and Correlations from Images, Pointclouds and Meshes

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Abstract

This thesis addresses the development of a novel sample thesis. We analyze the requirements of a general template, as it can be used with the LaTeX text processing system. (And so on...) The abstract should not exceed half a page in size!

Zusammenfassung

Diese Arbeit beschäftigt sich mit der Entwicklung einer neuartigen Beispielausarbeitung. Wir untersuchen die Anforderungen, die sich für eine allgemeine Vorlage ergeben, die innerhalb der LaTeX-Textverarbeitungsumgebung verwendet werden kann. (Und so weiter und so fort…) Die Zusammenfassung sollte nicht länger als eine halbe Textseite sein!

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Introduction

The price for breast enhancement surgery was estimated to be $3718 in 2017 according to the American Society of Plastic Surgery[1]. Next to the financial aspects there are also risks connected to undergoing surgery and also not knowing exactly what the result will look like. Before commiting to this kind of operation, it should be possible to generate a preview of the outcome from a few images. This thesis aims to design a method that is able to predict a 3D model of the outcome by learning a mapping between paramteric models. Additionally, the idea is explored if it is possible to generate a parametric model from a character modelling software.

1.1. Parametric Model

A previous implementation by Biland [Bil17] was used to create parametric models. A parametric model can describe all data that went into the model with its parameters. For example, the physical appearance of a person can be roughly described by their height, skin tone and hair color, where these three are the parameters of this parametric model. This is of course only an approximation as the description of the person would increase with more parameters. It is also possible that one parameter influences multiple features. In the previous example, when the height of a person is raised, the length of the arms is also proportionally increased.

[1] https://www.plasticsurgery.org/cosmetic-procedures/breast-augmentation/cost

1.2. Mapping

A mapping between sets associates each element in the first set with one or more elements of the second set. An example for a simple mapping could be the numbers one to twenty-six as the first set and the letters of the alphabet as the second. In the case of two paramteric models, the goal is to find a mapping that describes the relationship between the parameters of the first and second model.

1.3. Applications

-Breast shape/look prediction -Medical applications

2

Related Work

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Sample references are [ZRB$^+$04] and [Alt89].

3

Methods

In this chapter the methods needed to create a parametric model and a mapping between parametric models are introduced and explained. First off, the data gathering and preprocessing are outlined. Multiple variants of the parametric model are discussed. Different learning approaches for the mapping are reviewed. Lastly, a character editor is presented that is used to generate data for a parametric model.

3.1. Data Acquisition and Preprocessing

Optimally it would be necessary to have a large data set of images of women before and after breast enhancement surgery, where the patients pose topless. It is very unlikely though that such a database exists, due to the fact that having breast surgery is a very personal topic and people generally don't enjoy posing naked. Therefore the images used were downloaded from a website[1] that offered to simulate various plastic surgical procedures including breast enhancement. For each user a 3D model of their torse was displayed side by side with different enhancements varying in size. Each model was made up of a sequence of 24 images displaying the torse from different angles. This dataset fit the requirements nicely as images are available for *before* and *after*, except the *after* is generated and based on their model. Additionally, each after image sequence had a short label, usually describing how much silicon was added, that was also saved for further evaluation. In total 2'937 examples were retrieved and preprocessed. This dataset included images from 748 subjects of which each one was comprised of one *before* and at least one *after* image sequence.

[1]https://my.crisalix.com/

In a next step these image sequences needed to be transformed into point clouds. This was done using a general-purpose Structure-from-Motion (SfM) [SF16] and Multi-View Stereo (MVS) [SZPF16] pipeline called COLMAP. This generated point clouds spanning from 5'000 to 15'000 points. Some of the images needed to be discarded, due to the fact that SfM created a point cloud with less than 1'000 points or the point clouds had holes, such that certain areas had no points and were not defined at all. The remaining point clouds were cleaned using a C++ implementation by Biland [Bil17] that removed white points around the point clouds.

