Natural Language to AI Face Generation Using Machine Learning

Prepared by
Abel Abraham, Beyza Soylu, Edward Plesa, Ryan Jasiak

CS 440
University of Illinois Chicago

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I Project Description

1 Project Overview

The threat of crime is a certainty that comes with living in a modern society, and especially when living in the city. Even with the resources allocated to remedy and prevent crime, it still isn't enough to completely eradicate it. This Natural Language to AI Face Generation tool will allow both federal and local law enforcement agencies to create a better representation of a possible culprit to a crime.

This will happen in three main parts. First, there is the need for input. The way this software works is that it will process common language descriptors for features of a human face. It will also accept an already created sketch done by hand to provide a base model to work on. Second, will be the creation of the image and/or strengthening of a sketch. Local governments will allow the use of camera/ video surveillance equipment already available to create a database of images from various angles of a person's head to aid the software in facial recognition and the design of a face. Finally, an output of a 3-D model of a human face will be created. This output will be able to be matched against the faces of those in a lineup or a digital image to scan for similarities and give a percentage of how similar they are.

2 The Purpose of the Project

2a The User Business or Background of the Project Effort

Local and federal law enforcement, even today, still employ the old timey concept of taking eye witness reports to create a physical composite of the face of a criminal at large. Even though many aspects of these agencies have been modernized with the use of computers to get more accurate results, there are still legacy systems that need help getting to the standard of today. The use of AI and software to provide an easier to use and more effective tool will pave the way for allowing these agencies to provide a safer world for all to live in.

2b Goals of the Project

The goal of this project is to aid judicial bodies in creating a better portrayal of suspects. This software will enhance the systems already in use (sketch artists) with a more refined implementation. Since the software uses an AI to learn, it can keep learning and get better over time on how to portray specific descriptors to a face. The ease of just typing in, and even utilizing an already created sketch to provide a base model will make it that much more efficient to get a working model of a criminal that can be used to help victims or eyewitnesses identify them.

2c Measurement

The main way to gauge how effective this software is, starts by asking the agencies on their internal reports and metrics. First, we ask them how high the rate of identification of a criminal is before giving them the software to establish a baseline. Then, we ask them after one year how their rates have changed since the introduction of the software. If there is at least a 20% increase in identification of suspects, then we consider the software a success. The AI of this software will get better over time as it learns patterns of recognition, meaning a substantial amount of time must be spent using it to accurately assess how well it works, making a 20% increase within the first year a realistic goal.

3 The Scope of the Work

The scope of the work addressed is the utilization of AI technology in combination with natural language processing to identify criminals; the scope of the work is a part of a larger whole, known as the business, in which we can establish as part of this project to refer to the criminal justice system and law enforcement agencies. The scope will include implementing redesigned methods using current technologies and infrastructure in order to meet the demands of our modern needs and capabilities.

3a The Current Situation

Creating a sketch of a criminal has gotten down to a finely tuned methodology. The current way of generating a composite image is by gathering clues from eye witnesses about how the perpetrator looks. Of the whole process, this is the hardest part. The accuracy of a bystanders' recollection of how a criminal looks when they are fleeing from the crime scene poses the biggest challenge in terms of modeling a detailed and incriminating image. The participants mainly start with the largest portions of the face (hair, skin color). However, the smallest, seemingly insignificant, details are the parts that matter the most when creating the composite. The challenge is to find and identify criminals based on some set of descriptors, with varying accuracy and reach.

3b The Context of the Work

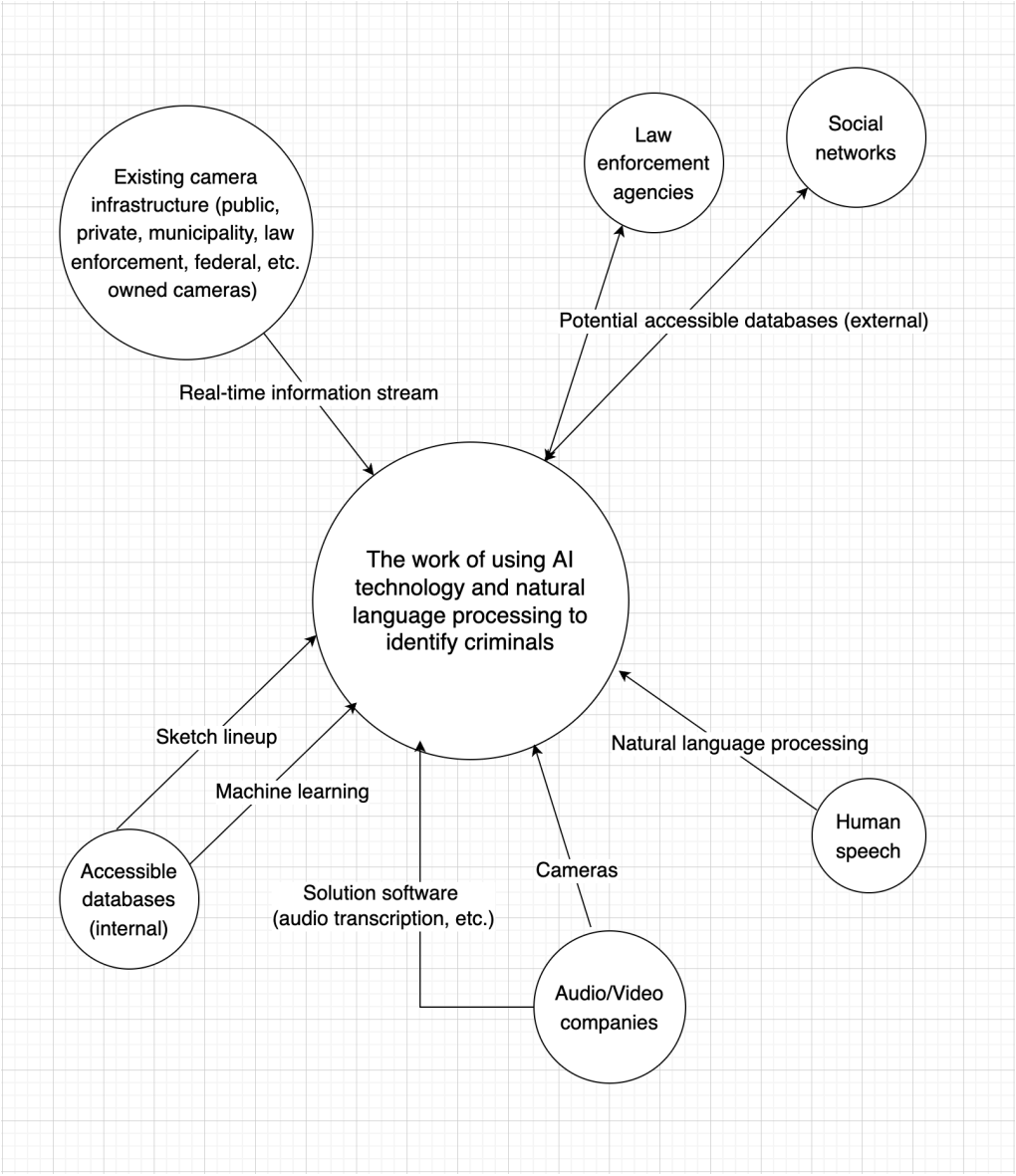

Figure 1 - Context of the Work Diagram

3c Work Partitioning

Table 1 - Business Event List

Event Name	Input and Output	Summary
Infrastructure upgrade	Better stream of info (in)	When technology improves, AI must adapt.
Change in social media	Changing database (in) New ways to match (out)	AI must also be able to adapt with software/DB.
Accent detected in speech	Understood meaning (in)	AI understands accents.
Criminal match found	Alert to agencies (out)	Send an alert for a match
New company structure	Permissions change (in)	Secure software for owner

3d Competing Products

Some existing products which the client could use instead, are the applications developed by Clearview AI: Clearview AI Software and Clearview AI Search Engine. As stated on their Wikipedia page, “Clearview AI is an American facial recognition company, providing software to companies, law enforcement, universities, and individuals. The company’s algorithm matches faces to a database of more than three billion images indexed from the internet, including social media applications.” As stated on the Clearview website, “Clearview AI is a privately-owned, U.S. based company, dedicated to innovating and providing the most cutting-edge technology to law enforcement to investigate crimes, enhance public safety, and provide justice to victims.” The Clearview product line aids law enforcement by matching an input image against its internal database of web scraped publicly available images, however it does not include the ability to utilize natural language processing to conduct its work. Additionally, it relies on having an already taken image to use as input meaning it can only work if the perpetrator has an online/ digital persona.

There is also Identi-Kit which is a very advanced image manipulation tool. It allows the control of every facial feature, even including accessories that may have been worn. It gives the options to resize, adjust transparency, alter styles of hair, etc, to create a composite much as how it's already done by hand. The main issue regarding this software is that it necessitates the knowledge and expertise of someone who knows how to operate graphic design tools, meaning it is somewhat cumbersome to use. It also creates a 2-D sketch of an individual rather than a 3-D model, as our software proposes.

4 The Scope of the Product

The scope of this product entails a software application packaged with the ability to input common facial descriptors, receiving an image, or strengthening of a sketch, and outputting a 3-D human facial model, all out of the box. The product will also have the capability to connect with the databases of currently existing infrastructure that gather real-time information via cloud (such as street cameras) databases of publicly accessible social network profiles, and other solution software which will help aid in the process. The product will be solely the software application; no physical peripherals will be included, and mileage may vary with full product capability depending on the available resources the client has at hand.

4a Scenario Diagram(s)

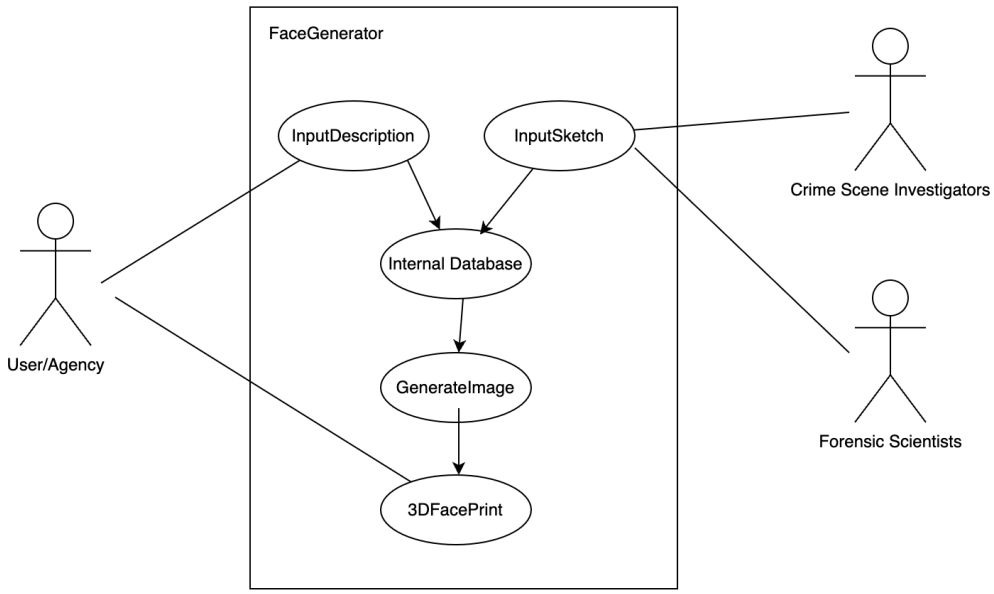

Figure 2 - Scenario Diagram

4b Product Scenario List

Table 2 - Product Scenario List

Scenario Name	External Actors Involved	Other Relevant Info
Input Description	User/Agency	Can be skipped if input sketch is chosen.

