
System Requirements Specification

for

Facial Analyzer for Rhinoplasty Surgery (Option 9)

Version 2.2 approved

**Prepared by Priscilla Carbo, Marvin Cazeau, Jared Curtis, Maree Kelly,
Alessandra Oo**

Embry Riddle Aeronautical University, Daytona Beach Campus

8 April 2022

Table of Contents

Introduction	4
Purpose	4
Intended Audience and Reading Suggestions	4
Product Scope	4
References	4
Overall Description	5
Product Perspective	5
Product Functions	5
User Classes and Characteristics	6
Operating Environment	6
Design and Implementation Constraints	6
User Documentation	6
Assumptions and Dependencies	6
External Interface Requirements	7
Physical Environment Requirements	7
Interface Requirements	7
Functional Requirements	7
Documentation Requirements	8
System Features	8
Output similar faces using CNN	8
Render 3D Face of Patient	9
Other Nonfunctional Requirements	10
Performance Requirements	10
Safety Requirements	10
Security Requirements	10
Software Quality Attributes	10
Business Rules	10
Other Requirements	10

Revision History

Version	Name	Date	Reason for Changes
v1.0	P.C., M.C., J.C., M.K., A.O.	16 September 2021	Formatted template, added introduction
v1.1	P.C., M.C., J.C., M.K., A.O.	28 September 2021	Completed introduction, added references.
v1.2	P.C.,J.C., M.K, M.C, A.O.	26 October 2021	Added document conventions, added overall description, reformatted document
v1.3	P.C.,J.C., M.K,M.C,A.O.	30 November 2021	Refined system requirements, Modified system descriptions
v2.0	A.O, J.C, P.C, M.C, M.K	04 February 2022	Fixed format, modified system requirement, descriptions and formats
v2.1	A.O, J.C, P.C, M.C, M.K	06 March 2022	Fixed format, refined requirements, and modified project scope
v2.2	A.O, J.C, P.C, M.C, M.K	08 April 2022	Fixed format, refined and further specified requirements.

1. Introduction

1.1. Purpose

The software requirements specification for Digitized Rhinoplasty v2.1 covers the general system requirements, scope of the project, and intended use for all applicable audiences.

1.2. Document Conventions

No document conventions while writing this System Requirements Specification.

1.3. Intended Audience and Reading Suggestions

This document is intended for developers, users, testers, customers, and product owners alike to provide insight into the specifications and scope of the project. The suggested sequence for reading the document is beginning with the overall description and overview sections then proceeding through the sections that are most pertinent to the user.

1.4. Product Scope

The product being designed is a system that will build a database of 3D facial scans and generate clusters of similarly structured faces. It will use a GAN model, which takes three 2D images of a person's face as input (a front view and 2 side views with a straight face), to generate a 3D model of the person's head and face. Key facial landmarks will then be plotted by hand manually using the Digitized Rhinoplasty web application on the 3D model and entered into the database. To elaborate, these landmarks will be used to make clusters of similarly structured faces and assign a patient to whichever cluster they most closely resemble. A patient will then be able to choose another patient from the cluster that they want to use as a reference to generate new landmarks for their nose before undergoing rhinoplasty surgery.

1.5. References

- I. "Digitized Rhinoplasty." *Digitalization of Rhinoplasty Research*, <https://digitized-rhinoplasty.com/>.
 - A. This is a web application intended to digitize the rhinoplasty by novel methodologies for pre-surgery planning, intraoperative guidance, and post-surgery evaluations.

2. Overall Description

2.1. Product Perspective

Digitized Rhinoplasty is a system designed to aid surgeons and patients who are about to undergo rhinoplasty surgery. It is an update to the previously developed Nova Initia system, which presented similar functionality in allowing users to preview desired facial surgeries. This system requires some hardware and multiple pieces of software in order to function, which is modeled below. The camera is initially utilized to take the necessary images of the users' face, which is then uploaded into the Digitized Rhinoplasty website. A JSON file is then uploaded into the database. Then, through the use of the selected Machine Learning models, the user is grouped with similarly structured patient's and presented with different selections in potential facial modifications.

