
# An Artwork Super-Resolution Scanning Application

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*Client/Advisor – Dr. Thomas Daniels*

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# Executive Summary

## Development Standards & Practices Used

### Python – Version 3.11.3

All frontend and backend functionality of the ArtScan application is built using the latest version of Python.

### OpenCV – Version 4.7.0

OpenCV (Open-Source Computer Vision Library) is an open-source computer vision and machine learning software library. We use OpenCV functions for the backend image processing functionality of the ArtScan application.

### Pantone Color Matching

A Pantone color match card is a physical card that displays colors from Pantone's standardized color reproduction system. The cards serve a dual purpose, providing a reference point for image boundary detection and color-correction reference points.

## Summary of Requirements

- User-friendly GUI
- Ability to ingest 10+ high-resolution images for processing.
- Python functions capable of the following:
  - Detecting edges/corners of the artwork
  - Perspective correction
  - Noise reduction
  - Image stitching

## Applicable Courses from Iowa State University Curriculum

### EE 224 – Signals and Systems I

In this course, we learned the fundamentals of signal processing and signal manipulation.

### EE 285 – Problem Solving Methods and Tools for Electrical Engineering

For those of us studying electrical engineering, this course was our first venture into software development. In later labs, we built basic low-level image processing functions in C.

### EE 324 – Signals and Systems II

This course was an expansion of 224 materials, introducing advanced signal processing and digital filters.

### COM S 309 – Software Development Practices

This course provided fundamental knowledge required to develop, test, and maintain computer programs.

## New Skills/Knowledge Excluded from Past Courses

### Python

Despite our entire application being developed with Python, no one in our group had any experience with the language.

### Computer Vision

Computer vision is a field of study that focuses on enabling computers to interpret/understand visual information from an image or video. This project is our first venture into computer vision.

The following computer vision concepts were learned for our application:

- Image perspective correction
- Hough transforms – for feature extraction
- Canny edge detection
- Scale-invariant feature transform (SIFT) – for feature matching

# 1 – Team

## 1.1 Team Members

### Isaac Plambeck

- Major – Software Engineering
- Specialization – Full Stack Application Development
- Hometown – Sioux City, IA

### Samuel Schaphorst

- Major – Electrical Engineering
- Specialization – Signal processing and power systems
- Hometown – Omaha, NE

### Reece Dodge

- Major – Electrical Engineering
- Specialization – VLSI and Embedded Systems
- Hometown – Cedar Rapids, IA

### Garrett Powell

- Major - Electrical Engineering
- Specialization – Signal Processing and Electrical Hardware Design
- Hometown – Marion, IA

## 1.2-3 Required Skill Sets and Team Coverage

### Python Software Development

The ability to deliver a reliable, functional, and user-friendly application that meets user needs and expectations.

Coverage – Isaac and Reece (primarily Isaac)

### Signal/Image Processing

The ability to understand mathematical algorithms and techniques to analyze, manipulate, and transform images.

Coverage – Sam and Garrett

## 1.4 Project Management Style Adopted by the Team

Our group will utilize a mixture of **waterfall** and **agile** project management styles.

### Waterfall

The waterfall project management style is a linear, sequential approach to project management. It involves breaking down a project into distinct phases, with each phase building on the previous one. Each phase must be completed before the next one can begin, with little overlap between them.

We're applying this style by separating development phases according to the stages of super-resolution image processing.

### Agile

An agile approach involves breaking down a project into small, manageable chunks called sprints. The team focuses on delivering an incremental working product at the end of each sprint, incorporating feedback and making adjustments as needed. The agile approach emphasizes collaboration, adaptability, and client satisfaction over strict adherence to a plan.

We're applying this style by allowing design phase flexibility. On occasion, we'll reach stages where it's necessary to look forward or backward between super-resolution scanning steps.

## 1.5 Initial Project Management Roles

### Isaac – Development Lead

Isaac will spearhead software development and version control.

### Reece – Conceptual Design Lead

Reece will provide outlines and guidance concerning application functionality/concept flow.

### Samuel – Testing/Quality Assurance Lead

Samuel will lead testing procedures, monitoring software functionality/robustness through each phase.

