Three-Dimensional Facial Analysis and Deep Neural Network Algorithm in Facial Reconstructive Surgery

Presenter: Ju-Yi Hung
Advisors: David Myung and Andrea Kossler
Update on September 30, 2019
Outlines

- A Big Picture of the Project
- Marketing Research
- Large Scale Data Analysis
- Deep Learning Experiments
- Schedule and Goals
- Collaborations and Acknowledgements

2019 Summer BBQ of the Myung Lab
The Myung Laboratory
A Big Picture of the Project
BeautyVision
Ju-Yi Hung

Data Visualization assisted by Ching-Wei Lin, PhD
A Big Picture

**Diagnosis**
1. **Auto-diagnosis** of extensive facial diseases
2. **3D Measurements** for differential diagnoses

**Evaluation**
1. **Surgical Methods Selection**
2. **Quantify** the amount of tissue removal
3. **Pinpoint** precisely for facial treatments
4. **Aid Post-operative** assessments

**Simulation**
1. Discover diverse **Aesthetic Concepts**
2. **3D Prediction** of post-operative appearance
3. **AR/VR Support**

Data Visualization assisted by Ching-Wei Lin, PhD
Marketing Research
Marketing Research in 2017 Winter

PRS* Conference, Seoul, South Korea
*The 75th Congress of the Korean Society of Plastic and Reconstructive Surgeons, November 10 to 12, 2017

Observation in clinics: Eyelid surgeries account for 80-90% in total plastic and cosmetic services

Bellus3D Company

1. Dr. Ahn, Seoul, South Korea

2. Dr. Choi, Seoul, South Korea

3. Dr. Chang, Taipei, Taiwan
Expanding Cosmetic Market Globally

- By 2016, the Cosmetic Services* globally had been increasing to **533 billion USD**

- The estimated value will be increased with **5.5% CAGR** to **649 billion USD** by 2019.

- The market share in the Asian is about **19.2%** and has been increasing

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* Cosmetic services includes medications, surgeries, medical instruments-related or any associated invasive or irreversible intervention, which manage to remodel the appearance of the faces or any part of the body in humans.

* CAGR : Compound Annual Growth Rate

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Data Visualization by Ching-Wei Lin, PhD
Marketing Research in 2018

Facial Recognition software and Plastic Surgery are on the rise - can they coexist?

By Chioma Azeh, Oct 2017

2018 Plastic Surgery Statistics
Large Scale Data Analysis
List 1. The 18 identifiers Based on HIPAA\textsuperscript{a} Regulations

1. Names
2. All geographic subdivisions smaller than a state, including street address, city, county, precinct, Zone Improvement Plan (ZIP) code, and their equivalent geocodes, except for the initial three digits of the ZIP code if, according to the current publicly available data from the Bureau of the Census:

1) The geographic unit formed by combining all ZIP codes with the same three initial digits contains more than 20,000 people; and

2) The initial three digits of a ZIP code for all such geographic units containing 20,000 or fewer people is changed to 000

1. All elements of dates (except year) for dates that are directly related to an individual, including birth date, admission date, discharge date, death date, and all ages over 89 and all elements of dates (including year) indicative of such age, except that such ages and elements may be aggregated into a single category of age 90 or older

2. Telephone numbers
3. Vehicle identifiers and serial numbers, including license plate numbers
4. Fax numbers
5. Device identifiers and serial numbers
6. Email addresses
7. Web Universal Resource Locators (URLs)
8. Social security numbers
9. Internet Protocol (IP) addresses
10. Medical record numbers
11. Biometric identifiers, including finger and voice prints
12. Health plan beneficiary numbers
13. Full-face photographs and any comparable images
14. Account numbers
15. Any other unique identifying number, characteristic, or code, except as permitted by paragraph (c) of this section [Paragraph (c) is presented below in the section “Re-identification”]: and
16. Certificate/license numbers

\textsuperscript{a}HIPAA: Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule. Standards for Privacy of Individually Identifiable Health Information, establishes national standards for the protection of certain health information by the U.S. Department of Health and Human Services (HHS) (https://www.hhs.gov/hipaa/
Analysis of Dataset