Input Sketch	Crime Scene Investigators, Forensic Scientists	Can be skipped if input description is chosen.
Update Internal Database	N/A, info gathered above*	*Cameras also actors.
Generate Image	N/A, info gathered above	Image generated from either description or sketch.
3-D Facial Printing	User/Agency	N/A

4c Individual Product Scenarios

1. **Input Description:** For the input description, the end user (which should be a private agency - this product will not be marketed or sold to the general public) can choose to provide the FaceGenerator with an input description of a suspect based on their findings. Alternatively, this step can be bypassed if Scenario 2 is chosen as the route of the investigation. Biometrics should be included if possible. The end user will be able to verbally describe to the FaceGenerator a description of the suspect, which will then send that information to the internal database and create a profile for the suspect, and continue on to for further processing.

2. **Input Sketch:** For the input sketch, the end user will hand off this step to external actors (such as crime scene investigators or forensic scientists) who will then provide sketches based on their description of a suspect. This step should only be taken if Scenario 1 is not chosen as the route of the investigation. The input sketch should also include any biometrics if available. The external actors will be able to provide a sketch, in which the software will create a profile for the suspect based upon said sketch, and will then continue along to the next steps for further processing.

3. **Update Internal Database:** In this scenario, information gathered from earlier scenarios (either an input description from 1 or an input sketch from 2) will be provided to the software's internal database. The database will create a profile for the suspect and any relevant information will be stored here, such as a possible name, date of birth, physical features, etc, as well as any possible biometric information. The end user will be able to update this suspect profile as more information arrives, and once ready, ship the user profile to be processed in the following scenario.

4. **Generate Image:** In the Generate Image scenario, the software will receive a suspect profile from the previous scenario and generate an image

based on all of the information from this suspect's profile. If the chosen route was to give information from an input description, the software will create this generated image from scratch, using machine learning and artificial intelligence technologies to recreate this description to the best of its capabilities. If the chosen route was to give information from an input sketch, the software will instead strengthen the details of the sketch to the best of its abilities based on the data it has gathered over time.

5. **3-D Facial Printing:** In the final scenario state, the software will then take the image generated from the previous scenario and apply the necessary transformations to create an accurate 3-D rendering of a suspect's face. This 3-D facial printing will be stored within the software's internal database and connected to the suspect's profile. If the end user has the opportunity to connect the software to external databases, such as any cloud services which are connected to physical cameras, or social media databases, the software will keep a tab on this stream of real-time information and alert the end user if a close enough match has been found.

5 Stakeholders

5a The Client

The primary client for this project is expected to be the U.S. federal government and/or security companies providing service to the government. The use cases are specifically tailored for use by government law enforcement agencies, and as such should work closely with them so as to ensure the best possible synergy with their needs and existing systems.

5b The Customer

Law enforcement agencies: All levels of law enforcement including federal, state, local and international agencies are expected to get use out of this product. It can significantly aid in efforts to find missing persons and identifying and tracking down criminals when identifiable images of the person of interest may not exist.

Colleges and universities: The software can be used to make the jobs of professors and TAs taking attendance and preventing cheating during exams and similar situations easier. The software could also find effective use in preventing school shootings, as it could monitor suspicious and/or high risk individuals based on reports. This functionality does overlap with law enforcement.

Marketing and advertising industry: As the program can scan for specific traits and descriptions of people, it can also be useful for marketers looking to target specific groups and audiences for their campaigns.

5c Hands-On Users of the Product

In law enforcement contexts, the program would be used by police officers, detectives and forensic investigators. Any victims or witnesses who can give physical descriptions of the person(s) of interest would naturally also be involved in the use of the program.

In an educational/anti-cheating context, the primary hands-on users would be instructors and examiners. TAs may or may not be involved in the use of the program depending on the schools policies and discretion of individual instructors. Campus security would also find use of the program as other law enforcement officers would.

In advertising contexts, the program could be used by marketing coordinators, market researchers and managers, as well as campaign directors and researchers for political and advertisement campaigns.

5d Maintenance Users and Service Technicians

Software developers who will continue to update software past launch and respond to any bugs or issues. Service technicians to provide live support. System administrators, network administrators, database administrators, devops teams. Security administrators and a security team to keep sensitive user data safe.

5e Other Stakeholders

Facial recognition technology is controversial so we may run into objections for this project's development and implementation for use by law enforcement or otherwise. There are groups concerned with privacy and the possibility of misuse of this kind of software whose interests the project might go against.

Forensic artists may be negatively impacted by the widespread implementation of this technology as it might shift their existing duties to be more digital and involved with software than it previously did, or might eliminate their jobs altogether.

Individuals with access to this technology could certainly use it outside of its intended purpose, such as for stalking or tracking down people outside against their will and outside of the context of law enforcement and this is a negative consequence we must be vigilant against for victims of such misuse.

5f User Participation

We need groups to take part in research to develop the facial recognition AI for this project. The research group will be involved in describing different faces to allow the algorithm to learn from their responses and improve itself accordingly.

Forensic artists, who have been tasked with similar job descriptions as this program, should also be involved in the research and development of this project as their expertise and knowledge is valuable.

User data will be collected and utilized to further develop the capabilities of the software and provide a larger pool of data for it to draw upon.

5g Priorities Assigned to Users

Key users are law enforcement using the software to identify and track down persons of interest in criminal cases. Forensic artists in particular may find good use of the product; however, as mentioned in 5e, it is also possible that forensic artists may object to the tool being developed as it might lead to lower overall demand for forensic artists. However, our aim is for our product to be used by and in conjunction with forensic artists, not to replace them.

Schools and advertising agencies are lower on the target user priorities but we still expect the program to be of use and interest to them.

6 Mandated Constraints

6a Solution Constraints

Description: The product shall include a natural-language processor for a natural and ‘easy-to-use’ feel.

Rationale: The product is to be marketed towards crime investigation agencies and should simplify the methods of face-generation that already exist.

Fit criterion: The product should be as close to human interaction as possible.

Description: The product should utilize scanned photos from security cameras in order to update face-generation knowledge.

Rationale: In order for the face-generation aspect to be as accurate as possible, new information should be constantly added so that the machine can learn.

Fit criterion: Drawing skills should become better over time, and the AI should have a method of bettering itself.

6b Implementation Environment of the Current System

The product shall be available on mainstream desktop operating systems: Windows, MacOS, and Linux

6c Partner or Collaborative Applications

The product shall utilize public security camera database systems around the country.

6d Off-the-Shelf Software

The software will be offered directly to crime investigators/agencies. The software will not be offered publicly, nor will it be available for anonymous download on the internet. Implementation specialists will directly assist companies/organizations in the setup of the product.

6e Anticipated Workplace Environment

- The product should be usable in any crime-agency office.
- The product should be used by crime investigation specialists.
- The computing process will require certain computing ability from the computer's CPU.

6f Schedule Constraints

Access to public security camera information must be accomplished first. Once done, the face-generation AI can be developed, followed by the learning aspect of the AI by increasing its database with images coming in from the security camera systems.

Each aspect of the software will require significant reliance on the other, so the order of things must be precise and strategic.

6g Budget Constraints

Implementation of dynamic AI face generation with natural language processing will take a great deal of time and expertise to create. An estimated 20 engineers will be required over the course of 5 years to achieve. While the overarching time-frame of the project is possibly unpredictable, it will take an estimated $15 million.

7 Naming Conventions and Definitions

7a Definitions of Key Terms

- Natural language descriptors: Everyday language, which are used to describe features of a face (e.g.: large nose, small eyes, etc).

7b UML and Other Notation Used in This Document

Documentation of figures, tables, and diagrams follows Martin Fowler's "UML Distilled" [3].

7c Data Dictionary for Any Included Models

Input sketches and database images are of a typical image file format (png, jpg, etc) for maximum compatibility.

8 Relevant Facts and Assumptions

8a Facts

- The Natural Language processing aspect will only support certain languages, most likely languages commonly used by crime investigators in the U.S.
- At product setup time, software will immediately scan all known images in the database, initializing AI knowledge. AI will periodically scan for new images in the database.

8b Assumptions

- User's computer will have line/internet access to the image database(s).
- User's computer is powerful enough to handle machine learning and AI generation aspects.
- User speaks one of the languages included in the natural language processing aspect.
- Direct access to image and video surveillance infrastructure.

II Requirements

9 Product Use Cases

9a Use Case Diagrams

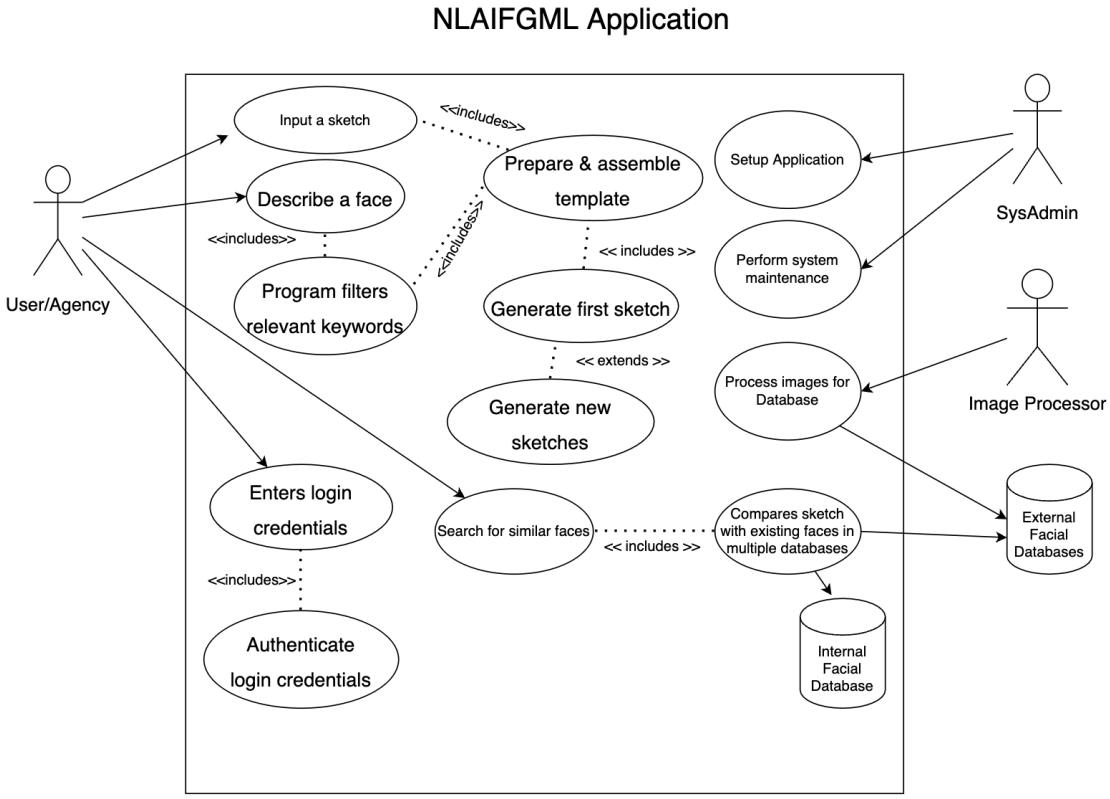

Figure 3 - Product Use Case Diagram for NLAIFGML

9b Product Use Case List

Table 3 - Product Use Case Table

Use Case	Description	Actors
User inputs sketch	When the user inputs a sketch, the application will create an assembled template with features from that data.	User/Agency

User logs in	When the user attempts to log in to the application, a security check will be run (prompted with 2FA) to ensure safe login.	User/Agency
User inputs natural language descriptors	When the user inputs common language descriptors, the application will create an assembled template with features from the parsed input.	User/Agency
User initiates sketch generation	After the user is logged in and input either a sketch, or common language descriptors, the system returns a generation of a face	User, Facial Database
Save facial model	After the user receives the facial model, the user can specify where to save the model for future use.	User, local storage
User submits bug report	The user can contact a system administrator that will make note of the issue to correct.	User/agency, SysAdmin
Software setup	The system administrator will come on site and remain on site to set up the software for the agency.	Agency, SysAdmin
User initiates facial recognition process	After the application has generated a series of faces matching the description, user can choose to search databases for a match	User/Agency, Facial Database

9c Individual Product Use Cases

Use case ID: 1 Name: User inputs sketch

pre-conditions: User or agency must have a provided sketch on hand.

post-conditions: Object must be created from class “template” with info from sketch.