### Garrett – Product Delivery Lead

Garrett will ensure progress is consistent, monitoring development and timely delivery.

# 2 – Introduction

## 2.1 Problem Statement

In today's world, freelance artists, print shops, museums, and art galleries have no way of cheaply/easily producing a true-to-life digital version of physical artwork.

Many artists and businesses have both small budgets and few ways to profit from their artwork, outside of selling the original version. With an adequate scanning tool, they can unlock new ways to monetize their work while preserving ownership of the original piece. Additionally, a high-quality "backup" of their art will become available in the event of theft or destruction.

## 2.2 Requirements & Constraints

### Functional Requirements

- Capability for the user to upload and display multiple images
- Automatic performance of image processing algorithms
  - Corner/border detection
  - Perspective correction
  - Noise reduction
  - Color correction
- User confirmation protocols to ensure the algorithms perform as expected

### Non-functional Requirements

- Application based on Python/OpenCV
- Easy to use UI to allow for efficient navigation
- Simplified algorithms to reduce computational overhead

### Technical Constraints

- Limited to capabilities of Python/OpenCV
- Limited to image quality of the camera in-use
- Anticipated to accept only common image file formats (PNG, JPEG, HEIC)
  - iPhones produce HEIC files
- Cheap and accessible hardware
  - Smartphone/Raspberry Pi camera
  - Pantone color match cards

## 2.3 Engineering Standards

### IEEE 610.4-1990 IEEE Standard Glossary of Image Processing and Pattern Recognition Terminology

This standard provides specifications and guidelines for our image processing infrastructure. The standard covers things like interpolation techniques and gaussian normalization protocols for pixelation

### IEEE 1857 Standard for Second-Generation IEEE 1857 Video Coding

This standard elaborates on the first with further detail regarding image stitching, camera region of interest, and advanced colorization standards.

### IEEE 1858-2016 IEEE Standard for Camera Phone Image Quality

This standard's application is straight forward; we'll be using it as a reference for our camera integration.

## 2.4 Intended Users and Uses

### Independent Artists

- Printing and resale – Artists can sell large-scale prints while keeping the original piece
- Digital showcasing – Artists will have a new way of showcasing artwork on their website or social media
- Archival purposes – Artistic legacy can be digitally preserved which provides a safety net in the event of destruction or art theft

### Print Shops

- Providing "scan and print" services to artists – Print shops can advertise the ability to print copies of physical artwork

### Art Galleries/Museums

- Digital showcasing – Like independent artists, galleries and museums can create digital versions of their art galleries
- Virtual reality galleries – Hyper-realistic versions of artwork can be displayed in virtual reality
- Physical real-estate savings – With the addition of a digital counterpart, galleries can be expanded without using physical space

# 3 – Project Plan

## 3.1 Project Management / Tracking Procedures

### Waterfall + Agile Development

During the development of our application, some separate phases will be isolated and subsequently allowed to flow into each other. Additionally, there will be cycles where multiple phases can be run in parallel, causing parts of development to occur simultaneously. Therefore, justifying the use of a waterfall + agile approach to our project management style.

To assist with project management, several tools will be used. One of which will be Microsoft Teams. Through Teams, documents pertaining to the project and other related subjects will be kept and organized, becoming easily accessible to each member from any location. Additionally, GitHub will be used to store files associated with our project application, such as python/OpenCV code. Finally, Trello will be used to assign tasks and track progress for the application's development.

## 3.2 Task Decomposition – Design Phases

### Application Framework

- Build general framework for software component implementation
- Framework will be fluid, adapting to the needs of our application

### File Ingest/Image Uploading

- Add support for multiple file types
- Add support for uploading multiple images
- Add ability to organize and label uploaded images

### Automated Image Processing Algorithms

- Corner/border detection for target artwork
- Image cropping
- Perspective correction
- Image overlay/alignment
- Pixel mapping to create foundation of super-resolution image
- Recoloring – Pantone color matching
- Image noise reduction

### Application Finalization and Refinement

- Add manual confirmation steps throughout automated image processing for the user to monitor accuracy
- Improve GUI aesthetics
- Add customization features
- Add quality-of-life features

