Facial Analyzer for Rhinoplasty Surgery (Option 9)

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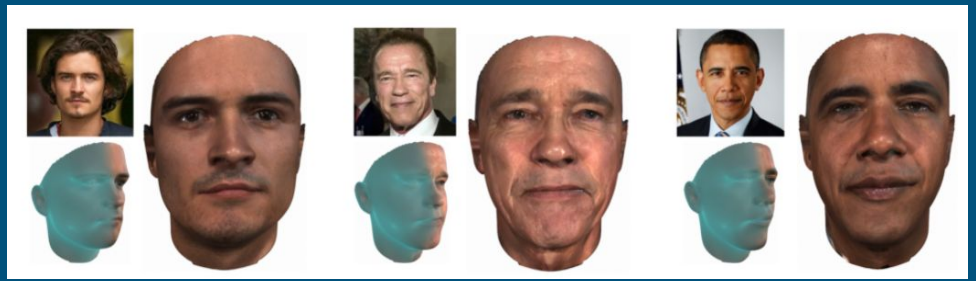
Introduction

Main Goals for this semester:

- 3D modeling of synthetic faces to grow dataset
- Landmark detection through Machine Learning
- Clustering of faces based on landmarks

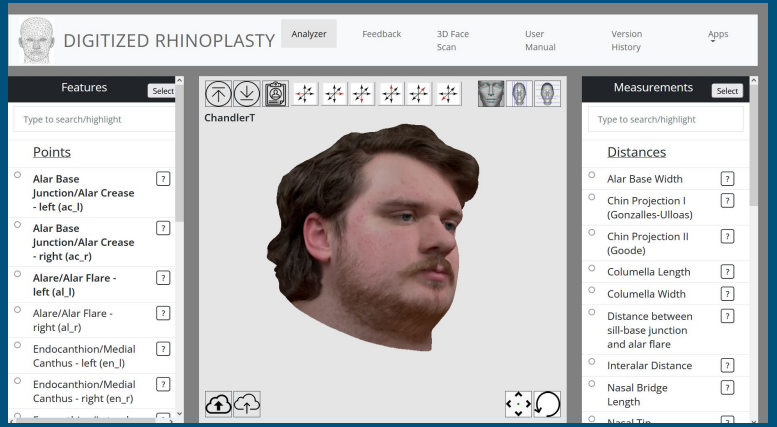
3D Facial Modeling

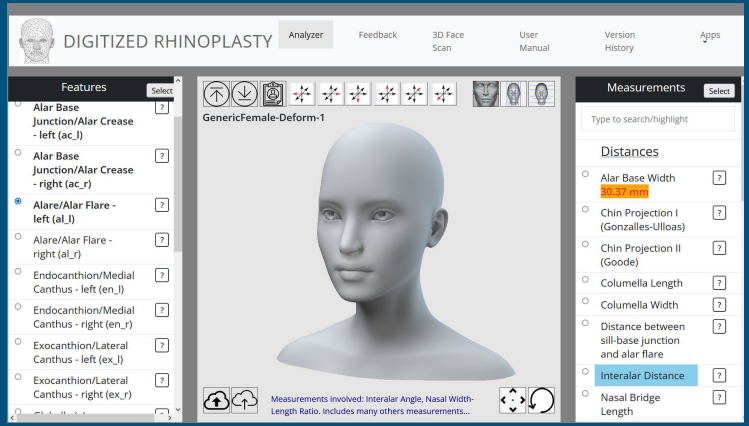
- Researching various machine learning algorithms to create 3D models for dataset
  - GANs?
  - GANFit?
  - FaceGen?
  - Reallusion?
  - Constraints with FaceGen:
    - File Output as .fg
    - FaceGen Software
    - A JPG of profile/front face



Database: Scanned faces

- 96 scanned faces using Bellus3D (iOS application, discontinued) + synthetic faces
- Looking for new ML algorithm to train to be able to point the landmarks automatically





Database: Digitized Rhinoplasty

- Using Digitized Rhinoplasty website to point the landmarks manually
- Pointing the landmarks that are the most important (highlighted green)
- All together there are 20 important points