Initiated by: User

Triggering Event: When a user uploads a sketch to be used in the application.

Additional Actors: N/A

Sequence of Events:

1. User uploads sketch with accepted file format into application.
2. Application takes this sketch and runs tests to determine data for retrieval.
3. Application detects data to be classified (e.x. black hair, dark skin tone).
4. Application classifies data which will be stored into an object with a template for specifications.
5. Application creates final sketch object.

Alternatives: Related use case based instead on description (Use case ID 3).

Exceptions: Minimum sketch requirements must be met for objects to be created.

Use case ID: 2 Name: User logs in

pre-conditions: User must have a valid account within the system.

post-conditions: User will have access to the NLAIFGML application.

Initiated by: User

Triggering Event: When a user attempts to log in to the system.

Additional Actors: N/A

Sequence of Events:

1. User opens up the NLAIFGML application.
2. Application will prompt the user to log in (enter a username and password).
3. User will enter in login information.
    a. If login fails after 5 attempts, no further steps will be taken and application will be locked out until Sysadmin unlocks application.
4. Once user has logged in securely, user will be prompted to verify using 2FA.
    a. If 2FA fails after 2 attempts, user will be prompted to log in again. The number of login attempts will also increase by 1.
5. Once 2FA check has been passed, user will have access to application.

Alternatives: N/A

Exceptions: N/A

Use case ID: 3 Name: User inputs natural language descriptors

pre-conditions: Application is started up and the user is logged in.

post-conditions: Object must be created from class “template” with info from sketch.

Initiated by: User

Triggering Event: User inputs descriptors into system

Additional Actors: N/A

Sequence of Events:

1. User inputs a string of natural language descriptors into the application search box.
2. Application parses input and extracts language descriptors.
3. Application classifies data which will be stored into an object with a template for specifications.
4. Application creates final sketch object.

Alternatives: Related use case based instead on inputting sketch (Use case ID 1).

Exceptions: Parsed input yields no terms fit for sketch creation.

Use case ID: 4 Name: User initiates sketch generation

pre-conditions: User has inputted either a sketch or a string of natural language descriptors into the system and a sketch object is created.

post-conditions: N/A

Initiated by: User

Triggering Event: User presses “Generate” model button.

Additional Actors: N/A

Sequence of Events:

1. User presses the “Generate” model button.
2. System generates a 3-D model of the previously input sketch/ language descriptors with the sketch object that was created.

Alternatives: N/A

Exceptions: N/A

Use case ID: 5 Name: Save facial model

pre-conditions: User has received the facial model

post-conditions: Facial model has been saved in local storage

Initiated by: User

Triggering Event: Clicking ‘save’

Additional Actors: Facial model, local storage

Sequence of Events:

1. User clicks ‘save facial model’, and selects a location to save the facial model
2. Facial model is saved in the location that the user selected.

Alternatives: These would be normal and expected variations from the base case.

Exceptions: These would be unusual variations from the base case, often caused by problems.

Use case ID: 6 Name: User submits a bug report

pre-conditions: User finds a bug

post-conditions: System Administrator has been notified

Initiated by: User

Triggering Event: Clicking ‘file bug report’

Additional Actors: Bugs

Sequence of Events:

1. User clicks ‘submit bug report’
2. User fills out

Alternatives: These would be normal and expected variations from the base case.

Exceptions: These would be unusual variations from the base case, often caused by problems.

Use case ID: 7 Name: Software Setup

pre-conditions: New customer has purchased software, and no setup has yet taken place

post-conditions: Software is fully installed on new customer’s system

Initiated by: Customer

Triggering Event: Purchase

Additional Actors: Professional Software Setup-er

Sequence of Events:

1. User logs into the product website.
    a. Server authenticates user login information.
2. User presses the download button for the latest release of the NLAIFGML software.
    a. Server authenticates software license and, if passed, an executable file is downloaded onto the user's machine.
3. User runs the executable file.
    a. Software installation wizard runs through the setup process.

Alternatives: If the user does not have a valid license, the software will not download. A system administrator may handle installation in place of the user in some cases.

Exceptions:

Use case ID: 8 Name: User initiates facial recognition process

pre-conditions: User has generated a series of faces based on description

post-conditions: User has found best matching face

Initiated by: User

Triggering Event: User generates faces

Additional Actors: N/A

Sequence of Events:

1. User right-clicks a generated sketch and selects “Initiate Facial Recognition’ option.
    a. System requests information from all available databases
2. Databases respond to system requests by providing facial information.
    a. System compares generated sketches with images pulled from databases.
    b. System returns a list of top similar faces and associated identifying information for the user to peruse.

Alternatives: User may select which databases to run facial recognition on instead of all available databases as default.

Exceptions: No databases available: no facial recognition can be run.

10 Functional Requirements

F1 - User Login

Description: The application must allow a user to login into the system with their own credentials.

Rationale: The user should expect their software to save work to their own profile and maintain a degree of security.

Fit Criterion: Previously completed or started work will be saved and reopened when the user is logged in to their own account.

Acceptance Tests: TR5, TE1, TA4

F2 - User Sketch Input

Description: The application must allow a user to upload an image as a template for facial generation.

Rationale: The application allowing a sketch will allow the user to create an image without necessitating the system on hand.

Fit Criterion: The application must be able to identify the image and be able to create a model from it.

Acceptance Tests: TE2

F3 - User Natural Language Input

Description: The application must have a field for the user to input natural language descriptors and parse it accurately.

Rationale: The system must allow a user to input basic descriptive words and parse it in order to generate a facial model.

Fit Criterion: The application must be able to identify the input words and be able to derive a model from it.

Acceptance Tests: TR1, TE2

F4 - User Presses Initiate Model Button

Description: The application must allow a button for the user to begin facial model generation, after some input was supplied.

Rationale: There must be a clear way for the user to tell the application to begin processing the input data and begin the model creation process.

Fit Criterion: The user presses the button and the system creates a facial model based on the input.

Acceptance Tests: TE2

F5 - User Local Save

Description: The application must allow its user the option to locally save the 3-D model created.

Rationale: To allow the user to send the model to other colleagues, continue where they left off, or to save it for internal agency documentation.

Fit Criterion: The system will create a directory with application data file in local storage that can be identified by application for future use.

Acceptance Tests: TE3, TB3

F6 - User Submits Bug Report

Description: The application must provide a form for the user to input logistics on what error has occurred.

Rationale: The user should be able to clearly deliver information to a system administrator regarding any potential bugs.

Fit Criterion: A systems administrator must receive a report from a user.

Acceptance Tests: TB5

F7 - User Begins Facial Recognition Process

Description: The system must allow the user to match an output 3-D model against a database of images of real people.

Rationale: This is to allow the user to scan the database profiles and see if they have found a potential match.

Fit Criterion: The system must pull up a series of profiles with varying degrees of similarity to the 3-D model.

Acceptance Tests: TE4, TR2

11 Data Requirements

D1 - Sketch Input Format

Description: The application must be able to accept and process any JPEG or PNG image file format.

Rationale: JPEG and PNG are by far the most commonly used and readily available file formats for images.

Fit Criterion: The application being able to identify and process an input sketch to a 3-D model.

Acceptance Tests: TE2

D2 - Natural Language Input

Description: The application must accept and be able to parse words from the English language.

Rationale: The software is built to be used by crime agencies in the United States, meaning a standard language must be used by all users.

Fit Criterion: The application must only be able to identify English words and let the user know if any of their inputs do not follow the standard.

Acceptance Tests: TE2

D3 - Save Data

Description: The application must store the locally saved work done, in a separate directory for each new project started. The directory must contain a file as xml data to store/restore the previous configuration and the 3-D model as a file format that can be read by any mainstream 3-D modeling software.

Rationale: The user must be able to easily download their work to their local machine.

Fit Criterion: Upon saving a session, the user must be able to locate the directory where their work was saved to.

Acceptance Tests: TE3, TB3

D4 - External Database File Format

Description: The application must be able to process JPEG or PNG image file formats for the external image database.

Rationale: The file format for the real time data must be of a known and easily identifiable standard.

Fit Criterion: The external image database contains images of a JPEG or PNG file format.

Acceptance Tests: TE4, TR2

D5 - Internal Database File Format

Description: The application must be able to create an internal database with a directory for every suspect in the database. The directory will contain an image file with a JPEG or PNG file format, and an xml file containing various stats about the suspect (name, age, birthdate, address, etc).

Rationale: The application must be able to match a 3-D model against an internal database of various people's profiles. Having a standard will make it easier to create new profiles as the machine learning algorithm gets better.

Fit Criterion: Every internal database suspect's profile must be viewable in a directory.

Acceptance Tests: TE4

12 Performance Requirements

12a Speed and Latency Requirements

P1 - User Launch

Description: The application must launch within 20 seconds of the user launching it.

Rationale: The software does not have very many front end assets to handle during startup so it should not take long to open.

Fit Criterion: The application is open and ready to use in 20 seconds.

Acceptance Tests: TE5

P2 - User Login

Description: The application must log a user in within a 5 second time frame.

Rationale: User login must be a simple check to see if the user is part of a crime agency and log them in quickly.

Fit Criterion: The user is ready to start adding some input to the application within 5 seconds after being logged in.

Acceptance Tests: TE5

P3 - User Model Generation

Description: The application must provide a 3-D model after pressing the "Generate" model button within 5-10 minutes.

Rationale: Given that the application relies heavily on machine learning and AI algorithms, it is expected that the generation of a 3-D facial model will take some time to create.

Fit Criterion: After pressing the "generate" model button, a 3-D model must be presented within 5-10 minutes.