## 3.3 Proposed Milestones, Metrics, and Evaluation Criteria

Application template- A functioning GUI with upload capabilities

- Upload process-Software will be able to upload and display desired photos
- Image processing
  - Border detection works with 85% accuracy
  - Image alignment works with 85-90% accuracy
  - Noise detection eliminates 85-90% of noise
- Application revision-software has 0 bugs

## 3.4 Project Timeline / Schedule


In the schedule seen above, we plan to spend ultimately all of our time in senior design working on the image processing aspects of the project

Our plan is to have 2 aspects, image processing and border detection finished before the spring semester ends

## 3.5 Risks and Risk Management/Mitigation

- Application Template/Upload Process
  - Potential problems with upload format and or image display; should be a simple correction
- Image Processing
  - Border detection-Accuracy less than 85% RF=.4
  - Image alignment- Accuracy less than 85% RF=.2
  - Noise correction-Accuracy less than 85% RF=.1

## 3.6 Personnel Effort Requirements

| Task | Estimated Person-Hours Required | Explanation |
|---|---|---|
| **Requirements gathering and analysis** | 5 | This involves collecting and analyzing user requirements, determining the scope of the application, and defining the necessary features and functionalities. |
| **System Design** | 15 | This includes creating a detailed system design that outlines the architecture, user interface, algorithms, and data flow of the application. |
| **Algorithm Development** | 50 | This involves developing and testing the algorithms that will be used to perform the super resolution scanning process. This may include machine learning models and image processing techniques. |
| **Application Development** | 50 | This involves coding the application and integrating the algorithms into the system. The application must also be tested and debugged to ensure it is functioning properly. |
| **Quality Assurance and Testing** | 15 | This includes testing the application to identify any bugs or issues that may arise. Testing may involve unit testing, integration testing, and user acceptance testing. |
| **Documentation and Training** | 10 | This involves creating user manuals, technical documentation, and training materials to ensure that users can effectively use the application. |

| | | |
|---|---|---|
| **Deployment and Maintenance** | 20 | This includes deploying the application and ensuring it is properly installed and configured. Ongoing maintenance may be required to ensure the application remains up-to-date and functioning properly. |

## 3.7 Other Resource Requirements

- Smart phone/Raspberry Pi camera
- Visual Studio Code
- Python/OpenCV
- Pantone color match cards

# 4 – Design

## 4.1 Design Context

### 4.1.1 Broader Context

| Area | Description | Examples |
|---|---|---|
| **Public health, safety, and welfare** | Our application for an artwork super-resolution scanner does not affect the general well-being of the public. | N/A |
| **Global, cultural, and social** | Our project aims to protect the values and practices reflected by all groups it may affect. The art community is the primary group in mind, while smaller sub-groups stem from that. This can include each individual's ethnic culture. | Maintain a large amount of original detail from the artwork. Preserving the decisions of the artists as it may pertain to their communities/cultures. |
| **Environmental** | Due to the project taking the form of a software application, we do not expect the artwork super-resolution scanner to have any environmental impact. | N/A |
| **Economic** | We aim for our project to have as little economic impact as possible. Ideally, there will be no need for any user to spend money on the application. | The application will be free to use for all users.<br><br>Image capture through the use of already accessible hardware, such as smartphones. |

### 4.1.2 User Needs

Independent artists need a way to create a true-to-life digital format for their physical artwork for the purpose of printing, arching, distributing, and to maintain an income.

### 4.1.3 Prior Work/Solutions

The process to create a super-resolution image for artwork exists today. This can be accomplished by using already available software, such as Adobe Photoshop. Through this application, each step can be performed manually. The algorithms behind Photoshop are extremely complex and the software is quite reliable as far as photo-editing is considered. However, this procedure is extremely time-consuming and requires a lot of processing power. By creating an application to perform these processes automatically, the time it takes to digitize artwork will be dramatically reduced while lessening the required processing power, allowing it to be used on a wider range of devices.