The mapping required to have one set of point clouds of *before* examples and the corresponding[2] *after* examples. Therefore the data was split into sets of *before* and after point clouds. Additionally, to create a better mapping, only the *after* examples that were labelled "350" were included. This resulted in 57 examples in the *before* and 57 in the *after* set. All of these point clouds were further processed in a MATLAB implementation by Biland [Bil17] to generate mesh files.

3.2. Parametric Model from Meshes

In this section it is described how a parametric model is obtained using principle component analysis (PCA). Given n meshes $m_i \in \mathbb{R}^{k\times 3}$, where k describes the amound of vertices m has, each mesh needs to be transformed to be of shape $\mathbb{R}^{1\times 3k}$. Then, all transformed meshes are stacked into a matrix $M \in \mathbb{R}^{n\times 3k}$. As the differences over each column isn't significant, the mean $\bar{m}$ of the matrix M is subtracted from each row of M.

$$A := \begin{bmatrix} m'_1 - \bar{m} \\ m'_2 - \bar{m} \\ \vdots \\ m'_n - \bar{m} \end{bmatrix} \in \mathbb{R}^{n\times 3k} \tag{3.1}$$

and additionally, two further variants of the parametric model are explored.

[2] Corresponding meaning, based on the same subject.

3.2.1. Variants

Point

Point Normals

Deformation

3.3. Mapping

3.4. Linear Method

3.5. Non-Linear Variants

3.5.1. Random Forest

3.5.2. Decision Tree

3.5.3. Multilayer Perceptron

3.6. Parametric Model from Editor

3.7. Evaluation

3.7.1. Mapping

3.7.2. MH

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Results

4.1. Error Metrics

4.1.1. Distance Point

4.1.2. Face orientations

5

Conclusion and Outlook

A

Information For The Few

Nein, meine Texte les ich nicht, so nicht, stöhnte Oxmox. Er war mit Franklin, Rockwell und dem halbtaxgrauen Panther Weidemann in Memphis (Heartbreak Hotel) zugange. Sie warteten auf die fette Gill, um bei der Bank of Helvetica die Kapitälchen in Kapital umzuwandeln. Oxmox liess nicht locker. Ich fleh euch an, rettet meine Copy, gebt meinem Body nochn Durchschuss! Kein Problem, erbarmte sich Old Face Baskerville, streichelte seinen Hund, zog seine einspaltige Poppl, legte an und traf! (Zeidank nichts Ernstes — nurn bisschen Fraktur.) Oxmox: Danke, ist jetzt mit Abstand besser. Derweil jumpte der Fox leise over the Buhl, die sich mal wieder immerdar wie jedes Jahr gesellte. Diesmal war Guaredisch ihr Erwählter, weil seine Laufweite einem vollgetankten Bodoni entsprach und seine ungezügelte Unterlänge ihre Serifen so serafisch streifte, dass sie trotz Techtelmechtelei die magere Futura, jene zuverlässige und gern eingesetzte Langstreckenläuferin, rechtsbündig überholen konnten.

A.1. Foo Bar Baz

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A.2. Barontes

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A.3. A Long Table with Booktabs

Table A.1.: *A sample list of words.*

ID	Word	Word Length	WD	ETL	PTL	WDplus
1	Eis	3	4	0.42	1.83	0.19
2	Mai	3	5	0.49	1.92	0.19
3	Art	3	5	0.27	1.67	0.14
4	Uhr	3	5	0.57	1.87	0.36
5	Rat	3	5	0.36	1.71	0.14
6	weit	4	6	0.21	1.65	0.25
7	eins	4	6	0.38	1.79	0.26
8	Wort	4	6	0.30	1.62	0.20
9	Wolf	4	6	0.18	1.54	0.19
10	Wald	4	6	0.31	1.63	0.19
11	Amt	3	6	0.30	1.67	0.14
12	Wahl	4	7	0.36	1.77	0.42
13	Volk	4	7	0.45	1.81	0.20
14	Ziel	4	7	0.48	1.78	0.42
15	vier	4	7	0.38	1.81	0.42
16	Kreis	5	7	0.26	1.62	0.33
17	Preis	5	7	0.28	1.51	0.33
18	Re-de	4	7	0.22	1.56	0.33
19	Saal	4	7	0.75	2.10	0.43