Acceptance Tests: TE5

12b Precision or Accuracy Requirements

PA1 - 3-D Model Match

Description: The application must match a 3-D model against an internal database of suspects profiles and returns matches with up to 65% accuracy.

Rationale: Models created by the application can not always be completely accurate. Therefore, it must return a list of possibly similar matches to cover any possible suspects.

Fit Criterion: When matching a model against the internal suspect database, the application must return a list of matches within 65% facial identification accuracy

Acceptance Tests: TE5

12c Capacity Requirements

C1 - Users Support Per Computer

Description: The application must be able to handle, at maximum, 50 users per computer.

Rationale: Computers are shared amongst many employees, each with their own log-ins.

Fit Criterion: The application must account for 50 users per computer without loss of functionality or data.

Acceptance Tests: TA5

C2 - Total User Support

Description: The application must be able to handle, at maximum, 4 million users.

Rationale: The amount of law enforcement agents varies from year to year, and may even increase in the future.

Fit Criterion: The application must account for 4 million users without loss of functionality or data.

Acceptance Tests: TA5

C3 - External Database Size

Description: The application's external database must support up to 5 trillion total processed images.

Rationale: Using real time data from many sources will contribute to many images being taken of people from various angles.

Fit Criterion: The application's external database must support up to 5 trillion images without any loss of data.

Acceptance Tests: TE4, TA5

C4 - Internal Database Size

Description: The application's internal database must support up to 1 billion total suspect profiles.

Rationale: The amount of people in the USA continues to grow on a fairly consistent basis. 1 billion profiles should be enough to account for all the people in the USA for many years.

Fit Criterion: The application's internal database must support up to 1 billion suspect profiles without any loss of data.

Acceptance Tests: TE4, TA5

13 Dependability Requirements

13a Reliability Requirements

Dep1 - No Data Loss

Description: The application must maintain the integrity of its internal and external databases as well as session information upon a failure.

Rationale: The user should expect any sensitive information and work to be maintained without loss.

Fit Criterion: No data corruption or loss of any previously done work, internal and external databases must be unaffected upon failure.

Acceptance Tests: TB5

Dep2 - Failure Rate

Description: The application must not fail more than once a month.

Rationale: The user should expect a professional, high quality product, to aid in a very sensitive occupation with no disturbances.

Fit Criterion: Upon normal use, the application will not fail more than once in a one month period.

Acceptance Tests: TB5

13b Availability Requirements

A1 - Application Uptime

Description: The application must maintain 99% uptime.

Rationale: The application should be able to be used at any given time and moment, save for any maintenance or updates that must be pushed (during non peak hours).

Fit Criterion: Over the course of a year, the software must be available to be used at any moment with the only down time being during maintenance or scheduled updating.

Acceptance Tests: TB5

A2 - Application Downtime

Description: The application must recover from any type of downtime within a 6 hour time period.

Rationale: The application should be able to quickly recover from any maintenance, updating, or failure within a relatively short time.

Fit Criterion: After experiencing any form of downtime, the application should be able to resume with full functionality within 6 hours.

Acceptance Tests: TB5

13c Robustness or Fault-Tolerance Requirements

R1 - Internet Connectivity

Description: The application must work without an internet connection as long as an admin is logged in.

Rationale: The application will mainly be communicating with 2 databases, which will most likely be remote. Therefore the need for a way to log in without the internet is necessary, but we still do not want anyone without special privileges to use the software.

Fit Criterion: The application will allow an admin to log in and use the software without an internet connection, while a normal user should not be able to.

Acceptance Tests: TA3, TE1

13d Safety-Critical Requirements

SC1 - Software Hardware Safety

Description: The application must not overheat the hardware it runs on to the point of causing a system failure.

Rationale: Machine learning algorithms can be pretty taxing on a computer system. The software should not use up so much CPU power such that it causes overheating in components or failures.

Fit Criterion: While generating a facial model, the system CPU temperature must not exceed 85 celsius.

Acceptance Tests: TB5

14 Maintainability and Supportability Requirements

14a Maintenance Requirements

MS1 - Backups

Description: The system must automatically back data up to a cloud server.

Rationale: To prevent important files and data from being lost.

Fit Criterion: Display a syncing progress bar on start while syncing to the cloud.

Acceptance Tests: TA1, TA3, TB3, TE4

MS2 - Updates (Non Major)

Description: The system must automatically update itself (non-major versions).

Rationale: To make sure the application has the latest security patches and features.

Fit Criterion: Display software version on splash screen which shows if updates are available.

Acceptance Tests: TA1, TA3

MS3 - Updates (Major)

Description: The sysadmin must update the system (major versions).

Rationale: To make sure the application has the latest security patches and features.

Fit Criterion: Display software version on splash screen which shows if updates are available. Update will only go through if sysadmin credentials are used.

Acceptance Tests: TA1, TA3, TA4

14b Supportability Requirements

MS4 - Troubleshooting

Description: The system must have a help menu option available in-app to provide support for usage or troubleshooting.

Rationale: To allow users to understand the full functionality of the application, and provide for help when encountering an issue.

Fit Criterion: Try techniques detailed within help troubleshooting and check for resolution.

Acceptance Tests: TR4, TA2, TB5

MS5 - Connect with Sysadmin

Description: The system must provide the user a connection to a sysadmin.

Rationale: To ensure that human support is available to address local concerns.

Fit Criterion: Click a “Connect with Sysadmin” button within the Help menu option and check if connection to a sysadmin goes through.

Acceptance Tests: TA3

MS6 - Contact Support

Description: The system must provide a means for the user to contact support.

Rationale: To ensure that the user can report system bugs or other issues.

Fit Criterion: Click a “Contact Support” button within the Help menu option and check if connection to a customer support representative goes through.

Acceptance Tests: TA3, TB5

14c Adaptability Requirements

MS7 - Windows 10

Description: The application must be compatible with Windows 10 or higher.

Rationale: To provide compatibility with a large number of users while maintaining a minimum level of safety with a modern OS.

Fit Criterion: Run a check on installation that determines if the OS is compatible.

Acceptance Tests: TA5, TB5

MS8 - macOS 10.13

Description: The application must be compatible with macOS 10.13 (High Sierra) or higher.

Rationale: To provide compatibility with a large number of users while maintaining a minimum level of safety with a modern OS.

Fit Criterion: Run a check on installation that determines if the OS is compatible.

Acceptance Tests: TA5, TB5

MS9 - Linux Kernel 5.10

Description: The application must be compatible with any Linux distro (Debian, Red Hat, Arch, etc.) built upon the Linux Kernel v5.10 or higher.

Rationale: To provide compatibility with a large number of users while maintaining a minimum level of safety with a modern OS.

Fit Criterion: Run a check on installation that determines if the OS is compatible.

Acceptance Tests: TA5, TB5

14d Scalability or Extensibility Requirements

MS10 - Enterprise Edition

Description: The system must have a specific version designated for use with servers and large-scale applications.

Rationale: To ensure preparedness in supporting large networks greater than solely one agency.

Fit Criterion: The application will verify the scale of intended use upon installation and make recommendations if needed.

Acceptance Tests: TA5, TB4

MS11 - Mobile Edition

Description: The system must support a mobile application (on a smaller scale) which provides just enough extensibility for basic usage.

Rationale: To allow users to stay connected to the application in an ever increasing mobile world.

Fit Criterion: Ensure that the application can also be scaled down for basic mobile usage.

Acceptance Tests: TA3, TB5

14e Longevity Requirements

MS12 - Longevity

Description: The application is expected to have a minimum lifespan of 10 years.

Rationale: To ensure that user needs are met in regards to lengthy cases of finding criminals.

Fit Criterion: The application lifespan should be in accordance with the local statute of limitations at minimum.

Acceptance Tests: TR1, TR2, TR3, TR4, TR5, TA1, TA2, TA3, TB1, TB5, TE2, TE3, TE4, TE5

15 Security Requirements

15a Access Requirements

S1 - Sysadmin

Description: The system must provide the Sysadmin with complete control.

Rationale: To allow the sysadmin to handle administrator-level issues, updates, installation, user creation, etc.

Fit Criterion: During installation, the application prompts the user if they are designated as the agency's Sysadmin, and proceeds with installation if they are.

Acceptance Tests: TA4

S2 - Users

Description: The system must provide non-Sysadmins with user-level control.

Rationale: To ensure that users don't access or modify system-wide data.

Fit Criterion: All system accounts created after installation will be designated as a user-level account and maintain permissions as such.

Acceptance Tests: TA4

15b Integrity Requirements

S3 - 2FA

Description: The system must require a 2FA login process for all users.

Rationale: To provide an additional layer of security.

Fit Criterion: All accounts (including Sysadmin) must provide either a phone number or e-mail address to register for 2FA upon account creation.

Acceptance Tests: TR5, TA4, TE1

S4 - Cloud

Description: The system must regularly maintain cloud backups for all accounts.

Rationale: To safeguard from data loss in any unexpected event.

Fit Criterion: The system will prompt a user upon login to backup data to the cloud if a backup hasn't occurred in 7 days.

Acceptance Tests: TA3, TB3, TE4

S5 - Destroy All

Description: The system must provide a means to initiate a remote deletion of all data.

Rationale: To ensure confidential data is not accessed in the event of loss or theft of the host machine.

Fit Criterion: Sysadmin will have access to a remote "Destroy All" option on the cloud-based controller.

Acceptance Tests: TA3, TA4, TB3, TE4

15c Privacy Requirements

S6 - Privacy Policy

Description: The system must provide a means for users to be aware of the privacy policy.

Rationale: To ensure that users know their rights with data usage.

Fit Criterion: An easy to read message will be shown somewhere during account creation to inform users of the system's privacy policy.

Acceptance Tests: TA2

S7 - Legal Compliance

Description: The system, and all usage of the system, must comply with all local and federal legal requirements.

Rationale: To ensure that users are not infringing on the rights of others or breaking any laws.

Fit Criterion: All major software updates must take into consideration local and federal laws or regulations which may affect usability.

Acceptance Tests: TB1

15d Audit Requirements

S8 - Receipts

Description: The system must provide digital receipts for any transactions made, whether for the software itself or for in-app purchases.

Rationale: For the user to have proof of purchase and/or for business related expenses for tax documentation.

Fit Criterion: Digital receipts should be emailed to the user after any transaction.

Acceptance Tests: TA5

15e Immunity Requirements

S9 - Data Encryption

Description: The system should provide a means for all data to be encrypted.

Rationale: In order to keep all information secure.

Fit Criterion: The system will practice end to end encryption with any information sent out to other sources or within itself.

Acceptance Tests: TB5

16 Usability and Humanity Requirements

16a Ease of Use Requirements

X1 - Use of Natural Language

Description: Must allow the user to communicate with natural language

Rationale: The ability to describe the face with words allows for the most intuitive usability.