### 4.1.4 Technical Complexity

The design of our project consists of multiple components that each utilize distinct scientific, mathematical, or engineering principles. For example, to create a super-resolution image, several image processing techniques/algorithms will need to be applied to the image. This is seen through border detection, perspective correction, and noise reduction. Additionally, the final design of the project will be a software application. The program will be based in Python and will utilize several existing libraries to create the application.

The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards. The basis for this program is to have an application that automatically creates a super-resolution image for physical artwork in a digital format. This, in of itself, is a highly challenging task. To complete this task, several separate components will need to be combined. Each individual component presents their own challenges. Once combined, the final design of the project will exceed current solutions to this task for reasons previously stated.

## 4.2 Design Exploration

### 4.2.1 Design Decisions

- Image stitching vs no image stitching
- Having a scanner like physical component vs free hand
- Using a raspberry pi camera vs user handheld phone camera

### 4.2.2 Ideation

For the decision of picking image stitching vs no image stitching we decided to research each topic thoroughly. We ended up going with image stitching because based off the videos and data we collected along with outside input from our advisor, we found that image stitching would yield more accurate and detailed results. In order to accomplish this, we considered

many different things including perspective correction, border detection, image alignment, noise reduction, and pixel mapping.

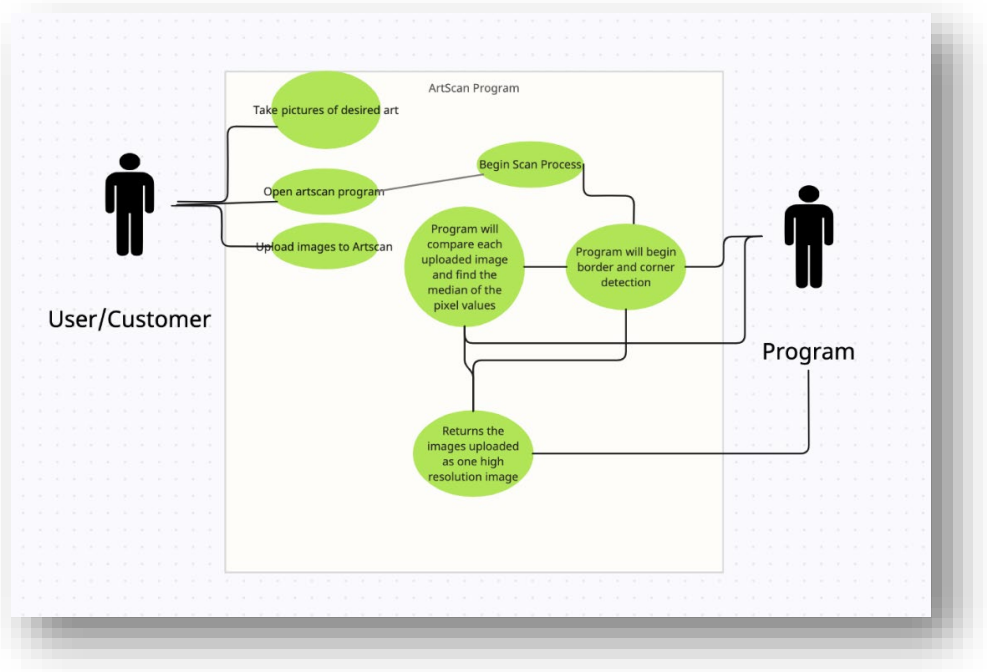
### 4.2.3 Decision Making and Trade off

To make decisions on different aspects of our project we typically all give our own inputs listing mainly the cons and then discussing how we could possibly resolve the given cons

## 4.3 Proposed Design

So far, we have been able to create a functioning GUI capable of taking in and displaying images with manual cropping abilities. With that we have been working with different image processing techniques such as autonomous border and corner detection. We have been able to test how accurate our border detection has been and corrected the code accordingly. We have also been discussing how to approach other aspects we have not been able to reach yet, this would include perspective correction and noise reduction.

### 4.3.1 Design and Visual




This diagram shows our main objective with our project. We want to make the GUI as convenient as possible for the consumer. To accomplish this, we will be implementing different image processing techniques; border detection, noise reduction, perspective correction, image stitching and image alignment using various coding functions with OpenCV.