- Retrospectively collected from 2009 to 2018 (10+ years)
- Categorized into 43 types of surgeries
- Surgeries were performed by one surgeon
- All taken by the digital camera, Canon DIGITAL IXUS 950 IS
- Estimated* number of the participants involved: 2,036
- Total 8,966 files, 28.7 GB in size
- 17,932 eyes in the data set

* The number of the participants is estimated by the number of the folders
## Categories in Dataset

<table>
<thead>
<tr>
<th>Surgery Type</th>
<th>Files</th>
<th>Folders</th>
<th>Surgery type</th>
<th>Files</th>
<th>Folders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ant blepharotomy</td>
<td>313</td>
<td>110</td>
<td>15. Lid eversion</td>
<td>81</td>
<td>23</td>
</tr>
<tr>
<td>2. Blepharophimosis</td>
<td>12</td>
<td>3</td>
<td>16. Lid retraction</td>
<td>77</td>
<td>30</td>
</tr>
<tr>
<td>3. Bony decompression</td>
<td>277</td>
<td>65</td>
<td>17. LMR</td>
<td>2148</td>
<td>447</td>
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<tr>
<td>4. Brow elevation</td>
<td>3</td>
<td>1</td>
<td>18. LMR recession</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>5. Decompression+ant blepharotomy</td>
<td>6</td>
<td>3</td>
<td>19. LMR-L</td>
<td>137</td>
<td>32</td>
</tr>
<tr>
<td>6. Dermatochalasia</td>
<td>69</td>
<td>27</td>
<td>20. Lower lid ptosis</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>7. Dermatochalasia+fat reposition</td>
<td>5</td>
<td>1</td>
<td>21. Lower lid retraction</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>8. Dermatochalasia+ptosis</td>
<td>1,009</td>
<td>272</td>
<td>22. Lower lid retraction(+Tarsys)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>9. Dermatochalasia+ptosis+fat reposition</td>
<td>8</td>
<td>2</td>
<td>23. Midface lift</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. Ectropion</td>
<td>178</td>
<td>40</td>
<td>24. Mullerectomy</td>
<td>56</td>
<td>18</td>
</tr>
<tr>
<td>11. Entropion</td>
<td>65</td>
<td>22</td>
<td>25. Ptosis</td>
<td>63</td>
<td>18</td>
</tr>
<tr>
<td>12. Epiblepharon</td>
<td>30</td>
<td>8</td>
<td>26. Ptosis-fat reposition</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>13. Epicanthoplasty</td>
<td>8</td>
<td>2</td>
<td>27. Ptosis-congenital</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14. Fat removal</td>
<td>27</td>
<td>12</td>
<td>28. Ptotic repair</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Surgery Type</td>
<td>Files</td>
<td>Folders</td>
<td>Surgery Type</td>
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<td>----------------------------</td>
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<td>---------</td>
</tr>
<tr>
<td>29. Fat reposition</td>
<td>1,469</td>
<td>234</td>
<td>36. Puttermann</td>
<td>1,524</td>
<td>267</td>
</tr>
<tr>
<td>30. Fatty decompression</td>
<td>597</td>
<td>147</td>
<td>37. Sling</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>31. Gortex sling</td>
<td>90</td>
<td>33</td>
<td>38. Suture crease</td>
<td>441</td>
<td>121</td>
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<tr>
<td>33. Lateral canthaloplasty</td>
<td>4</td>
<td>1</td>
<td>40. Tear trough</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>34. Levator recession</td>
<td>12</td>
<td>3</td>
<td>41. TED proptosis</td>
<td>58</td>
<td>23</td>
</tr>
<tr>
<td>35. Lid bag</td>
<td>13</td>
<td>6</td>
<td>42. Upper lid retraction correction</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>43. Y-V plasty</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surgery Types</th>
<th>Files</th>
<th>Folders*</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>8,966</td>
<td>2,036</td>
</tr>
</tbody>
</table>

*(To estimate the number of the involved participants)*
Analysis of Dataset - continued

- **Two-dimensional** color facial photographs
- Some covered whole faces and the other did the upper half of the faces
- For the purposes of pre-operation evaluation and post-operation care
- **90%** are for first-time surgeries, mainly periocular or orbital surgeries
- The rest (**less than 10%**) are for revisional surgeries
- Minimally invasion treatments are not included
Deep Learning Experiments
Design for Experiments
2019 Spring