Fit Criterion: The software will be equipped with a natural language processor to translate the user's natural language to the required format for creating the face(s)

Acceptance Tests: TR1, TR3

16b Personalization and Internationalization Requirements

X2 - Customize Image Origin

Description: User must have the ability to set the preferred geographical origins for the face generation to favor upon generating a face

Rationale: Geographical location plays an important role in security footage capturing

Fit Criterion: Application setting menu will contain an option to select/deselect preferred geographic locations

Acceptance Tests: TR2

X3 - Application Wallpaper/Font

Description: User must have the ability to change the wallpaper and font on the application home screen

Rationale: Everyone wants to feel homey when fighting crime

Fit Criterion: Application setting menu will contain an option to select your wallpaper and font

Acceptance Tests: TR3

16c Learning Requirements

X5 - Intuitive Video Instructions

Description: Software will include intuitive video instructions demonstrating how the software is used

Rationale: Videos are often times easier to understand than written instructions

Fit Criterion: Upon product setup, users will be sent a series of instructional videos.

Acceptance Tests: TR4

X6 - Owner's Manual

Description: Software will include an intuitive owner's manual.

Rationale: Software will require at least some sort of documentation

Fit Criterion: Owner's manual will be provided to the user at product setup time.

Acceptance Tests: TR4

16d Understandability and Politeness Requirements

X8 - Interactive GUI

Description: GUI will be responsive and clearly demonstrate what is happening with text descriptions and vibrant responses to user action

Rationale: A program's responsiveness deeply effects the user's experience in understanding what is going on

Fit Criterion: GUI's controls (buttons, text boxes, screen changes) will be clearly responsive to user input. When something is going on in the backend of

the application, a brief description of what the application is doing will be displayed as well.

Acceptance Tests: TR3

16e Accessibility Requirements

X9 - Natural Language

Description: Product must be controllable via natural language

Rationale: Those who for any reason are unable to operate a computer via mouse/keyboard will have the ability to operate via natural language

Fit Criterion: Software will include a natural language processor.

Acceptance Tests: TR9

16f User Documentation Requirements

X10 Login Information

Description: Users will be required to provide login credentials in order to use the product.

Rationale: Information about the user's preferences will be stored in their account.

Fit Criterion: Upon opening the application for the first time, the user can login or create an account. At any point, the user can log out of the current account.

Acceptance Tests: TR5

16g Training Requirements

X11 - Video Demonstration

Description: User(s) will be required to view video training videos before use.

Rationale: Product may be slightly confusing at first

Fit Criterion: At product setup time, users will be provided with videos to view before use.

Acceptance Tests: TR4

17 Look and Feel Requirements

17a Appearance Requirements

Z1 - Logo and Theme Colors

Description: NLAIFGML Logo must be visible at *all* times in application window

Rationale: The user may forget the name/logo of the company of the software they are using.

Fit Criterion: Software will have a base color that matches the logo, and the logo will always be somewhere on the screen

Acceptance Tests: TR3

17b Style Requirements

Z2 - Responsive Feel

Description: Program should feel responsive to any interaction the user provides

Rationale: Responsive programs feel great to use (by most)

Fit Criterion: GUI elements will light up, grow/shrink, move, etc. based on user input.

Acceptance Tests: TR3

18 Operational and Environmental Requirements

18a Expected Physical Environment

OE1 - Office Setting

Description: The product will be used on either a laptop or PC primarily in an office setting.

Rationale: The application is intended for use by public or private institutions rather than individual/personal use.

Fit Criterion: The product should be able to be comfortably used in an office setting.

Acceptance Tests: TB5 - Quality Assurance

18b Requirements for Interfacing with Adjacent Systems

OE2 - Internet Access

Description: Internet access is required.

Rationale: The application needs access to online databases to work properly and securely authenticate user credentials.

Fit Criterion: The application must be able to connect to the internet and request information from the various external databases.

Acceptance Tests: TA3 - Check Connection

18c Productization Requirements

OE3 - Online Distribution

Description: The product shall be distributed via a downloadable file.

Rationale: Modern users increasingly expect an online solution to their software downloads instead of having to keep track of physical CDs.

Fit Criterion: A website to download the software for licensed users should be available.

Acceptance Tests: TA3 - Check Connection, TB4 - Check Product License

OE4 - Subscription-based Licensing

Description: The product shall be sold as a renewable license that must be renewed for continued use.

Rationale: Subscription based software licensing allows for ongoing maintenance and updates to be made to the software to avoid obsolescence as well as continued support to the customers.

Fit Criterion: The product license should be renewed annually; the software will not be usable with an expired license.

Acceptance Tests: TA4 - Permissions Met, TB4 - Check Product License, TA1 - Check if Current

18d Release Requirements

OE5 - Backwards Compatibility

Description: A new release of the software shall not cause compatibility issues with any previous releases.

Rationale: Y The product is an ongoing service rather than a stand-alone single purchase and as such we want the user to be able to continue using their software despite any changes each release may bring with the license they paid for.

Fit Criterion: Conduct extensive bug and QA testing for each release to make sure no old functionality is compromised before release of updates.

Acceptance Tests: TB5 - Quality Assurance

19 Cultural and Political Requirements

19a Cultural Requirements

C1 - Eliminating Racial Bias

Description: The product shall not have racial bias in the facial data it produces or evaluates.

Rationale: Racial bias in facial recognition/generation software is a common flaw that interferes with proper identification of involved individuals as well as have devastating effects on those affected by it.

Fit Criterion: Comparisons must be done to make sure the application does not overrepresent any groups in the facial selection process.

Acceptance Tests: TB2 - Eliminating Bias

20 Legal Requirements

20a Compliance Requirements

L1 - Compliance With Regulations

Description: The product shall comply with existing FRT, Biometrics and General Privacy Regulations in the United States.

Rationale: As similar technologies are already commonplace, legal requirements for the product can be expected to be similar as well, with many overlapping requirements.

Fit Criterion: FRT, biometrics and General Privacy regulations in the state the product will be developed in must be followed.

Acceptance Tests: TB1 - Regulatory Compliance

20b Standards Requirements

L2 - Data Retention

Description: Use of images created or accessed by the software shall not be used for another purpose without appropriate consent and transparency.

Rationale: Misuse of the software by individuals for their own purposes must be prevented so as to avoid legal and ethical issues.

Fit Criterion: Clear rules for image use and retention (including where and how long images can be stored and under what circumstances and by whom the images can be used) must be defined.

Acceptance Tests: TB1 - Regulatory Compliance, TB3 - Data Retention

21 Requirements Acceptance Tests

21a Requirements – Test Correspondence Summary

Table 4 - Requirements - Acceptance Tests Correspondence

Tests	TR1	TR2	TR3	TR4	TR5	TA1	TA2	TA3	TA4	TA5	TB1	TB2	TB3	TB4	TB5	TE1	TE2	TE3	TE4	TE5
Requirements																				
F1					X				X							X				
F2																	X			
F3	X																X			
F4																	X			
F5													X					X		
F6															X					
F7		X																	X	
D1																	X			
D2																	X			
D3													X					X		
D4		X																	X	
D5																			X	
P1																				X
P2																				X
P3																				X
PA1																				X
C1										X										
C2										X										
C3										X									X	
C4										X									X	
Dep1															X					
Dep2															X					
A1															X					
A2															X					
R1								X								X				
SC1															X					
MS1						X		X					X						X	
MS2						X		X												
MS3						X		X	X											
MS4				X			X								X					
MS5								X												
MS6								X							X					
MS7										X					X					
MS8										X					X					
MS9										X					X					
MS10										X				X						
MS11								X							X					
MS12	X	X	X	X	X	X	X	X			X				X		X	X	X	X
S1									X											
S2									X											
S3					X				X							X				
S4								X					X						X	
S5								X	X					X					X	
S6							X													
S7											X									
S8										X										
S9															X					
X1	X		X																	
X2		X																		
X3			X																	
X4			X																	
X5				X																
X6				X																
X7									X											
X8			X																	
X9	X																			
X10					X															
X11				X																
Z1			X																	
Z2			X																	
OE1															X					
OE2								X												
OE3								X						X						
OE4						X			X					X						
OE5															X					
C1												X								
L1											X									
L2											X		X							

21b Acceptance Test Descriptions

TR1 - Accessibility Test

Description: User will attempt to communicate with Face Generator via natural language. If the software responds with face generation in an expected manner, we will accept the application.

TR2 - Image Origin Selection Test

Description: User will customize the geographical origin of images to be used by the AI face generator. If the images used by the face generator are from only those geographical locations, we will accept the code.

TR3 - Appealing Use Test

Description: User will select a wallpaper and font of their choice to be set in the application window. Additionally, the user will perform all interactions possible with the GUI. If the GUI is responsive to changing wallpaper and font, as well visually responsive to mouse/keyboard interaction, we will accept the code.

TR4 - Intuitive Instructions Test

Description: User will watch instruction videos. Then, the user will attempt to use the application with the manual at hand. If the user is able to use the program with ease after watching and reading the instructions, we will accept the code.

TR5 - Login Requirement Test

Description: User will start up a freshly installed copy of the software. If upon boot up the application requires the user to enter login information, we will accept the application.

TA1 - Check if Current

Description: This test will check if the software is current or up to date with services such as data backups, software updates, etc.

TA2 - Referenced Files

Description: For any files that are referenced by the software (e.x. software documentation), this test will check the validity of the reference to that file; in other words, this test will check if the reference to the file (or the file itself) actually exists.

TA3 - Check Connection

Description: This test will check if the software is connected to any necessary connections the test caller requires, such as internet, cellular, personal networks, etc.

TA4 - Permissions Met

Description: This test will check if the software-level permissions (e.x. sysadmin level, secure login success) are met for the test caller.

TA5 - Check if Requirements Met

Description: This test will ensure that the test caller's requirements are met, in the way that makes most sense for that test caller, to fulfill tested requirements.

TB1 - Regulatory Compliance

Description: A team of lawyers will look over the software documentation for any incompatibility with local and international laws that needs to be accounted for.

TB2 - Eliminating Bias

Description: Error rate for different ethnic groups as the subject identified by the image generation software will be compared against each other to make sure there are no discrepancies.

TB3 - Data Retention

Description: The application will make sure that data is encrypted and all actions made by a user are documented to allow accountability.

TB4 - Check Product License

Description: Check if the software license is expired or not using an authentication process for the user and unique ID for each licensed instance of the software.

TB5 - Quality Assurance

Description: Testing for bugs, incompatibility issues, ease-of-use, etc. by the quality assurance team.

TE1 - Credential Login Test

Description: This test will verify that the software must have a user, which is part of a law enforcement agency, log in before any functionality is available.

However, if there is no internet connection available, then an admin account will still be able to login.

TE2 - Input File Test

Description: This test will verify that the software must have a user input either a sketch (JPEG or PNG) or some natural language descriptors(English words) before being able to generate a 3-D model of a face.

TE3 - Save Directory Test

Description: This test will verify that the software must create a directory containing necessary files.

TE4 - Database Test

Description: This test will verify that the software has two databases with sufficient size. One external database for uploading the real time data for image processing. One internal database for creating suspect profiles. Each one must have the correct file types. Both these databases must communicate with the application.

TE5 - Speed Test

Description: This test will verify that the software performs specific actions in the mandated amount of time.

III Design

22 Design Goals

1. NLAIFGML should be easy to use and understand, requiring minimal training to use.
2. The software should be able to connect to multiple external facial databases to use as long as the owner of the program has access to them.
3. Any data accessed or created by NLAIFGML should be as secure as possible.
4. The possibility of misuse of the program should be minimized.

23 Current System Design

Currently similar tasks are carried out by forensic artists, who listen to a description of a suspect and draw an approximation of what they might look like to have a visual representation of a suspect.