Facial Landmark	Frequency in Important Measurements	Frequency of Studies in Literature
Alar Base Junction/Alar Crease - left/right (ac)	3	9
Alar Rim's Highest Point - left/right (armax)	1	0
Alare/Alar Flare - left/right (al)	1	8
Cheilion - left/right (ch)	0	19
Columellar Break Point (cb)	4	0
Columellar Rim - left/right (cmin)	1	0
Crista Philtri - left/right (cph)	0	4
Endocanthion/Medial Canthus - left/right (en)	2	15
Exocanthion/Lateral Canthus - left/right (ex)	1	22
Glabella (g)	4	2
Labiale Inferius (li)	0	12
Labiale Superius (ls)	3	12
Lateral helix of ear - left/right (la)	1	0
Maxillofrontale - left/right (ma)	1	0
Menton/Gnathion (me)	2	4
Nasal Parenthesis - left/right (np)	1	0
Nasion/Radix (n)	6	15
Pogonion (pg)	0	6
Pronasale/Tip (prn)	9	24
Pupil - left/right (p)	0	4
Stomion (sto)	1	7
Subalare - left/right (sbal)	1	3
Sublabiale/Mentolabial Sulcus (sl)	0	4
Subnasale (sn), Subnasale - left/right	7	13
Supratip Break Point (s)	1	0
Tip Defining Point - left/right (td)	2	0
Tragion - left/right (t)	0	1
Trichion (tr)	2	0
Zygion - left/right (zy)	1	1

Table 1: Facial landmarks usage frequency in measurements important for rhinoplasty and facial landmarks studied in the literature for detection based on their geometric properties on 3D face scans.

Machine Learning Algorithm

Current contender: Facial Key Points Detection

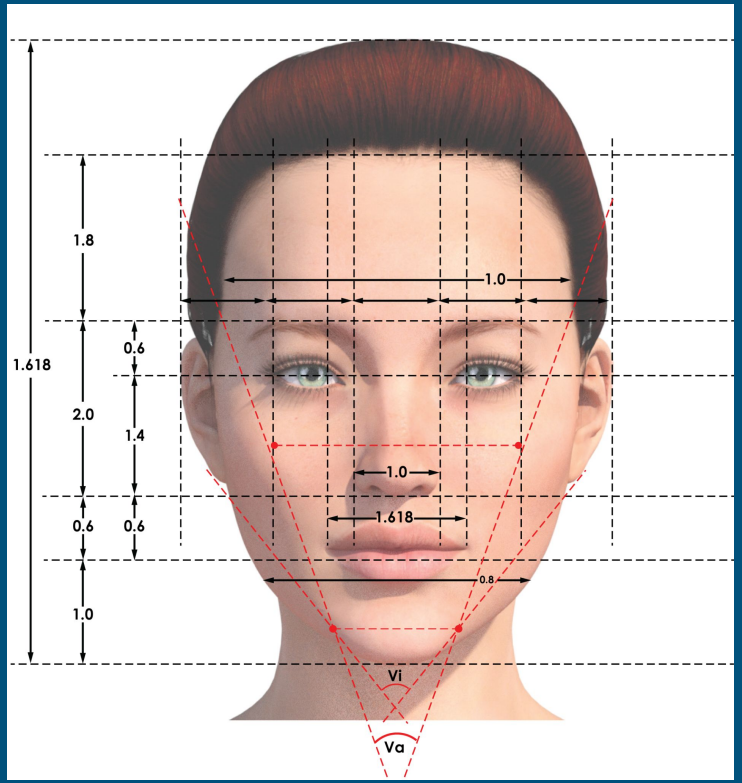
(Udacity AI Capstone Nanodegree)

Some design constraints:

- Only works on 2D images
- Too little landmarks
- Too generalised

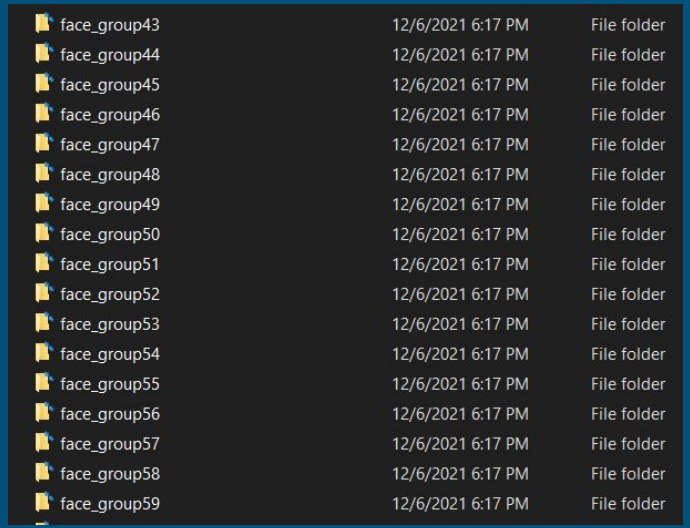
Face Clusters

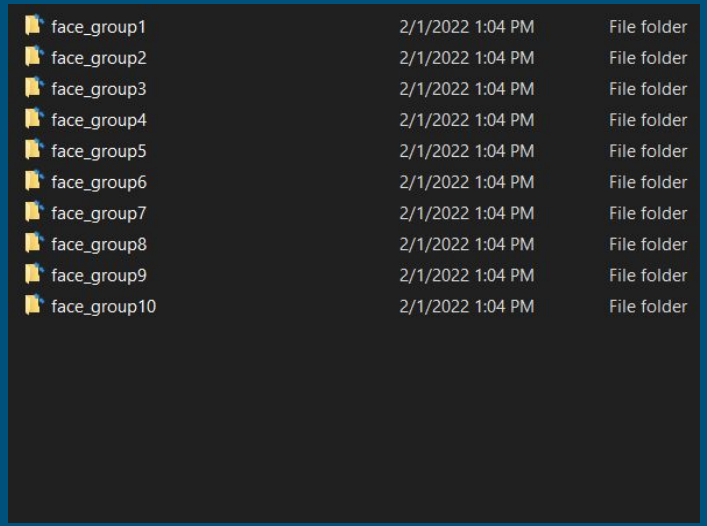
- Use database to sort patients by facial structure.
- Compares key ratios of the patient's faces.
  - i.e. distance between eyes/distance between lips



Face Clusters

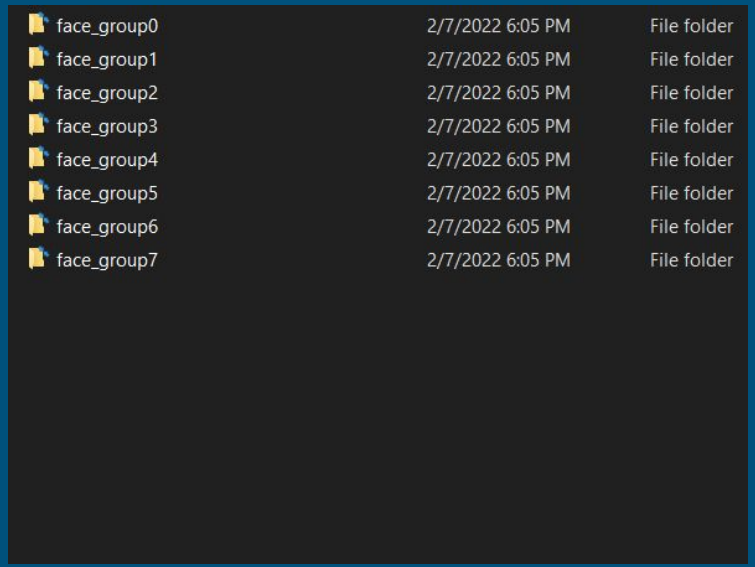
- Used 2 different methods for making face clusters with a KNN algorithm
  - A group for each patient containing their 10 most similar faces, allowing overlap
  - 10 groups containing the 8 most similar faces that are available, does not allow overlap

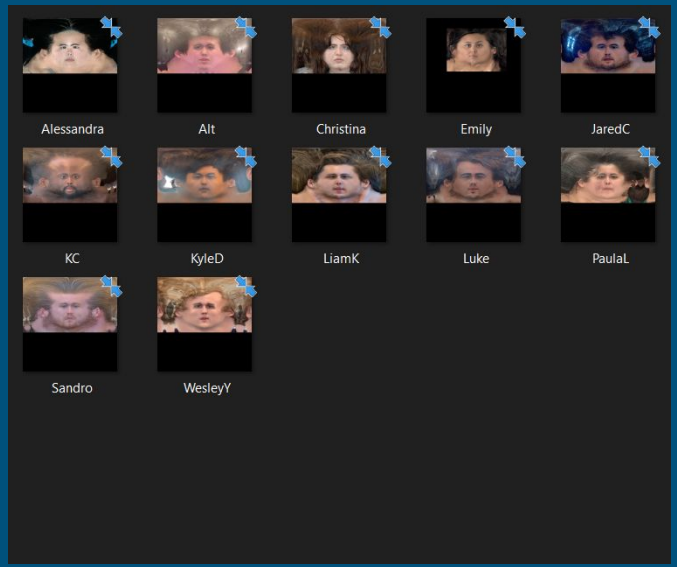




Face Clusters

- Used K-means algorithm to group patients
- Created 8 clusters of varying size, ranging from 1 → 18





Face Clusters

- The face clusters are not finalized
- We plan to remake them using different landmarks/key ratios
- Based on chart comparing the importance of various landmarks

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Lessons Learned

- Difficulties selecting optimal model
  - Needed to consider various options including facial recognitions, GANs, and standard NNs
- Difficulties trying to create and refine a database for the model
  - Problems in making the database large enough for training and testing as well as making it in a suitable format for the model
- Learned to optimize facial clusters
  - updates need to be made using 20 significant landmarks

Project Timeline

- Accomplishments
  - Researched ML algorithms for automatically mapping the landmarks
  - Generated face clusters
  - Researched ways to grow the database (GANs)

- Future Goals
  - Create 3D models to build database
  - Implement new key ratios
  - Determine and implement ML algorithm for mapping landmarks

Questions?

Thank you!