Final Presentation: A Computer Vision Approach to Non-invasive JVP Monitoring

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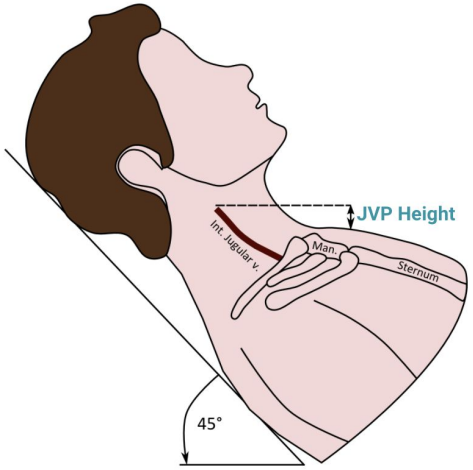
Motivation for Design

Why measure JVP?

- Jugular venous pressure (JVP) measurements yield prognostic information in patients with heart disease
- JVP correlates with the amount of water accumulated in a person's body
  - The more water accumulated the higher risk the patient is for heart failure
  - Gives doctors direction for treatment moving forward
- JVP can be especially useful for Congestive Heart Failure (CHF) patients
  - 5.7 million people in the U.S. suffer from CHF, resulting in over 1 million hospital visits annually

Current Approaches to JVP Monitoring

- In-person bedside exams by a physician at a hospital
  - Expensive and time-consuming
  - This exam requires the patient to recline at about a 30-45 degree angle. The physician then measures the highest level of the internal jugular vein pulsation, called the **JVP height**
- Need for an at-home, low cost solution to JVP monitoring



Design Criteria and Specifications

Customer Needs

Customer Needs (What does my customer need?)		
Number	*Need*	*Priority*
User Needs	Process video (amplified)	1
	Reasonable Processing Time (Desktop app for Doc)	5
	Easy and Effective Mobile App	2
	Can be used at home	3
	Automated transmission of Video to Doc	6
Payer Needs	Cost less than $300 to develop	7
Regulatory/Standards Needs	Self-Administered Measurement of JVP	4
	Does not offer treatment options	8

Target Final Specs

House of Quality, Specifications, Objectives

Project Name: JVP - Team Venous

		Functional Specifications						
		Spec #1	Spec #2	Spec #3	Spec #4	Spec #5	Spec #6	Spec #7
		Cost	Functions available in desktop app	Clinical Utility of Amplified Video	Number of hardware components for physician	Patient ease of use of mobile app	Processing Time	Number of hardware components for patient
	Process video (amplified)	X		X				
	Reasonable Processing Time (Desktop app for Doc)						X	
	Easy and Effective Mobile App		X			X		X
	Can be used at home	X			X	X		X
	Automated transmission of Video to Doc		X		X		X	
	Complexity	Med	High	High	Med	Med	High	Low
	Final Specifications	$300	Amplify and provide reference height in videos	Physician can determine location of JVP	Less than 3	At least 7 out of 10 users rate it 4 out of 5 stars	Less than 10 minutes	Less than 5

