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**ENGINEERING**  
TEXAS A&M UNIVERSITY

# **Team 72: Hand Gesture Recognition**

## **Bi-Weekly Update 5**

**Samuel Oncken, Steven Claypool**

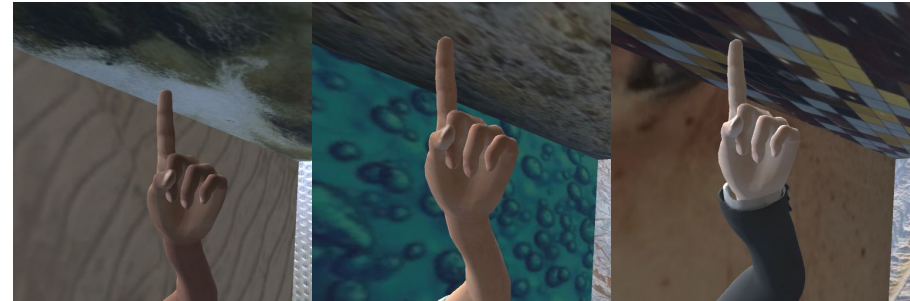
**Sponsor: Prof. Stavros Kalafatis**

**TA: Pranav Dhulipala**

# Project Summary

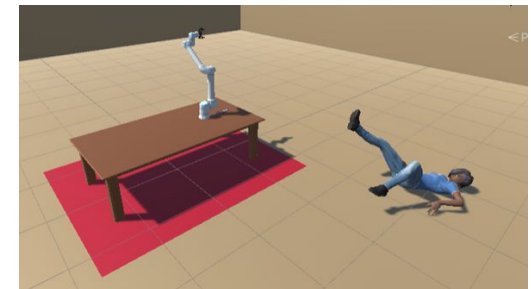
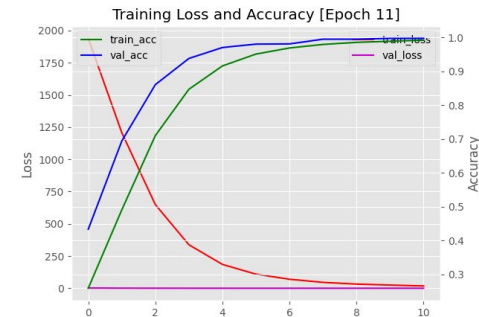
## Problem Statement

- Collecting the large amounts of data required to properly train a gesture recognition NN is **time consuming**, **resource intensive**, and **difficult to scale**