24 Proposed System Design

24a Initial System Analysis and Class Identification

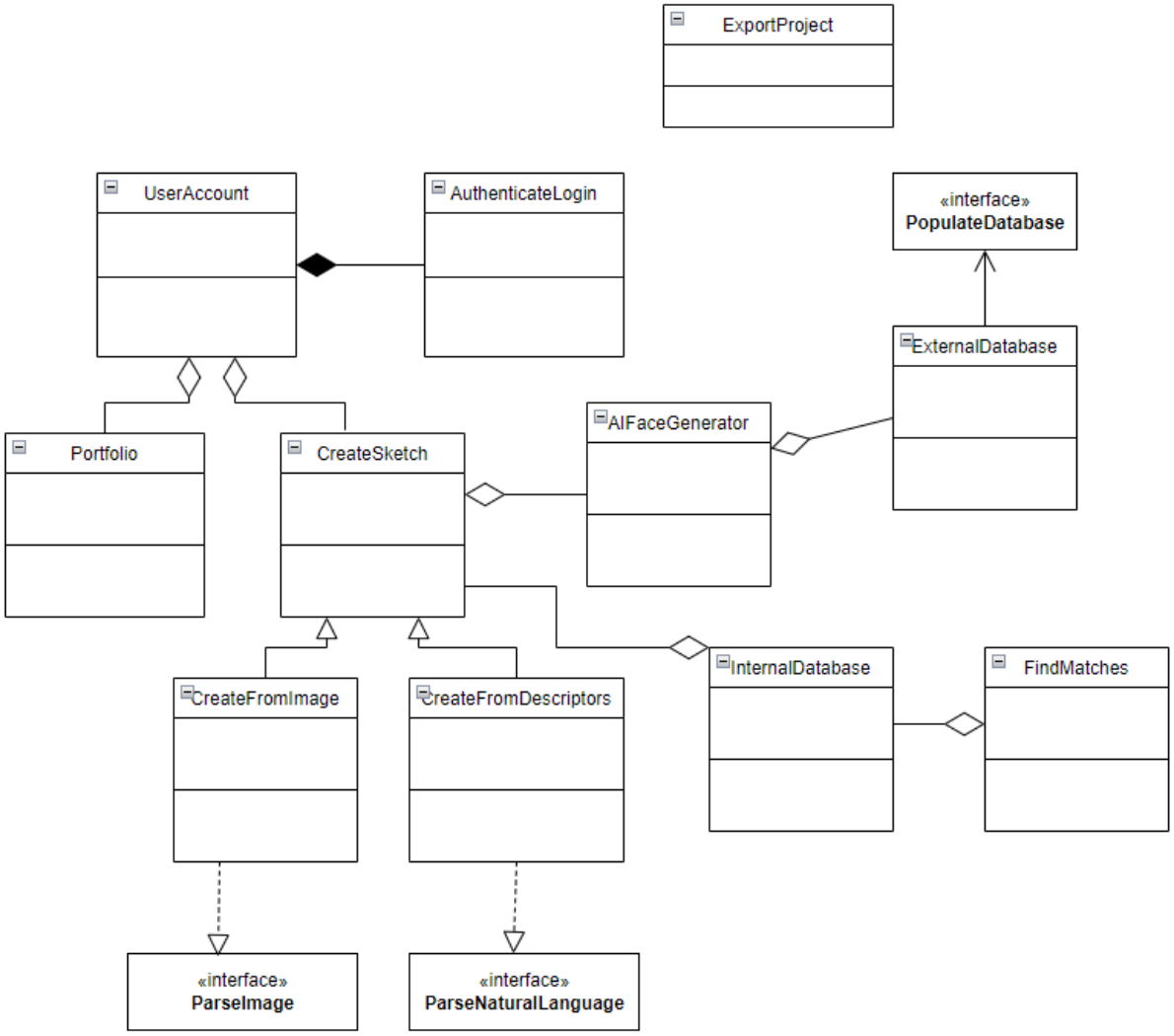

Figure 4 - Initial Class Diagram

24b Dynamic Modeling of Use-Cases

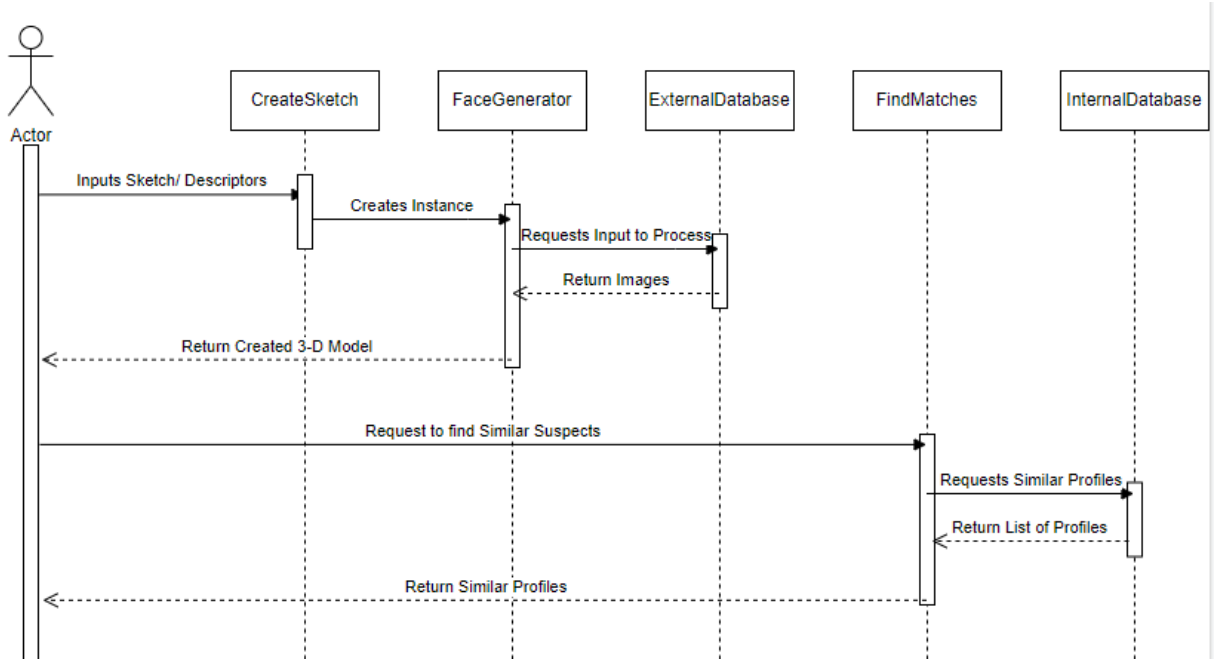

Figure 5 - Find Similar Suspects Sequence Diagram

24c Proposed System Architecture

The NLAIFGML application involves the use of a couple of remote databases in order to complete and deliver 3-D models of human faces. As such, the application is heavily reliant on a client-server architecture in order to receive the required resources for the AI algorithm to, not only learn how to modify existing facial models, but for users to receive the detailed profiles of similar in appearance suspects, all from a remote database. Additionally, this application is also a full GUI application meaning it would be the most optimal to split the GUI into a MVC style architecture.

24d Initial Subsystem Decomposition

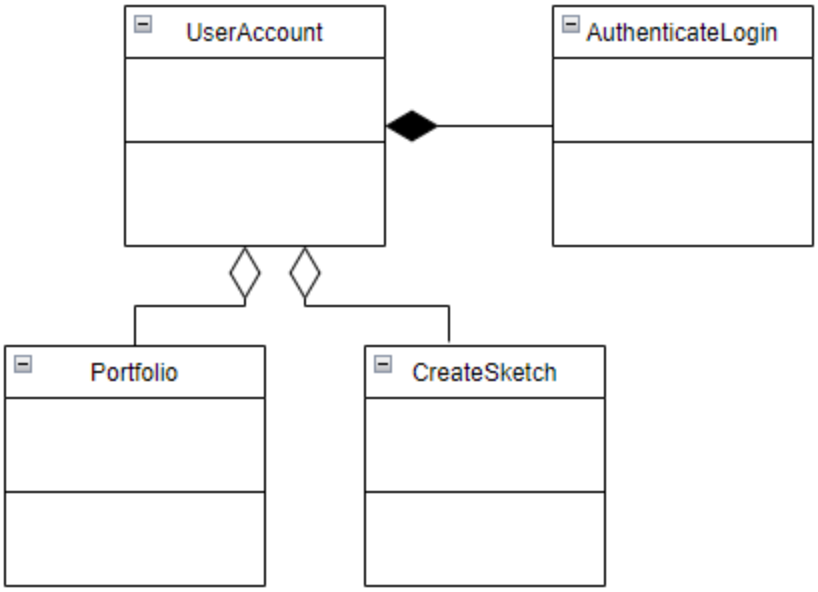

Figure 6 - User Subsystem

User Subsystem: This is mainly responsible for handling user login, by making sure a user is part of a criminal justice organization, and how a user can be using the software to begin creating 3-D models. Each user will also have a portfolio of their projects so they can view them at any time.

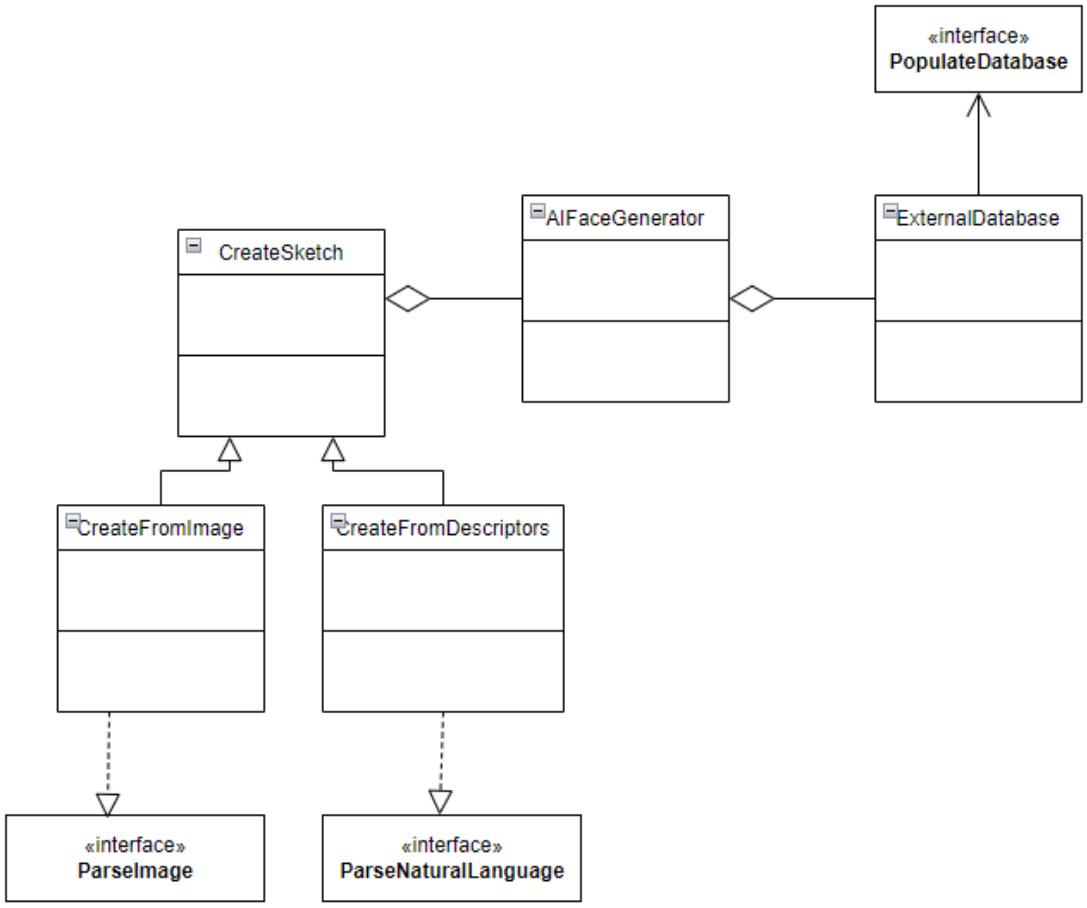

Figure 7 - Create 3-D Model Subsystem

Create 3-D Model Subsystem: This subsystem will handle the creation of a 3-D model. It will directly communicate with the external database of public images of human faces to supply the AI algorithm with input.