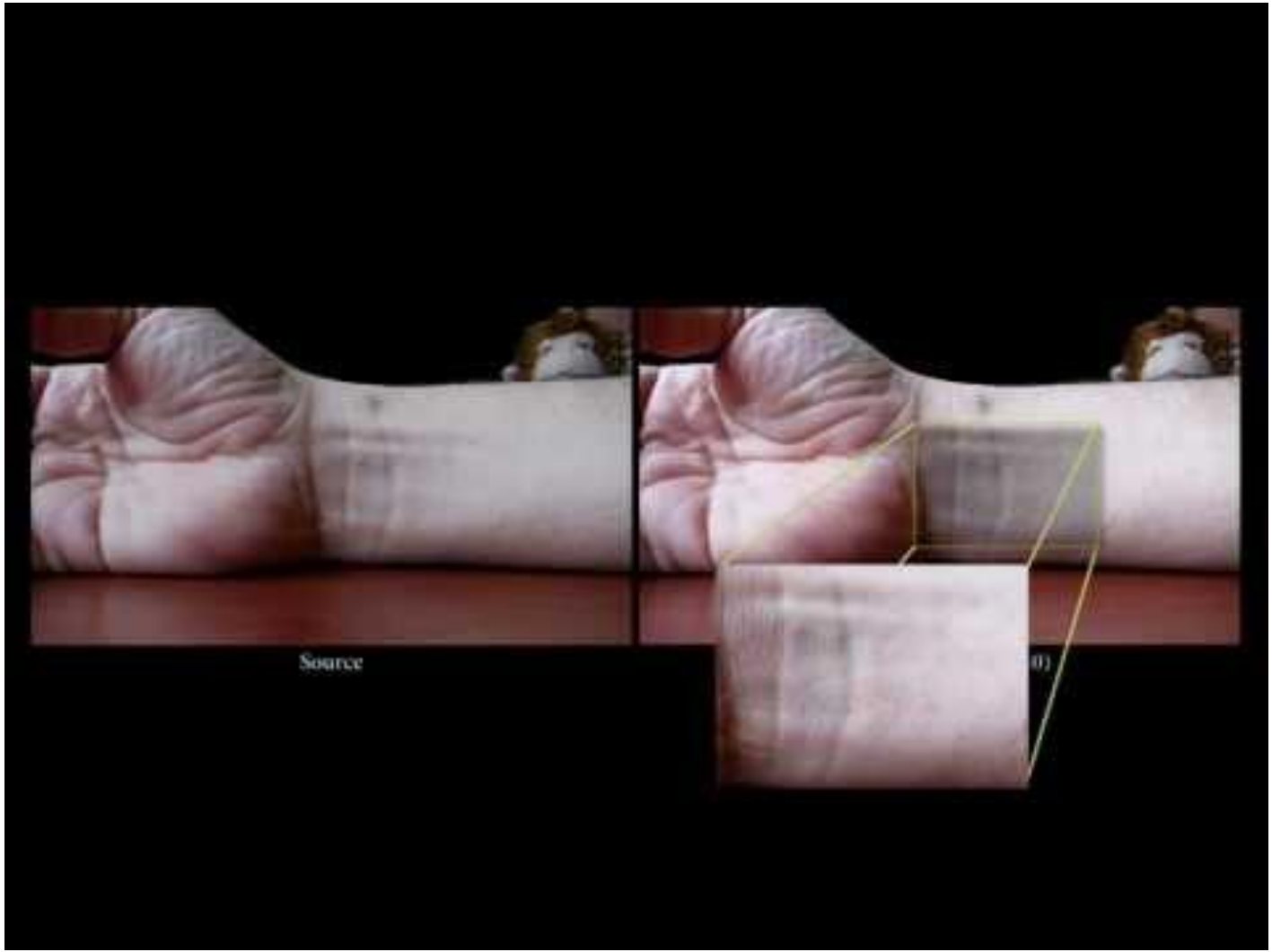
Target Final Specs with Point Values

Specs	Points
Cost	300
Functions available in desktop app	300
Clinical utility of amplified video	300
Number of hardware components for physician	300
Patient ease of use of mobile app	300
Processing time	300
Number of hardware components for patient	200
TOTAL	2000

Design Description

Eulerian Video Magnification