## Our Objectives

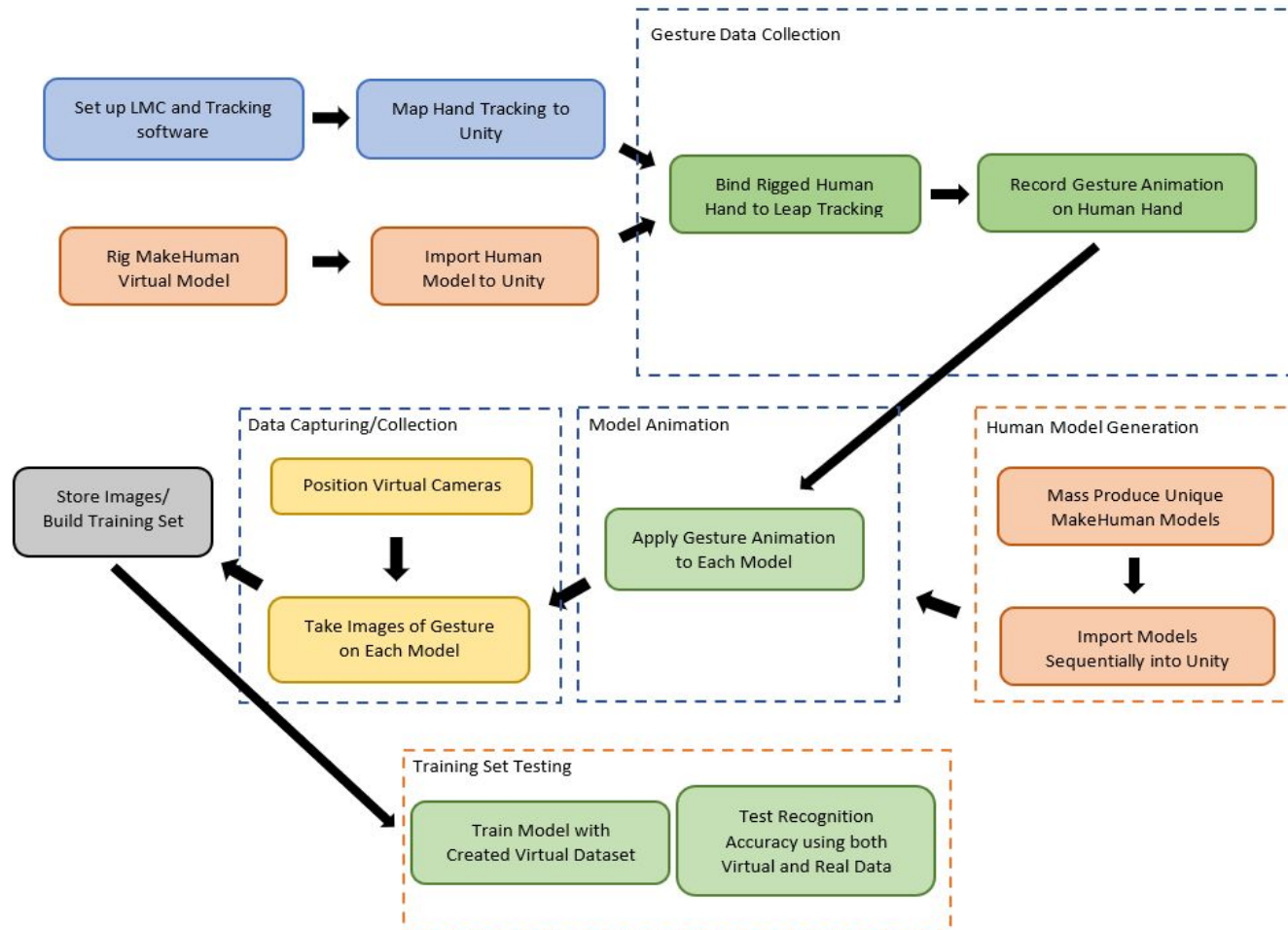
- Test viability of using **virtual data** to train a hand gesture recognition neural network
- Provide large amounts of **diverse data** (skin tones, hand sizes, accessories, etc.)
- Achieve **similar recognition accuracy** when tested against real, benchmark datasets
- Provide a **proof of concept** to extend virtual data usage to robotic arm training application



# Project/Subsystem Overview

----- - Steven Claypool

----- - Samuel Oncken







# Project Timeline

Create Virtual Training  
Set Generation Unity  
Environment  
(Completed 11/20)

Generate Alphabet  
and Numbers Datasets  
– 12,000  
Images/Gesture  
(Completed 12/12)

Complete Gesture  
Classification Analysis  
using Generated  
Datasets

~~(To be complete by  
03/31)~~

(To be complete by  
04/24)

Complete Object  
Localization/Detection  
Analysis using HANDS  
Generated Dataset

~~(To be completed by  
03/31)~~

(To be complete by  
04/24)

Complete Robotic  
Application  
Testing/Training  
Virtual Environment  
(To be complete by  
04/16)

Demo and Final Report  
(To be complete by  
04/28)