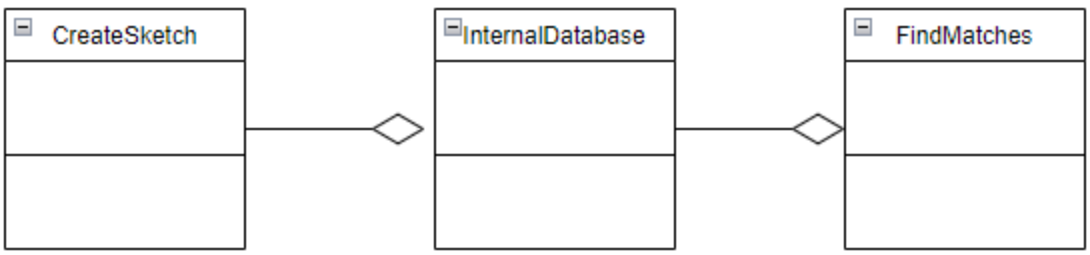

Figure 8 - Find Similar Suspects Subsystem

Find Similar Suspects Subsystem: This subsystem will handle finding profiles of suspects that match the 3-D model created. It will be communicating with an internal database of people's profiles to create a list of matches to return to the user.

25 Additional Design Considerations

25a Hardware / Software Mapping

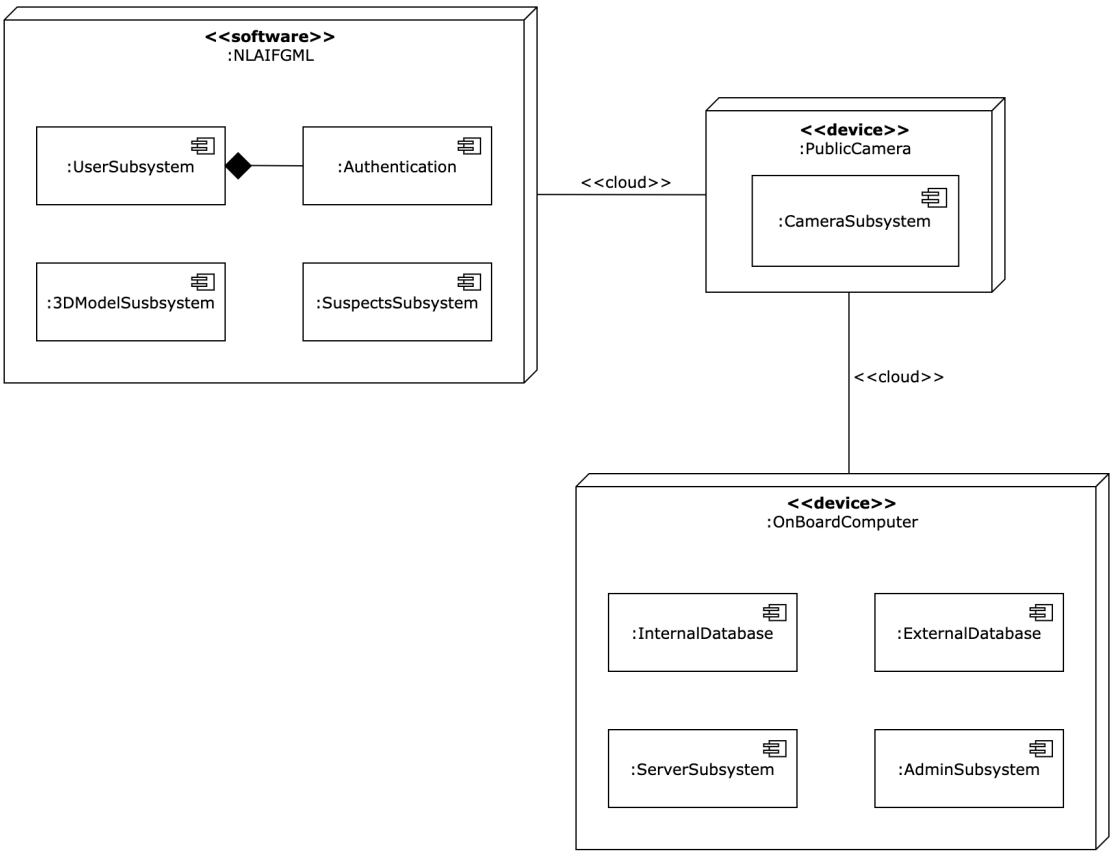

Figure 9 - Hardware / Software Mapping Diagram

25b Persistent Data Management

- User Subsystem
  - **User Accounts:** A list of all current accounts registered within the software system, complete with their login info and account information such as email and phone number.
  - **Account Data:** A package of that accounts information such as suspect profiles, 3D facially generated images, uploaded sketches, etc.

    - **Approved devices:** A list of devices which were last logged in to the account; this could be 1 or multiple desktops or mobile devices.
- 3-D Model Subsystem
    - **Generated Faces:** Files of all 3-D facially generated images, either final or those which were currently in progress, along with their context.
    - **Linked accounts:** A key/value list of accounts which had access to the subsystem and the corresponding facially generated images they created.
    - **History:** A history of the 3-D model subsystem including order access of profiles should be restored, specific to each account.

25c Access Control and Security

The user subsystem will handle all the necessary access control and security concerns, regarding any data needing to be accessed by users or having the credentials to even access the software in the first place.

25d Global Software Control

Developers and administrators will have complete control over every aspect of the software, including the databases. If there is any need to correct any issues, this group is allowed to login and make direct changes to the system and deploy any updates to the rest of the users.

25e Boundary Conditions

- Initial configuration and setup when first launched
    - Specific setup for admin setup, which should be first setup
    - Following setups for regular user accounts and additional admin
- Intentionally closing the application
    - Unsaved data should be asked to be saved, or changes discarded.
    - Saved should be the primary button.
- Unintentionally closing the application
    - Data should be auto-saved prior to closing down.
    - Mobile data should also be auto-saved prior to reaching low battery.