2.2. Product Functions

- 2.2.1. Generate a 3D scan of a user's face using a GAN model.
- 2.2.2. Use clustering algorithms to group similar faces.
- 2.2.3. Suggest changes to the patient's nose based on similarly structured faces.

2.3. User Classes and Characteristics

2.3.1. Surgeon

- 2.3.1.1. Must have full access to the database, with the ability to read from and add to the data.
- 2.3.1.2. Must have Python and Blender installed on their machine.
- 2.3.1.3. Must have access to the digitized rhinoplasty web application.
- 2.3.1.4. Must have access to any camera. Image cannot be blurry.
- 2.3.1.5. Must be able to view a patient's face in Blender.
- 2.3.1.6. Must be able to make changes to the user's nose in Blender.
- 2.3.1.7. Must be able to export the patient's altered face/nose.

2.3.2. Patient

- 2.3.2.1. Must be able to view similar faces.
- 2.3.2.2. Must be able to choose face(s) with similar noses.
- 2.3.2.3. Must be able to view the changes to their face before the operation.

2.4. Operating Environment

The software must operate on a computer running Windows 10 or later, or Mac OS 10.15.6 or later. The computer must have Python version 3.0 or later installed and must have access to the internet to ensure proper functionality.

2.5. Design and Implementation Constraints

- 2.5.1. The hardware must have Windows, Mac OS, or Linux OS installed for all functions of the software.
- 2.5.2. The hardware must have Python version 3.0 or later installed.
- 2.5.3. The hardware must have Blender version 2.90 installed.
- 2.5.4. The hardware must be connected to a network with internet access.
- 2.5.5. The hardware must have access to the database of patients.
- 2.5.6. The software must have access to the Digitized Rhinoplasty website.
- 2.5.7. The software and documentation is only available in English.
- 2.5.8. The software must require maintenance in order to work on each different machine (i.e. the file locations will need to be changed).
- 2.5.9. The hardware must have FaceGen Modeller installed.

2.6. User Documentations

Documentation for the software is available on GitHub under the Deliverables folder and can be viewed here: <https://github.com/jcurtis664/FacialAnalyzer/tree/main/Deliverables>.

2.7. Assumptions and Dependencies

- 2.7.1. All software must run on Windows 10.0 and Mac OS 10.15.6 or later operating systems.
- 2.7.2. GAN must correctly process a 3D image
- 2.7.3. Users must use the Digitized Rhinoplasty website to obtain a JSON file.
- 2.7.4. Users must have Blender version 2.90 or later installed on their system
- 2.7.5. The openpyxl module must be installed to Blender's python module directory (C:\Program Files\Blender Foundation\Blender 2.90\2.90\scripts\modules). If openpyxl is not installed there is a tutorial on the github called "Installing openpyxl to Blender"

3. External Interface Requirements

3.1. Physical Environment Requirements

- 3.1.1. The system must only be installed in a plastic surgery clinic.
- 3.1.2. The user must have the FaceGen modeler installed.
- 3.1.3. The user must have version 3.0 or later of Python installed.
- 3.1.4. The user must have version 3.0.9 of openpyxl installed in their Python site-packages.
- 3.1.5. The user must have at least 2.90.1 version of Blender installed.
- 3.1.6. The user must have version 3.0.9 of openpyxl installed in their Blender modules.

3.2. Interface Requirements

- 3.2.1. The system must display a preview of a 3D face with facial points.
- 3.2.2. The system must allow input of new patient data.

- 3.2.3. The system must output new user data to the database.
- 3.2.4. The system must execute Blender for manual face manipulation.
- 3.2.5. The system must allow the surgeon to input images of the user.
- 3.2.6. The system must output the patient's "before" model to Blender.

3.3. Functional Requirements

- 3.3.1. The system must generate new landmarks for the patient's nose.
- 3.3.2. The system must display the 3D model of the patient's face with a new nose.
- 3.3.3. The surgeon must mark points on the patient's face upon upload using the Digitized Rhinoplasty web application.
- 3.3.4. The system must display multiple similar face options for the patient to choose from.
- 3.3.5. The system must generate more similar face suggestions based on the patient's request.

3.4. Documentation Requirements

- 3.4.1. The documentation must be online through the FacialAnalyzer GitHub.