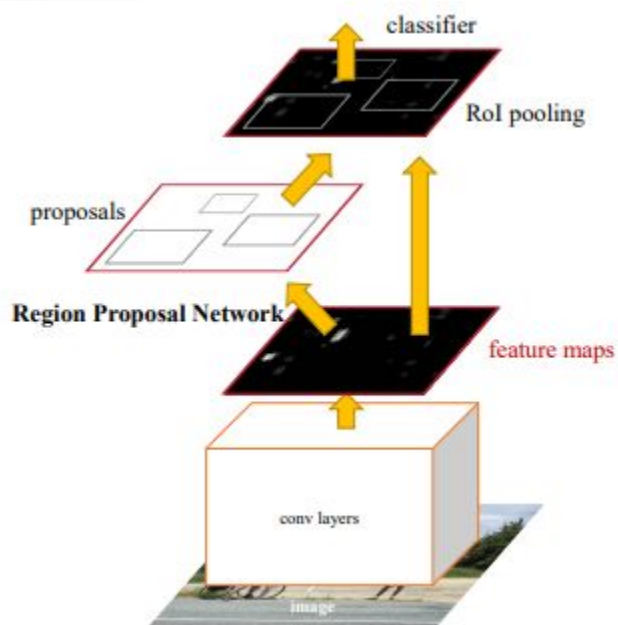
# ML Analysis Progress

Pranav Dhulipala, Steven Claypool

Accomplishments since last update 8 hours of effort	Ongoing progress/problems and plans until the next presentation
Found Tensorflow/Keras fast R-CNN (using RPN)	RPN is not separate from the fast R-CNN as a whole <ul style="list-style-type: none"><li>- Working on reimplementation using the fast R-CNN</li></ul>

# ML Analysis

Pranav Dhulipala, Steven Claypool

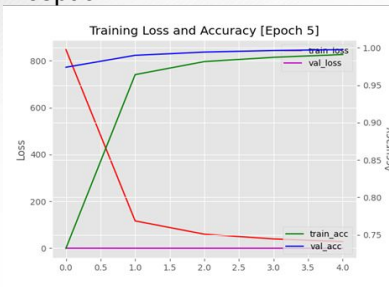


RPNs Available	speed (ms)	COCO mAP	Output
<a href="#">Faster R-CNN ResNet50 V1 640x640</a>	53	29.3	Boxes
<a href="#">Faster R-CNN ResNet50 V1 1024x1024</a>	65	31.0	Boxes
<a href="#">Faster R-CNN ResNet50 V1 800x1333</a>	65	31.6	Boxes
<a href="#">Faster R-CNN ResNet101 V1 640x640</a>	55	31.8	Boxes
<a href="#">Faster R-CNN ResNet101 V1 1024x1024</a>	72	37.1	Boxes
<a href="#">Faster R-CNN ResNet101 V1 800x1333</a>	77	36.6	Boxes
<a href="#">Faster R-CNN ResNet152 V1 640x640</a>	64	32.4	Boxes
<a href="#">Faster R-CNN ResNet152 V1 1024x1024</a>	85	37.6	Boxes
<a href="#">Faster R-CNN ResNet152 V1 800x1333</a>	101	37.4	Boxes
<a href="#">Faster R-CNN Inception ResNet V2 640x640</a>	206	37.7	Boxes
<a href="#">Faster R-CNN Inception ResNet V2 1024x1024</a>	236	38.7	Boxes