### 4.3.2 Functionality

As a consumer using our project, our goal is to make the process of using our product as convenient as possible. To accomplish this, we are implementing a GUI with easy navigation and quick, accurate results. Currently, we have a functioning GUI with upload capabilities, we are now working on the image processing portion of the project.

### 4.3.3 Areas of Concern and Development

Right now, our main concern is how accurate the different aspects of image processing will be. Obviously, we will not be able to attain 100% accuracy, but we want to have our program attain at least 85-90% accuracy. To accomplish this, we will need to continuously test each image processing aspect of our program to ensure the accuracy is consistent with what we desire. This may be more difficult to accomplish once we piece together every section of the image processing together.

## 4.4 Technology Considerations

Python is a powerful language when it comes to processing data. Because of this property, basing our application in Python will ensure us the most effective way of performing image processing in our application. Utilizing the OpenCV library allows us to implement various image processing methods/techniques more efficiently. This is because the OpenCV library contains several functions where the image processing methods have already been created and parameters are the only thing that will need to be provided.

## 4.5 Design Analysis

We have not been able to test our design quite yet. However, we have been testing and implementing a border detection function.

## 4.6 Design Plan

Based on the use case we made, the user would start the program, upload the desired photos and press a “compile” button that would begin the image processing. During the compiling process, the program would start by finding the borders of each photo and cropping the photos accordingly. Once each photo has been cropped, the program will begin perspective correction and image alignment to stitch the images together into one. Finally, the program will display one photo that is much more detailed and has higher quality than the previous photos uploaded into the program initially.

# 5 – Testing

## 5.1 Unit Testing

We will be testing and processing uploaded images using open cv to increase the resolution and quality of the desired artwork through image stitching.

## 5.2 Interface Testing

Our main interface will consist of a GUI that the user can install on a computer. Through interface testing, our goal is to develop a GUI that is very simple, quick, and easy to use for any user. This means the upload button in the GUI should work efficiently and the GUI will display the image upon uploading it. To ensure quickness, we will have to test the coding interfaces to remove any unnecessary image processing which will be corrected in the debugging process of our project.

## 5.3 Integration Testing

The integration testing will be the most important testing phase of our project. In this phase we will begin integrating each function of our image processing code and testing that they can work together. In this phase we will be using the debugging function to identify where any unwanted results may be coming from. In this phase we will be combining our edge detection, perspective correction, noise reduction, and image stitching functions all into one with the hopes. To have them all run together synchronously and return the correct results.

## 5.4 System Testing

In the system testing phase, we will be testing the GUI, its upload capabilities, the “scan” button that will enable the image processing, and the results it displays. While doing this, we will also be testing the code that is running and making sure each function is working properly.

## 5.5 Regression Testing

When incorporating a new piece of our program, before we incorporate it, we will test it to make ensure that it properly works. We will then combine it with another function, run them together and see what it will return. If it returns the incorrect results, we will begin debugging

the combined functions, locate the problem, then correct it until the desired results are given. This process will continue until each function is incorporated and our desired results are given.

## 5.6 Acceptance Testing

To demonstrate desired results, we will repeatedly test our program ourselves and determine if the photo looks more detailed than the original. Once we are satisfied with the results, we will allow our client to test it with multiple different pieces of artwork and let him determine if the program is accurate enough. Once his requirements are met, we will open the program to the public for anyone to use

# 6 – Implementation

As it stands now, we plan to develop each individual image processing method independently. We believe that this will allow for a more efficient debugging process. Once each method has been successfully created, they will all be compiled together to create the application and adjusted accordingly so that they can function together. While each member will ultimately get experience working on each aspect of the application, it is anticipated that Isaac will primarily focus on the development of the application while Reece, Sam, and Garrett will primarily focus on the development of the individual image processing methods.