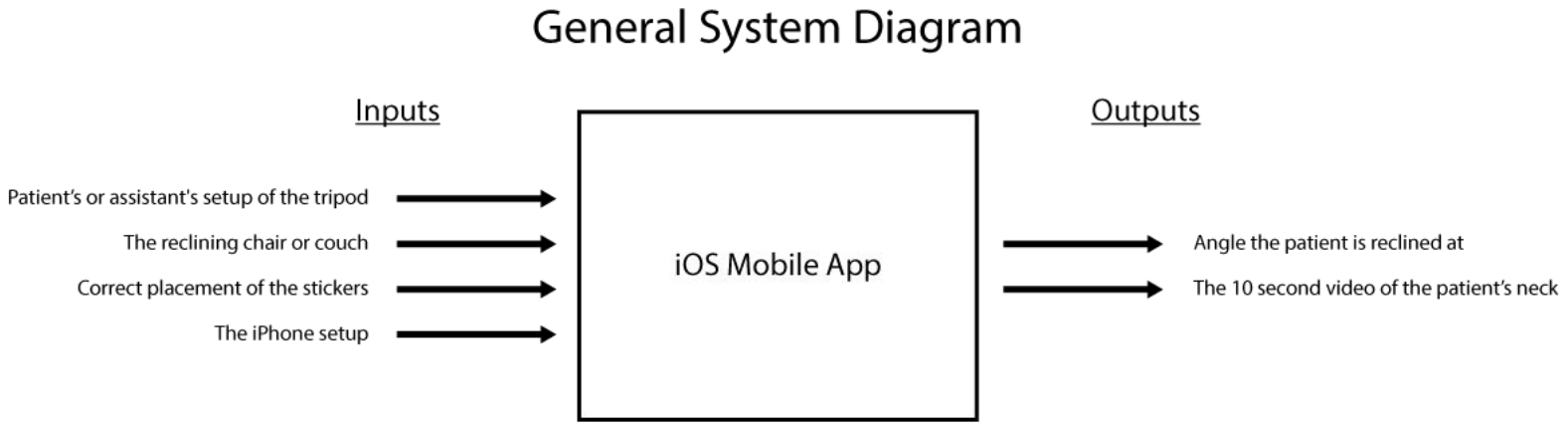
- **Our solution: A computer vision approach using the Eulerian video magnification algorithm**
- Eulerian magnification reveals subtle color variation and motion in videos that are imperceptible to the naked eye
- Applies spatial decomposition and temporal filtering to a normal video, resulting in a video that has certain parts amplified to reveal previously imperceptible information