Primitive sets of experiments

**Experiment 1:**
Can we train computer to recognize ptosis (drooping eyelid)?

- The estimated number of the **Ptosis-associated Photographs**: 4,938 (≈ 10,000 eyes)
- The number of the participants is 986 approximately
- Literature review: 2016 paper
  Drashtikon: Extra Ocular Disease Classification, Shloka Desai et al, 2016
First Pilot Study Design*

2019 Summer

- Deep Learning Algorithm, Convolutional Neural Networks (CNN)
- ResNet 18 layers
- Single image size: 480 x 320 Pixels (Original: 3264 x 2448 pixels)

<table>
<thead>
<tr>
<th>Experiment Group</th>
<th>Patient with Ptosis</th>
<th>Patient without Ptosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training set</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Validation set</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

* De-identification process has been completed for the pilot study
Preliminary Results of First Pilot Study*

<table>
<thead>
<tr>
<th>Experiment No.</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training accuracy</td>
<td>95%</td>
<td>91%</td>
<td>98%</td>
<td>98%</td>
<td>90%</td>
</tr>
<tr>
<td>Validation accuracy</td>
<td>75%</td>
<td>70%</td>
<td>50%</td>
<td>70%</td>
<td>80%</td>
</tr>
</tbody>
</table>

* De-identification process has been completed for the pilot study

Fig 1. Samples of eyes without ptosis

Fig 2. Samples of eyes with ptosis
## 2019 Computing Environment*

*STATE-OF-THE-ART Devices for AI Large-Scale-Analysis in Myung Laboratory

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Graphics Processing Unit (GPU)</td>
</tr>
<tr>
<td></td>
<td>NVIDIA <strong>RTX2080Ti</strong> WINDFORCE 11G</td>
</tr>
<tr>
<td></td>
<td>NVIDIA_Geforce_Graphics-Cards_RTX-2080-Ti</td>
</tr>
<tr>
<td>2</td>
<td>Central Processing Unit (CPU)</td>
</tr>
<tr>
<td></td>
<td>Intel i7-9700 [8-core]</td>
</tr>
</tbody>
</table>

*The computer is available for expanding to Multi GPU System
Schedule and Goals
Schedule and Goals
2019 Fall

2019 Fall
Large-scale-data analysis retrospectively in Automatic Diagnosis, aims in Better Performance than the Literature Review

2019 Winter
ARVO Conference and Peer-review Journals Submission

2020 Spring
Prospective IRB-approved Three Dimensional Facial Photographs Collection (Expected: 3-6 months)

2020 Summer
Another Retrospective Results submitted to Peer-review Journals

2020 Fall
Three-Dimensional Analysis Experiments and Results

Data Visualization assisted by Ching-Wei Lin, PhD
Collaborations and Acknowledgements
Acknowledgements

- 2018 - Present, mentored by Dr. David Myung, Director of Teleophthalmology, Co-Director of the Ophthalmic Innovation Program, Stanford
- 2019 - Present, mentored by Dr. Andrea Lora Kossler, Director of Aesthetic Eye Surgery Center, Co-Director of Thyroid Eye Disease, Stanford
- 2019 - Present, Literature Review, Dr. William Yan, Biomedical Informatics, The Myung Lab, Stanford
- 2018 - Present, Algorithm Consulting, Hsu-Kuang Chiu, MS, Computer Science, Stanford University
- 2017 - Present, Data Contribution and Acquiring IRB Approval, Prof. Shu-Lang Liao, National Taiwan University Hospital
- 2017 - Present, Computer Vision Consulting, Prof. Chiou-Shann Fuh, Computer Science and Information Engineering, National Taiwan University
- 2017 - Present, Marketing Research, Ching-Wei Lin, PhD, National Taiwan University
- 2018 - Present, Research Grants from 2018 LEAP@Stanford led by Prof. Curtis Frank and Prof. Ying-Chih Chang, Chemical Engineering
- 2018, Annotations for deep learning training, Dr. Chun-Chuan Hsu, Stanford-Taiwan Biomedical Fellow
- 2017, LEAP Program Consulting, Prof. Yen-Kuang Chen, National Taiwan University & Intel Company
- 2017, Comments on the proposal, Ruby, PhD, Stanford-Taiwan Biomedical Fellow