25f User Interface

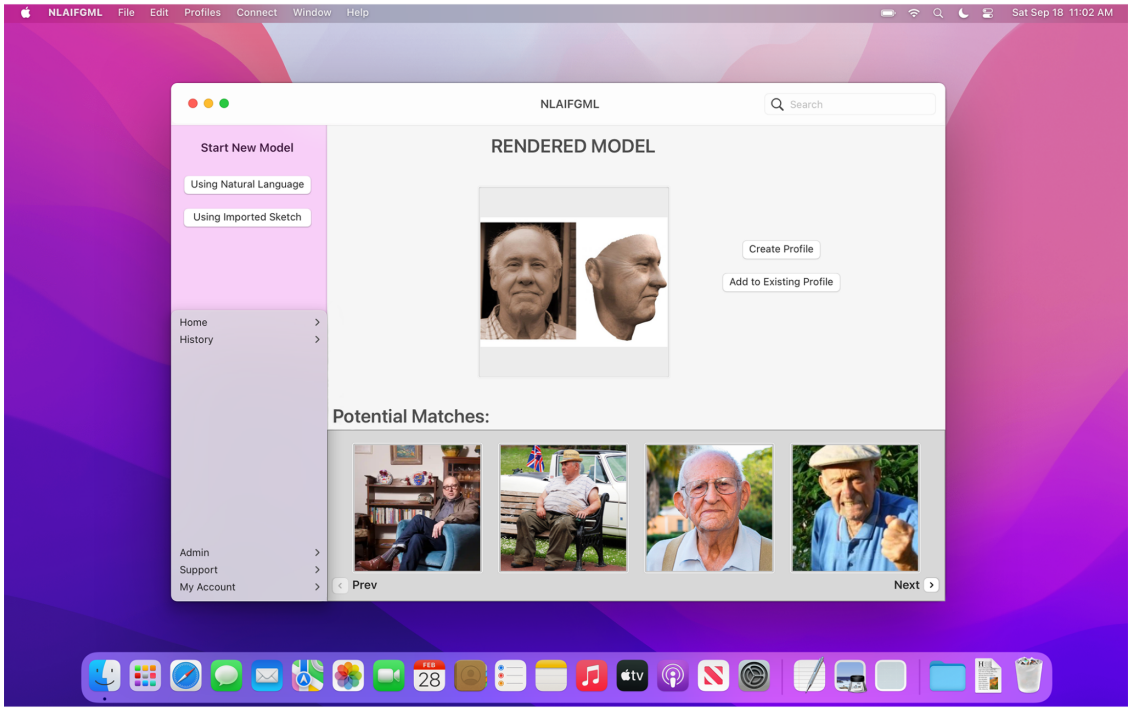

Figure 10 - High Fidelity Mockup

25g Application of Design Patterns

N/A

26 Final System Design

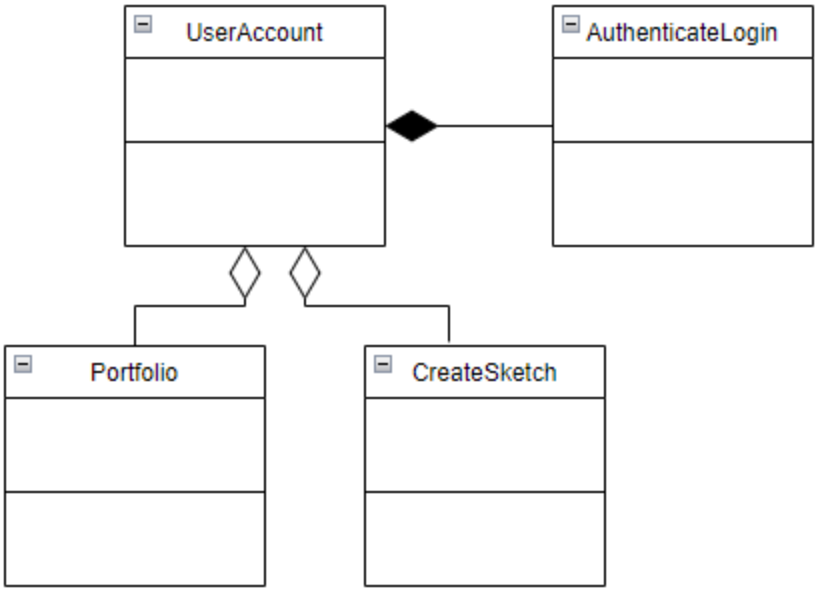

Figure 6 - User Subsystem

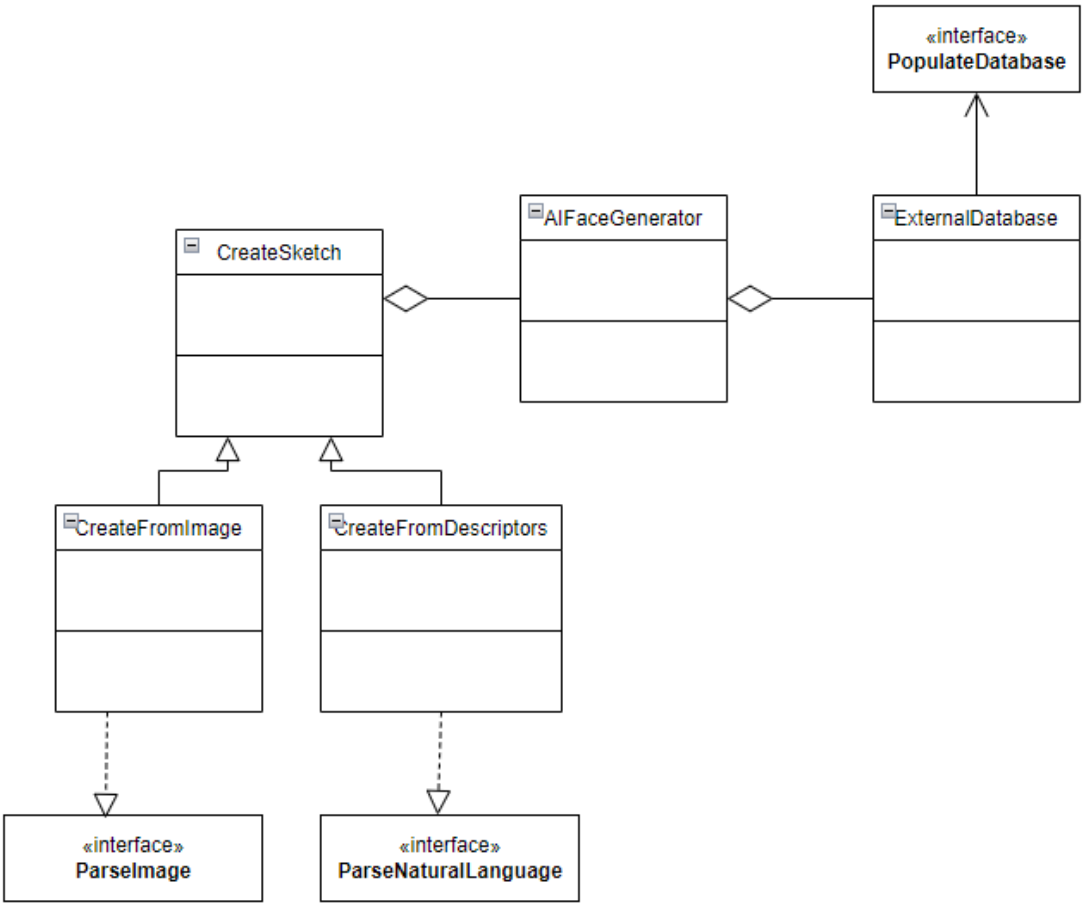

Figure 7 - Create 3-D Model Subsystem

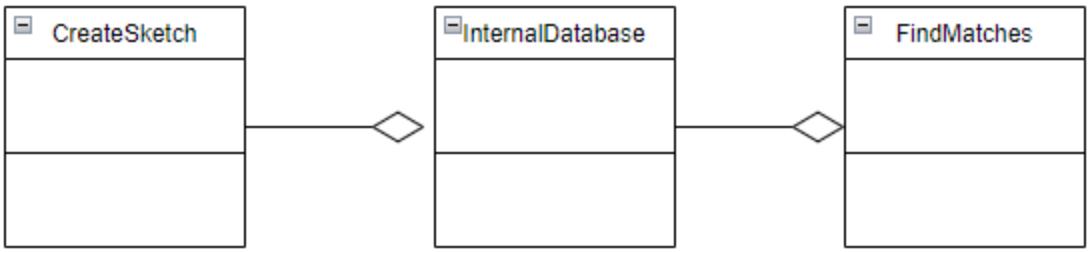

Figure 8 - Find Similar Suspects Subsystem

27 Object Design

27a Packages

The Piano Training Simulator has no current requirements of assigning classes to packages. Class, variable, method, and interface names should be independent and unique in that the environment the software is built upon should have no conflicts within its namespace.

27b User Subsystem

- AuthenticateLogin
- UserAccount
    - Portfolio
    - CreateSketch

27c Create 3-D Model Subsystem

- PopulateDatabase
    - ExternalDatabase
- AIFaceGenerator
- CreateSketch
    - ParseImage
        - CreateFromImage
    - ParseNaturalLanguage
        - CreateFromDescriptors

27d Find Similar Suspects Subsystem

- CreateSketch
- InternalDatabase
- FindMatches

IV Project Issues

28 Open Issues

- Voice recognition software as it currently exists is not advanced enough to be used comfortably; users often have to repeat what they said several times or speak slowly and pronounce things very deliberately for the software to understand them.
- 3D facial image generation via flat image scanning or natural language methods (such as stated above in voice recognition) may not be accurate enough to to be used in practice as it currently stands, and so this remains an open issue.
- Database integration and any classes/methods that utilize them as such is not polished enough yet to guarantee a fully functional and working experience; this

is not due to the fact that they *cannot* be implemented, but rather the fact that there are simply so many options to choose from, each with their own regulations and protections, which would make this a quite difficult task.

- In reference to the point above, it's pretty obvious that the largest and most up-to-date databases should be used, and so integration with those specific databases can be regarded as an open issue.
- Another possible open issue could be the file format of a 3D facially generated image. Do we choose to follow a specifically compatible already existing 3D format, or use our own custom proprietary file format that caters to our needs?

29 Off-the-Shelf Solutions

29a Ready-Made Products

1. Looking Glass AI and Zoetrope 5 are softwares that generate AI artwork based on user descriptions and a library of images provided to them to help them generate their images. These softwares can be modified and trained to work with faces specifically.

29b Reusable Components

1. Facial recognition databases that are already owned by institutions such as the FBI and CIA can be used with the program to provide a base to generate new facial images off of and to match up similar faces that were generated to potentially recognise culprits.
2. These libraries can additionally also be used to train the AI.

29c Products That Can Be Copied

N/A

30 New Problems

30a Effects on the Current Environment

The widespread use of this product may end up pushing forensic artists out of their work if it is much cheaper than hiring them. The other possibility is that forensic artists will simply gain a new tool to better do their work, possibly doing manual adjustments on images created by NLAIFGML or working with it to create the most accurate representation possible.

30b Effects on the Installed Systems

N/A

30c Potential User Problems

It may be possible for a user with access to this software to abuse it for their own means, however, that possibility exists within all similar softwares used in law enforcement.

30d Limitations in the Anticipated Implementation Environment That May Inhibit the New Product

N/A

30e Follow-Up Problems

N/A

31 Migration to the New Product

31a Requirements for Migration to the New Product

NLAIFGML is meant to replace artists who draw faces by hand, based on a description of a witness. Because of this, the user can choose to use NLAIFGML side-by-side with a face sketch artist at their own discretion until they feel comfortable with the results of the NLAIFGML.

31b Data That Has to Be Modified or Translated for the New System

No data modifications necessary.

32 Risks

- Push Back from Sketch Artists: Because NLAIFGML will be a direct replacement for sketch artists, we may experience push back from sketch artists who wish to keep their jobs.
- Access to Public Data: If the demand for Security Footage/Images from public security cameras increases, so might the cost of access to it.
- Overall Cost v.s. Budget of Crime Organizations: The production of NLAIFGML is no cheap task. The expensive cost of developing NLAIFGML will result in an expensive product, which may inevitably be outside the budget of most governments.

33 Costs

NLAIFGML is predicted to take ~5 years to complete. It will require ~20 Engineers to be paid $175,000 yearly. Given these stats, the product alone will cost upwards of $20 million to fund fully.

Outside of the production costs, there will be maintenance costs. Cities will begin charging for access to their data, and customers will be expecting updates to the

artificial intelligence and machine learning algorithms used in the initial deployment of the product.

34 Waiting Room

- Connectivity with Neuralink: In the future, a user with a Neuralink implant will be able to "think" about the face they witnessed, and the Neuralink will send the user's thoughts to NLAIFGML, allowing the software to display the face on the computer.
- 3D Holographic Display: NLAIFGML will support 3D Holographic Imagery in the future to more accurately represent a face developed by AI.

35 Ideas for Solutions

Machine Learning on footage and image data could be done utilizing pre-existing machine learning libraries, such as PyTorch.

AI Face-Generation will need to be swift. Image-rendering will need to take place quicker than a sketch artist can sketch. Most ideal tool for this sort of speed may be a custom rendering machine developed in C++. A demo of the product could be done using a pre-existing Graphics Library, such as OpenGL.

36 Project Retrospective

At conclusion of the (CS 440) project, here is a reflection on what worked well, what didn't work well, and the process could be improved in the future.

As far as the project goes, a big question that none of us thought to ask or research is: Will NLAIFGML be effective in what it's designed to do? (i.e. facial-drawing accuracy exceeds that of a sketch artist well enough to justify the cost). Perhaps a better start to the project may have been to contact/survey criminal investigation bureaucracies to discover where things could be improved in the crime-fighting efforts so as to give NLAIFGML's design strategies greater justification.

Additionally, more research should have been performed regarding how much image/footage data is truly out there for use by NLAIFGML. A critical component of the tool is to have access to image/footage data from security cameras placed around urban cities. As of now, it is unknown to us both the degree to which cities *record* and *save* their security camera capturings, and the extent to which their capturings may be available to the public.

V Glossary

Biometric: Relating to or involving the application of statistical analysis to biological data.

Facial Recognition: Technology capable of matching a human face from a digital image or a video frame against a database of faces, typically employed to authenticate users through ID verification services, works by pinpointing and measuring facial features from a given image.

FRT: Facial Recognition Technology.

Graphics Library: A program library designed to aid in rendering computer graphics to a monitor.

Machine Learning: Use and development of computer systems that are able to learn and adapt without following explicit instructions, by using algorithms and statistical models to analyze and draw inferences from patterns in data.

Natural language descriptors: Everyday language, which are used to describe features of a face (e.g.: large nose, small eyes, etc).

Neuralink: An implantable brain-machine interface currently in development (as of writing this report) by Neuralink Corporation.

OpenGL: Cross-language, cross-platform application programming interface (API) for rendering 2D and 3D vector graphics.

PyTorch: An open source machine learning framework, used for applications such as computer vision and natural language processing, primarily developed by Facebook's AI Research lab.

System administrator: Person who is responsible for the upkeep, configuration, and reliable operation of computer systems, especially multi-user computers, such as servers.

Sysadmin: System administrator.

VI References / Bibliography

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