Source

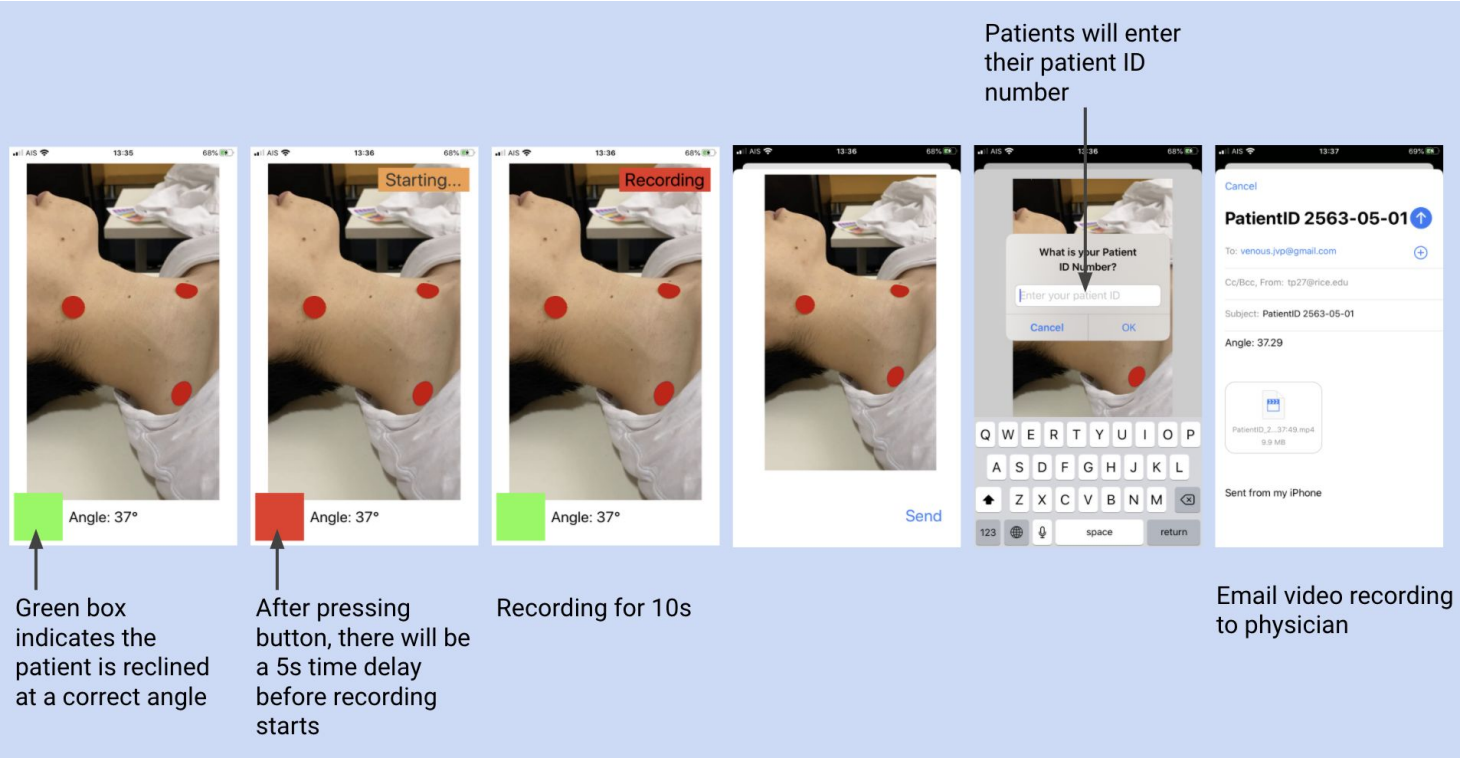
Our Design

- Setup
- 2 Main Parts: an iOS mobile app, and a Matlab desktop app

iOS mobile app System Diagram

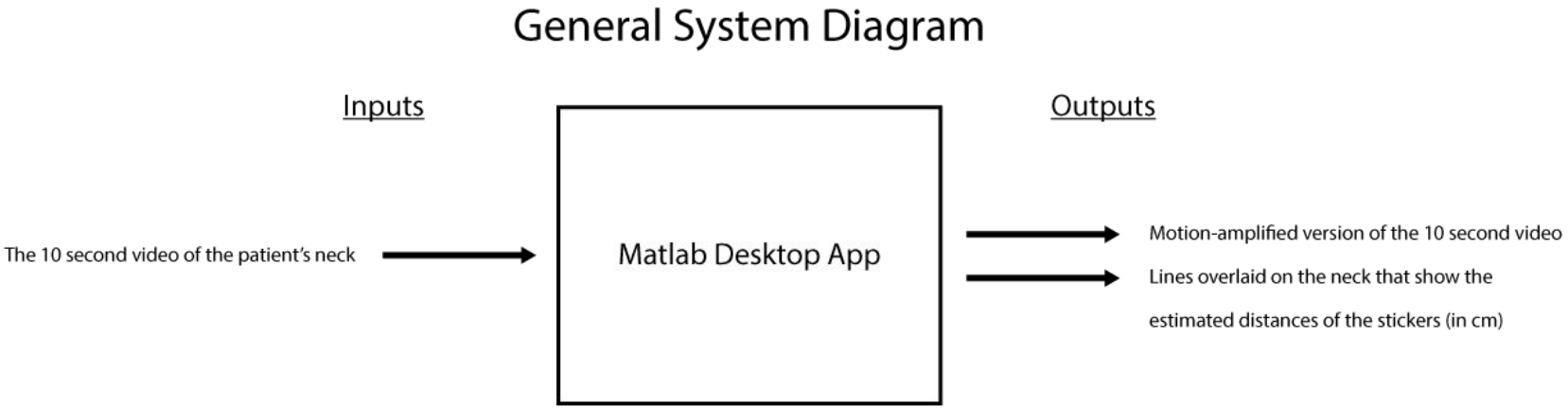


iOS mobile app Instructions

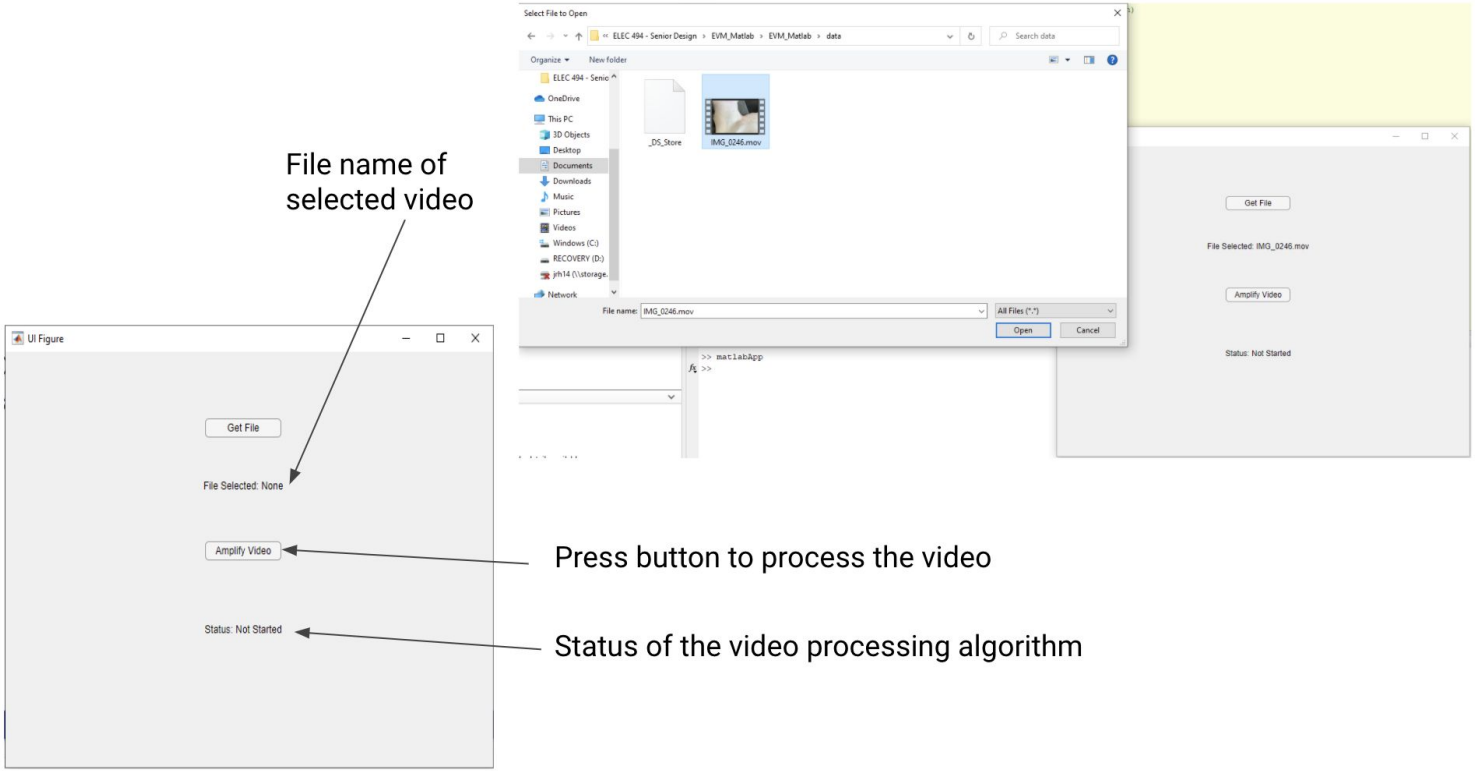


Link to Instruction Document:
https://docs.google.com/document/d/1IaSZSyR-wzz3cOvjBHWPVLPU4vBPkV20tVdJW3RANsU/edit?usp=sharing

Matlab desktop app System Diagram



Matlab desktop app Basic Instructions



Link to Instruction Document:
https://docs.google.com/document/d/1DTHhpWU8IUbEi8Se2kBC04M-IsM98uKgraDp17wjRJ0/edit?usp=sharing