4. System Features

Section 4 details a more specific list as put forward in section 2.2.

Services of the product: Generate 3D models using GAN, group patients with similar facial structures, and suggest changes to a patient's nose.

4.1. Generate 3D models using GAN

4.1.1. Description and Priority

A user should provide 1 front view and 2 side-profile view 2D jpegs of a face, one on each side, which will be used as the input for the generative adversarial network (GAN). The output of the GAN model will provide a 3D model of the face for future use. This feature is of high priority to the functionality of the system.

4.1.2. Stimulus/Response Sequences

First the surgeon will utilize a camera to capture a front facing image and 2 side profile images of the user's face. These images will then be inputted into the software FaceGen Modeler. By using this software the surgeon is able to create a 3D model of the user's face as well as export an .obj file, a .jpg file, and a .mtl file of said face. These files must then be saved in a folder with the naming convention "<Patient Name>" in the database's Scaninfo folder.

4.1.3. Functional Requirements

- 4.1.3.1. The user must have FaceGen Modeler installed.
- 4.1.3.2. The user must have access to camera
- 4.1.3.3. The computer must have access to the internet.
- 4.1.3.4. The computer must have python installed.

4.2. Group Patients with Similar Facial Structures

4.2.1. Description and Priority

A user should provide a JSON file containing the significant facial landmarks, which will be used to generate 5 key facial ratios to be loaded into the database. These ratios should then be used to fit the patient into an appropriate cluster. This feature is of high priority to the functionality of the system.

4.2.2. Stimulus/Response Sequences

First, the user will locate the .obj file, .jpg file, and .mtl file generated from the GAN model. These files should then be uploaded to the digitized rhinoplasty web application (digitized-rhinoplasty.com) where the doctor will choose the significant facial landmarks. Once the landmarks are selected, the user should export the JSON file and save it in the database's JSON folder with the naming convention "<Patient Name>.JSON". This file should then be used as the input of 'read_in.py' to generate the 5 key facial ratios, which will serve as the data to fit into the appropriate cluster based on multiple varying clustering algorithms, such as Kmeans, affinity propagation, BIRCH, agglomerative clustering, spectral clustering, and Gaussian mixture model.

4.2.3. Functional Requirements

4.2.3.1. The user must have access to the database and clusters.

4.2.3.2. The computer must have access to the internet.

4.3. Suggest Changes to the Patient's Nose

4.3.1. Description and Priority

Based on the cluster the patient has been assigned to, the system will use the ratios of the similarly structured faces to generate new facial landmarks specifically for the patient's nose. This feature is of medium priority to the functionality of the system.

4.3.2. Stimulus/Response Sequences

First, the patient must be assigned to an appropriate cluster of similarly structured faces. Next, the user will choose a few select faces that they believe reflects their face structure the best. The landmarks of these chosen faces will then be used as the input of "generate_new_points.py", which will use averaged ratios to alter the values of the patient's nose landmarks in order to suggest an improved nose shape and dimensions.

4.3.3. Functional Requirements

4.3.3.1. The user must have access to the database and clusters.

5. Other Nonfunctional Requirements

5.1. Performance Requirements

Section 5 details the current known requirements and regulations associated with this product of the Initial Release, Version 2.0.

5.2. Safety Requirements

There are no safety requirements for this system.

5.3. Security Requirements

- 5.3.1. The system must only allow access to authorized users.
- 5.3.2. The system must save patient data in a secure database.
- 5.3.3. The system must backup every time new patient data is uploaded.

5.4. Software Quality Attributes

There are no additional software quality attributes for the product. They were listed above in section 3.

5.5. Business Rules

- 5.5.1. Business Requirements
 - 5.5.1.1 The system must only accept a certified surgeon that specializes in rhinoplasty as a user.
 - 5.5.1.2 The patient must be over the age of 18 or have the consent of a parent or guardian.

6. Other Requirements

- 6.1 A patient should sign a document to allow the use of their face in the database.

Appendix A: Glossary

1. GAN - Generative Adversarial Network
2. JPEG - Joint Photographic Experts Group File
3. MTL - Material Settings File
4. OBJ - Geometry Definition File Format