## Alphabet Dataset

### Inception

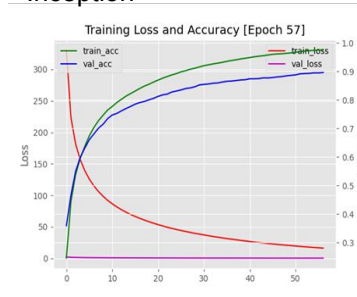


### VGG19

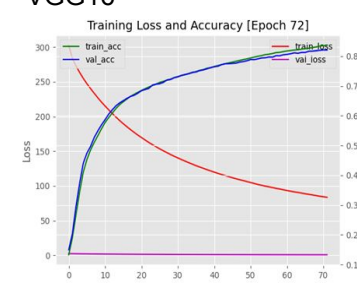


## Numbers Dataset

### Inception



### VGG16



### Xception







# Robotic Application Extension Progress

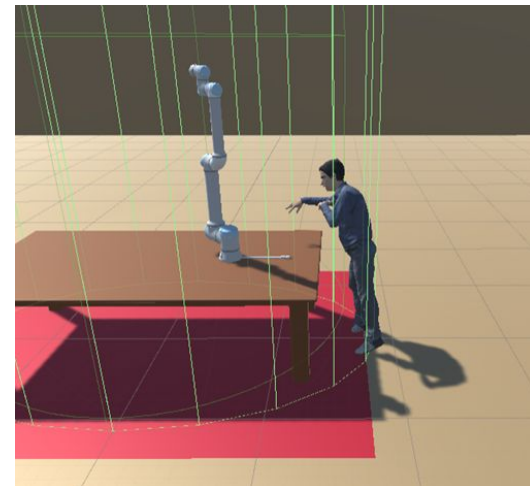
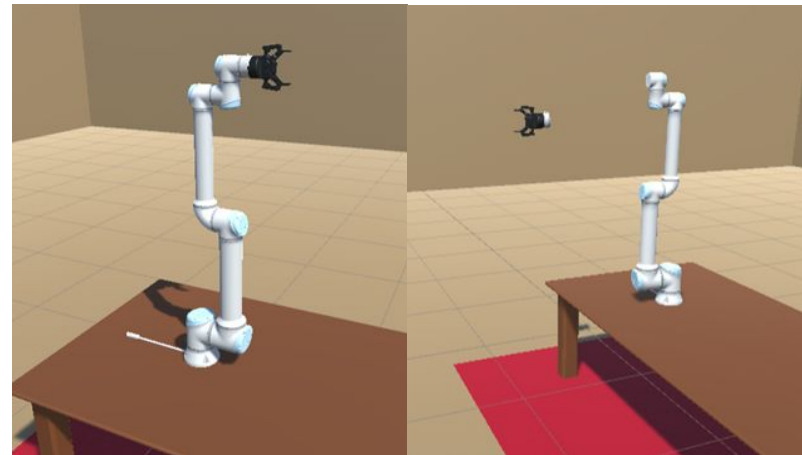
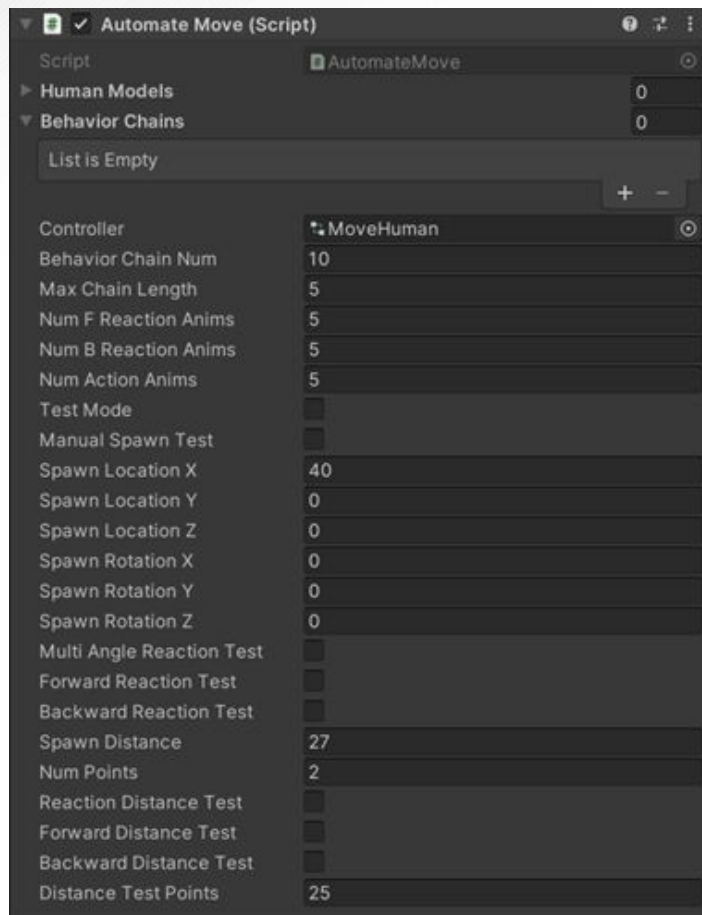
Samuel Oncken

Accomplishments since last update 9 hours of effort	Ongoing progress/problems and plans until the next presentation
<p>Edge Case Detection - Complete</p> <ul style="list-style-type: none"><li>- Invalid user input entry checks</li><li>- Test mode conditional user input checks</li></ul> <p>System Validation - Complete</p> <ul style="list-style-type: none"><li>- Reaction performance under various circumstances (angle and distance from robotic arm)</li><li>- Correct number of behavior chains generated according to user input</li><li>- All behavior chains play fully</li><li>- All choices of reaction and action animations have potential to play</li><li>- Once all behavior chains have run, system stops playing</li><li>- Test mode specific validation...</li></ul>	<p><u>Problem</u></p> <p>Reaction animations sometimes play prematurely due to “flying” gripper bug</p> <ul style="list-style-type: none"><li>- Reactions work fine with gripper disabled</li><li>- Will likely replace the gripper</li></ul> <p><u>Next Steps:</u></p> <p>Begin exploration of Unity AI Gym</p> <p>Update documentation with new testing instructions</p>