# 7 - Professionalism

## 7.1 - Areas of Responsibility

In comparison to the NSPE, the IEEE code of ethics has a few differences that we noticed in each category:

- **Work Competence:** IEEE and NSPE are similar in this area, both codes mention that to maintain and improve company technology, the worker must be qualified to do so.
- **Financial Responsibility:** For this area, IEEE only seemed to mention bribery rejection whereas NSPE discusses more about client employer faithfulness.
- **Communication Honesty:** In this area, IEEE went a little more into detail about what is expected, mentioning criticism and honesty. NSPE only brings up honesty as well but only in the public eye.
- **Health Safety and Well Being:** IEEE was direct in this area prioritizing public safety as well as the environment. Similarly, the NSPE code of ethics is also very direct about prioritizing public safety.
- **Property Ownership:** In this area, the IEEE code of ethics brings up the understanding of its technology whereas NPSE mentions client employer faithfulness and not really mentioning technology.
- **Sustainability:** Both codes briefly mention sustainability when they both prioritize public safety as well as the environment
- **Social Responsibility:** The IEEE code of ethics hits this area hard stressing fair treatment of peers and avoiding conflict with each other. Similarly, the NSPE code of ethics mentions conducting themselves honorably and respectfully.

| Area of Responsibility | IEEE Code of Ethics |
|---|---|
| Work Competence | To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations; |
| Financial Responsibility | Reject bribery of all forms |
| Communication Honesty | To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others; |

| | |
|---|---|
| | To be honest and realistic in stating claims or estimates based on available data; |
| Health, Safety, Well Being | To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment |
| Property Ownership | To improve the understanding of technology; its appropriate application, and potential consequences; |
| Sustainability | To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment |
| Social Responsibility | To assist colleagues and co-workers in their professional development and to support them in following this code of ethics.<br>To treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;<br>To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;<br>To avoid injuring others, their property, reputation, or employment by false or malicious action; |

## 7.2 - Project Specific Professional Responsibility Areas

The responsibility **Work Competence** applies to our project. The development for an application with the purpose of creating super-resolution scans of artwork will require each member to perform high quality work with integrity, timeliness, and competence in order to be successful. Doing so would help allow the development process to move forward more smoothly. It is expected that our team exhibits a high level of work competence as learning and improvement will be necessary throughout.

The responsibility of **Financial Responsibility** does not apply to our project. The purpose of this project is to create an application that will create super-resolution scans of artwork. Our gain from this project is not financial, but rather the experience and knowledge gained along the

way. Because of this, it will not be necessary to measure our team on the performance of this responsibility.

The responsibility **Communication Honesty** applies to our project. Our client and advisor's (Dr. Daniels) motive for assigning this project was to assist him in creating scans of the art his wife has created. Therefore, it is necessary to report our progress to Dr. Daniels truthfully while acknowledging his expertise in the field to seek ideas, knowledge, and criticism. Our team has performed this responsibility at a high level, which is evident from the weekly meetings with Dr. Daniels where we provide progress updates and ideas while seeking knowledge and criticism. Our team expects to maintain this level of performance.

The responsibility **Health, Safety, Well-Being** does not apply to our project. The basis of the project will be to create computer software (application) to create super-resolution scans of artwork. Although it is paramount for an engineer to hold the health, safety, and well-being of the public above all else, computer software poses no risk to the public in that regard. Therefore, it will not be necessary to measure our team on the performance of this responsibility.

The responsibility of **Property Ownership** applies to our project. The idea of the project is not our own, but rather our client's. Because of this, we must respect Dr. Daniels in this regard. Additionally, it is expected that any potential user will be uploading images to the software to create super-resolution versions. This information that the user will provide will need to be respected and used for no other purpose other than that of the function of the software itself. Our team has performed this responsibility at a high level as we all highly respect the ownership of the property, whether that be ideas or information.

The responsibility of **Sustainability** does not apply to our project. Because the project will be software based through a computer application, the development and design of the project will require no physical resources. With that in mind, no harm to the environment will occur. Because of this, it will not be necessary to measure our team on the performance of this responsibility.

The responsibility **Social Responsibility** does not apply to our project. Our team does not anticipate that our application will have any effect on society and communities. However, it is expected that each team member will assist and support each other professionally. Overall, it is not necessary to measure our team on the performance of this responsibility with respect to the benefit of society and communities. However, our team has performed at a high level regarding the support of professional development for everyone.