Technical Details of Apps

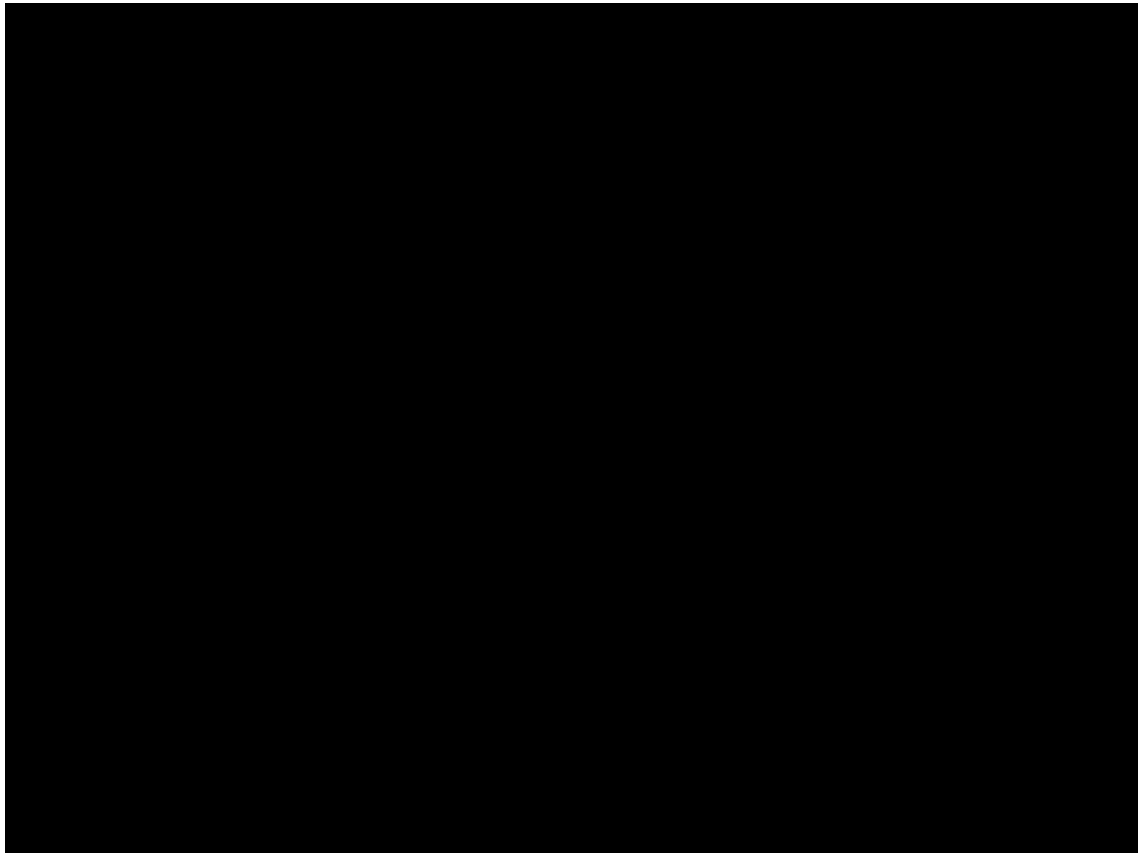
- iOS App
  - 1080p 30FPS video being recorded
  - .mp4 file format
  - Around 10MB per video, 10s, running on iphone 11, may vary based on phone
  - All the code is available on github in our final report
- MATLAB App
  - Requires MATLAB 2019a (or later) license to run
  - Outputs .mp4 file
  - Approx. 5-8 minutes processing time for 1080p 30FPS, 10s video
  - Can also run different video settings but processing time will vary

Project Results

DESIGN CRITERIA		
Criteria	**Target**	**Product**
Cost	**Less than $300**	**$0**
Desktop App Functions	**Amplify and provide reference height in videos**	**✓**
Clinical Utility of Amplified Video	**Physician can determine location of JVP**	**✓**
Hardware Components for Physician	**Less than 2**	**1**
Hardware Components for Patient	**Less than 5**	**3**
Patient Ease of Use	**User rating of 4 out of 5**	**✓**
Processing Time	**Less than 10 minutes**	**5-8 minutes**

- Physician requires a **computer**
- Patient requires an **iPhone, tripod, and stickers**
- Desktop app takes **5-8 minutes to process** videos

Amplified Video that Provides Reference Distances



Patient Ease of Use

Name	Rate App (out of 5)	Rate Instructions (out of 5)
Marcus Manca	3	4
Jake Flores	5	4
Katy Gehring	5	4
Hannah Park	5	5
Adrian Moga	4	4
Allie Miller	5	5
Kris Westgaard	5	4
Sam Morimoto	5	4
Siddarth Gorantala	4	4
Shami Mosely	5	4

- Successfully achieved our goal of having 70% of the students rate the app a ⅘ for usability and overall feel
- App rating: 90% rated ⅘ and above
- Instructions rating: 100% rated ⅘ and above