# Robotic Application Extension

Samuel Oncken





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# Thesis Writing

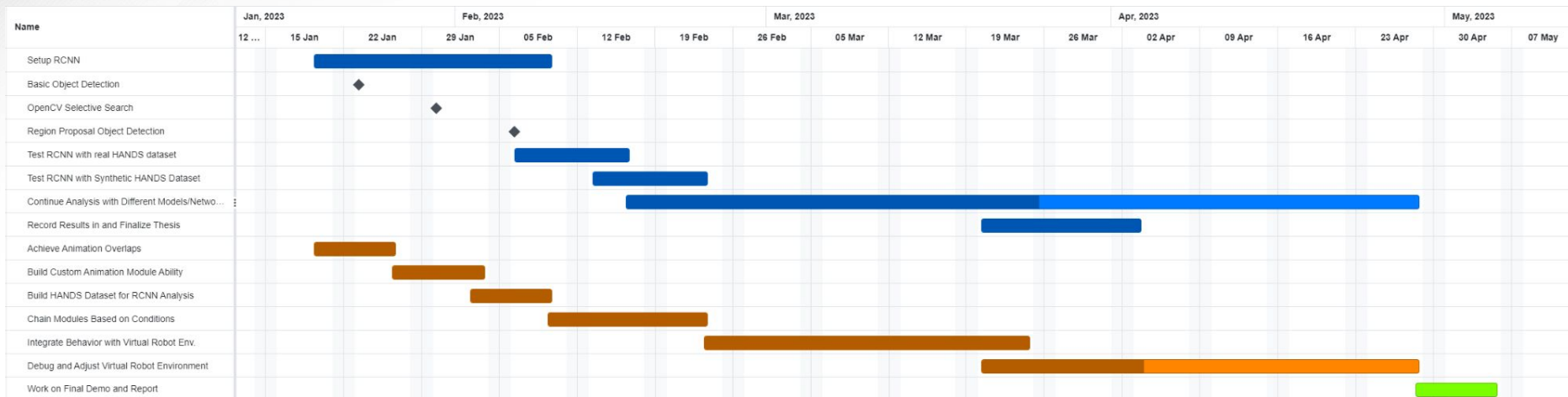
Samuel Oncken, Steven Claypool

Accomplishments since last update 6 hours of effort - each member	Ongoing progress/problems and plans until the next presentation
Finished writing thesis!	