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Table A.1.: *(Continued)*

ID	Word	Word Length	WD	ETL	PTL	WDplus
20	voll	4	7	0.48	1.82	0.24
21	weiss	5	7	0.21	1.59	0.36
22	Är-ger	5	7	1.16	2.69	0.59
23	bald	4	7	0.18	1.56	0.19
24	hier	4	7	0.40	1.70	0.43
25	neun	4	7	0.17	1.52	0.26
26	sehr	4	7	0.36	1.85	0.43
27	Jahr	4	7	0.50	1.82	0.43
28	Gold	4	7	0.04	1.35	0.20
29	Tä-ter	5	8	0.15	1.39	0.59
30	Tei-le	5	8	0.30	1.71	0.46
31	Na-tur	5	8	0.18	1.59	0.41
32	Feu-er	5	8	0.30	1.71	0.45
33	Rol-le	5	8	0.15	1.46	0.45
34	Rock	4	8	0.29	1.68	0.25
35	Spass	5	8	0.28	1.64	0.32
36	Gäs-te	5	8	0.49	1.75	0.66
37	En-de	4	8	0.36	1.72	0.33
38	Kunst	5	8	0.26	1.59	0.35
39	Li-nie	5	8	0.45	1.88	0.63
40	Bäu-me	5	8	0.48	1.92	0.45
41	Büh-ne	5	9	0.94	2.48	0.62
42	Bahn	4	9	0.21	1.62	0.42
43	Bür-ger	6	9	0.38	1.70	0.65
44	Druck	5	9	0.60	2.03	0.31
45	zehn	4	9	0.41	1.84	0.42
46	Va-ter	5	9	0.36	1.78	0.40
47	Angst	5	9	0.29	1.56	0.35
48	lei-der	6	9	0.13	1.47	0.52
49	häu-fig	6	9	0.82	2.31	0.52
50	le-ben	5	9	0.38	1.85	0.40
51	aus-ser	6	9	1.20	2.26	0.57
52	be-vor	5	9	1.28	2.75	0.39
53	Kai-ser	6	9	0.92	2.37	0.53
54	Markt	5	9	0.23	1.58	0.28
55	Os-ten	5	9	0.21	1.54	0.48
56	Krieg	5	9	0.33	1.67	0.50
57	Mann	4	9	0.31	1.47	0.25
58	Hal-le	5	9	0.24	1.65	0.45
59	heu-te	5	9	0.44	1.87	0.46
60	in-nen	5	10	0.36	1.80	0.45

continued on next page

Table A.1.: *(Continued)*

ID	Word	Word Length	WD	ETL	PTL	WDplus
61	Na-men	5	10	0.28	1.72	0.41
62	jetzt	5	10	0.70	2.07	0.32
63	kei-ner	6	10	0.28	1.62	0.53
64	Schu-le	6	10	1.02	2.12	0.48
65	Ar-beit	6	10	0.34	1.70	0.52
66	An-teil	6	10	0.27	1.63	0.53
67	di-rekt	6	10	0.67	2.04	0.47
68	vor-her	6	10	0.78	2.25	0.47
69	wol-len	6	10	0.44	1.85	0.51
70	Kampf	5	10	0.70	1.96	0.27
71	än-dern	6	10	1.18	2.62	0.65
72	lau-fen	6	10	0.21	1.64	0.52
73	Eu-ro-pa	6	10	0.23	1.53	0.66
74	statt	5	10	1.61	2.86	0.39
75	Wes-ten	6	10	0.29	1.60	0.54

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