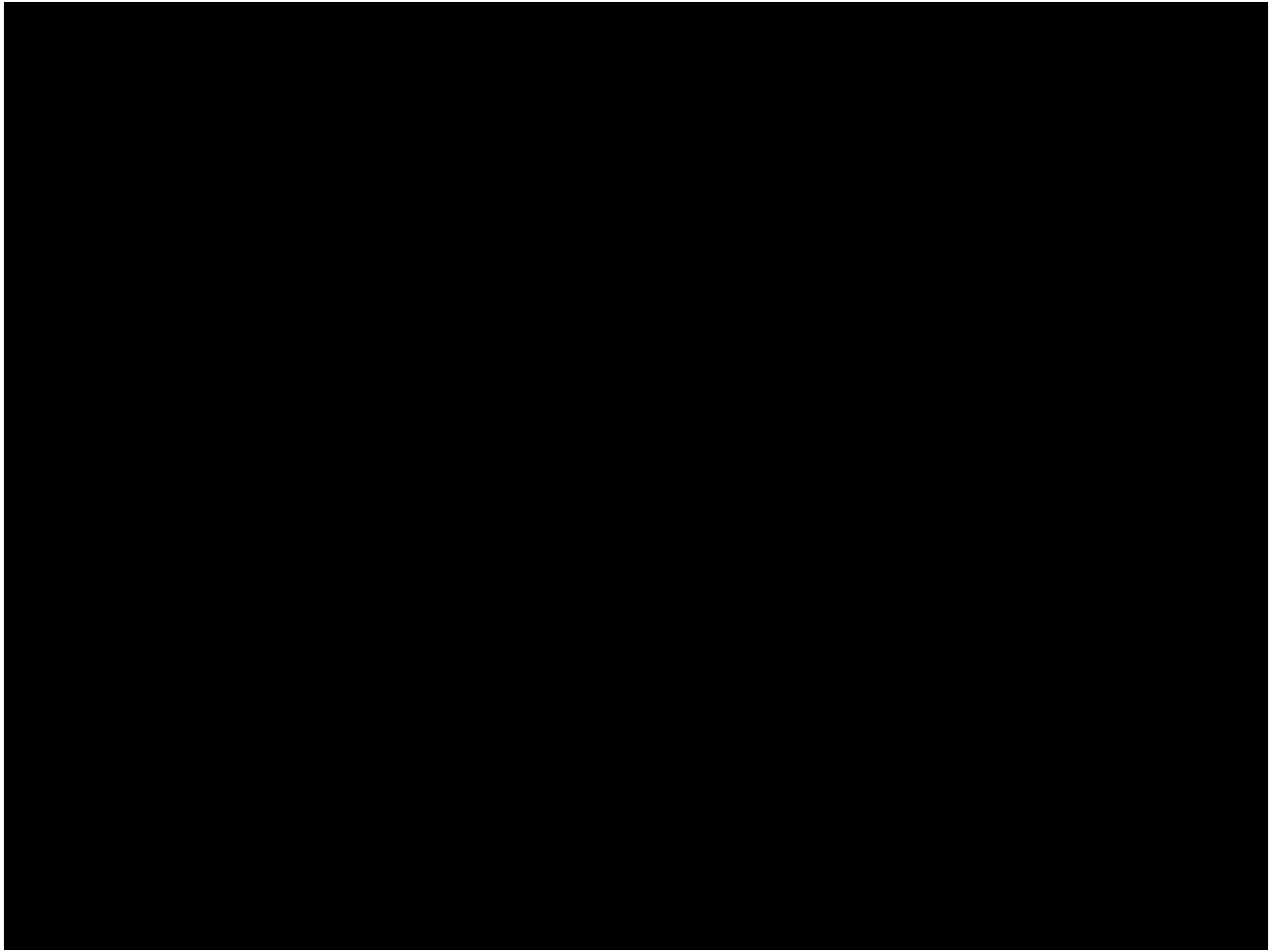
Final Objectives

Cycle 5 Objectives

Objectives	Points
Record JVP videos of a group member using the iOS app. Send the videos to Rohan and ourselves.	200
Process the videos with the desktop app. Send the videos to Rohan so he can compare them with the unamplified videos and give his feedback.	300
Document the end to end operation of the system and how well it works.	300
Finalize the iOS app	300
Finalize the doc facing desktop app	300
Publish code on Github	300
Add detailed documentation for code, readme files, comments, etc	300
TOTAL	2000

- Github link for iOS mobile app: https://github.com/tammi-p/JVP-mobile-app.git
- Github link for desktop app: https://github.com/tammi-p/JVP-desktop-app.git

Demonstration



Next Steps

Next Steps for Future Teams

1. Develop an algorithm to detect and measure JVP height
2. Further refine mobile and desktop apps
    a. Create a tutorial feature in the mobile app
3. Make instructional videos
4. Improve speed of algorithm so that amplification can occur on smartphone
5. Create an Android version of the iOS app
6. Obtain IRB approval and solicit patient feedback