### Legend

- Analysis Extension
- Robotics Integration
- Final work

Darkened = Completed





# 403 Validation Plan

Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
Benchmark Dataset Training	Gesture recognition neural network can run on our home computer and train using the real dataset. Results quantified	Download the benchmark data set and the code for the CNN. Run the code and confirm similar accuracy to benchmark logs provided.	TESTED - Pass	Steven Claypool
Virtual Dataset Training	Gesture recognition neural network can train using our built dataset and provide accuracy results	Take a final virtual dataset modeled after a real benchmark dataset and use it to train the same CNN as the benchmark. Ensure similar accuracy results.	TESTED - Pass	Steven Claypool
Gesture Recognition Accuracy	Accuracy of gesture recognition is within 5% of benchmark accuracy using our virtual dataset	Train gesture recognition neural network using real and synthetic sets and compare accuracy	TESTED - Pass	Steven Claypool
Synthetic Data on Real Data Accuracy	Test real data with CNN trained on synthetic data and achieve accuracy similar to benchmark.	Train a CNN using different methods/compositions with synthetic and/or real data, and test using real data.	IN PROGRESS	Steven Claypool, Pranav Dhulipala
Unity Hand Mapping	Real hand movement is mapped in Unity	Set up Unity, install Ultraleap plug-ins, map hand motion.	TESTED - Pass	Samuel Oncken
Import Rigged MakeHuman Model	A fully rigged MakeHuman model is imported into Unity	Import model into Unity and confirm appearance and functionality.	TESTED - Pass	Steven Claypool
Virtual Model Unity Hand Mapping	Map hand motion onto an imported MakeHuman model.	Use Hand Binder component/configure settings. Confirm natural motion.	TESTED - Pass	Samuel Oncken
Mounting Stability	Head mounted LMC remains in place during head motion	Mount LMC and plug the device into the computer. Rotate head in all directions and shake head left to right.	TESTED - Pass	Samuel Oncken
Apply Example Animation to Model	MakeHuman model is able to perform an imported full body gesture accurately.	Import an animation .fbx and apply the animation to the rigged human model. Confirm that motion is as expected.	TESTED - Pass	Samuel Oncken
Apply Recorded Gesture Animation to Model	Rigged MakeHuman model can perform a recorded gesture animation.	After recording an animation, apply it to an imported MakeHuman model using the Animator component.	TESTED - Pass	Samuel Oncken
Create and Import Rigged MakeHuman Models to Unity	Minimum 30 MakeHuman models can be generated and imported into Unity	Use MakeHuman "mass produce" function to generate unique character models, each fit with a "Default" rig, with 20% edge cases	TESTED - Pass	Steven Claypool
Data Capture Output and File Type	Virtual camera outputs image data as a .jpg files	Record images of gesture, validate that the data is stored, organized, and is of the desired file type.	TESTED - Pass	Samuel Oncken
Final System Validation	With the press of a button, a large, diverse virtual training set is produced	Run system and validate in output files that each gesture has at least 500 images of gesture performance on differing human models from numerous angles	TESTED - Pass	Samuel Oncken





# 404 Validation Plan

RCNN Validation	Create a functional RCNN that takes images as an input and outputs the image with correct bounding boxes	Using an image classifier with ImageNet weights, feed sample images into the RCNN and verify correct output of images with bounding boxes	IN PROGRESS	Steven Claypool
RCNN Object Detection on Real Data	Test the RCNN with the HANDS dataset and reach acceptable accuracy metrics	Feed dataset into RCNN and measure accuracy using Intersection of Union (IoU) to compare the predicted bounding box and the ground-truth bounding box	IN PROGRESS	Steven Claypool
RCNN Object Detection on Synthetic Data	Test the RCNN with a synthetic HANDS dataset and reach similar accuracy compared to the real dataset	Feed dataset into RCNN and measure accuracy using Intersection of Union (IoU) to compare the predicted bounding box and the ground-truth bounding box	IN PROGRESS	Steven Claypool
Import and Use Mixamo Animations	Animation clips from Mixamo FBX imported files can be applied to MakeHuman virtual models,	Download FBX (for Unity) files from mixamo.com for animations we wish to use. Import them into Unity project folder. Make each prefab "Humanoid" and extract and test animation clip on MakeHuman models	TESTED - Pass	Samuel Oncken
Randomly Select "Behavior" Animation	After model is spawned, depending on user input for desired "behavior", a randomly selected animation clip will play.	Use Unity C# to script the categorization of "behavior" specific animation clips and random selection. Use Animator on human model with an animation controller selected that includes all desired animation clips.	TESTED - Pass	Samuel Oncken
Ability to Chain "Behavior" Animations	While environment is running, user is able to manually create test behavior chains or system is able to automatically randomly generate behavior chains	Use Unity C# to script the choice of a "Test Mode" vs. automatic mode. In Test mode, user can manually create behavior chains which link animations clips one after the other in order established by the user. Automatic mode uses a method in Unity C# to randomly generate chains of behavior animations.	TESTED - Pass	Samuel Oncken
Virtual Robot Unity Environment Integration	Be able to merge the testing environment with the robotic arm simulation environment created by Pranav. Make sure all functionality is still available.	Transfer all necessary code, model prefabs, unity scenes, etc. through GitHub Desktop and integrate all of these into the environment already created by Pranav with included robotic arm model.	TESTED - Pass	Samuel Oncken
Human Model Interaction with Robotic Arm Model	If criteria is met such as human models becoming too close to robot arm, they perform a randomized reaction animation	Unity C# scripting for reaction animations to take place using a trigger collider around the robotic arm prefab. Once a model comes into contact with the trigger, all other behaviors in the behavior chain cease to run and a reaction animation is immediately played.	TESTED - Pass	Samuel Oncken



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**Thank you. Questions?**