## 7.3 - Most Applicable Professional Responsibility Area

One area we believe is most important relating to our project is **work competence**. Seeing how the program we are trying to create will require a very specific complex python script. The specifics that go into our final project will have to be perfect and making sure everything is running properly will take the most time and effort. The best way our group demonstrates this responsibility is taking initiative and researching areas which will prove challenging in the future. We're doing an excellent job of fully understanding the problems we're solving, like image stitching and pixel interpolation. Another way we demonstrate work competence is our thorough documentation, where every client meeting and brainstorming session is transcribed into bulleted notes.

# 8 – Closing Material

## 8.1 - Discussion

Our main project remains untested; however, we have been testing a few different border detection methods and editing that aspect of the program to increase accuracy. We have been able to significantly increase the accuracy of the border detection function but are still unsatisfied with its current accuracy.

## 8.2 - Conclusion

So far, we have been able to create a functioning GUI with upload and display capabilities. We have since been focusing on creating an accurate. Border detection function. In doing this, we have tried many different approaches and have made significant progress towards our accuracy goal. Our main goal is to have each function in our image processing code achieve at least 85% accuracy. Achieving this goal requires rigorous testing with many different images to ensure each function is consistent. To efficiently accomplish these goals each member is focusing on one function.

## 8.3 - References

[1] IEEE 610.4-1990, "IEEE Standard Glossary of Image Processing and Pattern Recognition Terminology."

[2] IEEE 1858-2016, "IEEE Standard for Camera Phone Image Quality."

[3] IEEE 1857, "Standard for Second-Generation IEEE 1857 Video Coding."

## 8.4 - Appendices

### 8.4.1 Team Contract

Team Members:

1) ___Isaac Plambeck_____ 2) ____Sam Schaphorst_____

3) ___Garrett Powell_____ 4) ____Reece Dodge_____

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:
    - Every Monday at 2:30
2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):
    - Webex
    - Microsoft Teams
3. Decision-making policy (e.g., consensus, majority vote):
    - Make decisions as a group
4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):
    - Files stored on Microsoft teams

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:
    - Meetings on Mondays are mandatory
2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:
    - Each group member is expected to have their work completed by the deadline
3. Expected level of communication with other team members:
    - Participation and contribution in group meetings is encouraged and expected
4. Expected level of commitment to team decisions and tasks:
    - Similar to participation, members are expected to contribute to decision making as well as tasks

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
    - Electrical engineer lead
    - Software engineer lead
    - Overall project lead
    - Quality/testing lead
2. Strategies for supporting and guiding the work of all team members:
    - Check each others work
    - Work together on bigger tasks
3. Strategies for recognizing the contributions of all team members:
    - Give member responsible for contribution credit in final design

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.
    - Reece Dodge- programming, signal processing
    - Sam Schaphorst-programming, signal processing
    - Isaac Plambeck-programming, app development, website development
    - Garrett Powell – programming, signal processing
2. Strategies for encouraging and support contributions and ideas from all team members:
    - Present new ideas to group and receive immediate feedback
    - Encourage members to ask other members for help if said member is confused over a task
3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)
    - Discuss as a group how we can revise our working routine in order to increase efficiency

Goal-Setting, Planning, and Execution

1. Team goals for this semester:
    - Have a functioning program capable of image processing and rendering
    - Everyone has at least one “showstopper” idea which involves risk taking and new concepts/ideas
2. Strategies for planning and assigning individual and team work:
    - Assign work that focuses on the group members strengths
    - Check each others work
3. Strategies for keeping on task:
    - Work together on tasks and keep each other accountable
    - Present completed or updated work to group

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?
    - Confrontation with the member that is accused
2. What will your team do if the infractions continue?
    - Get faculty advisor involved

**********

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) _____Sam Schaphorst_____ DATE _____2/19/2023___

2) _____Reece Dodge_____ DATE _____2/19/2023___

3) _____Garrett Powell_____ DATE _____2/19/2023___

4) _____Isaac Plambeck_____ DATE _____2/19/2023___