Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

Hand Gesture Recognition

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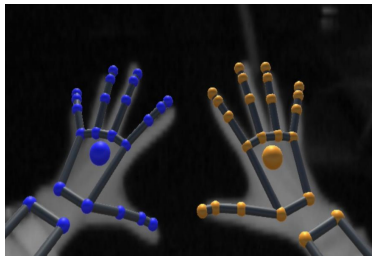
Project Description

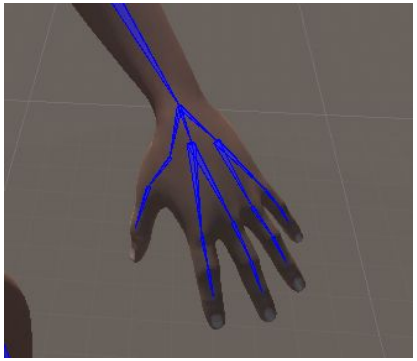
Problem Statement:

- Training a hand gesture recognition neural network requires **large amounts** of data
- Collecting this data is **time consuming** and **resource intensive**
- **Numerous participants** performing gestures
- **Expensive** camera equipment for recording data

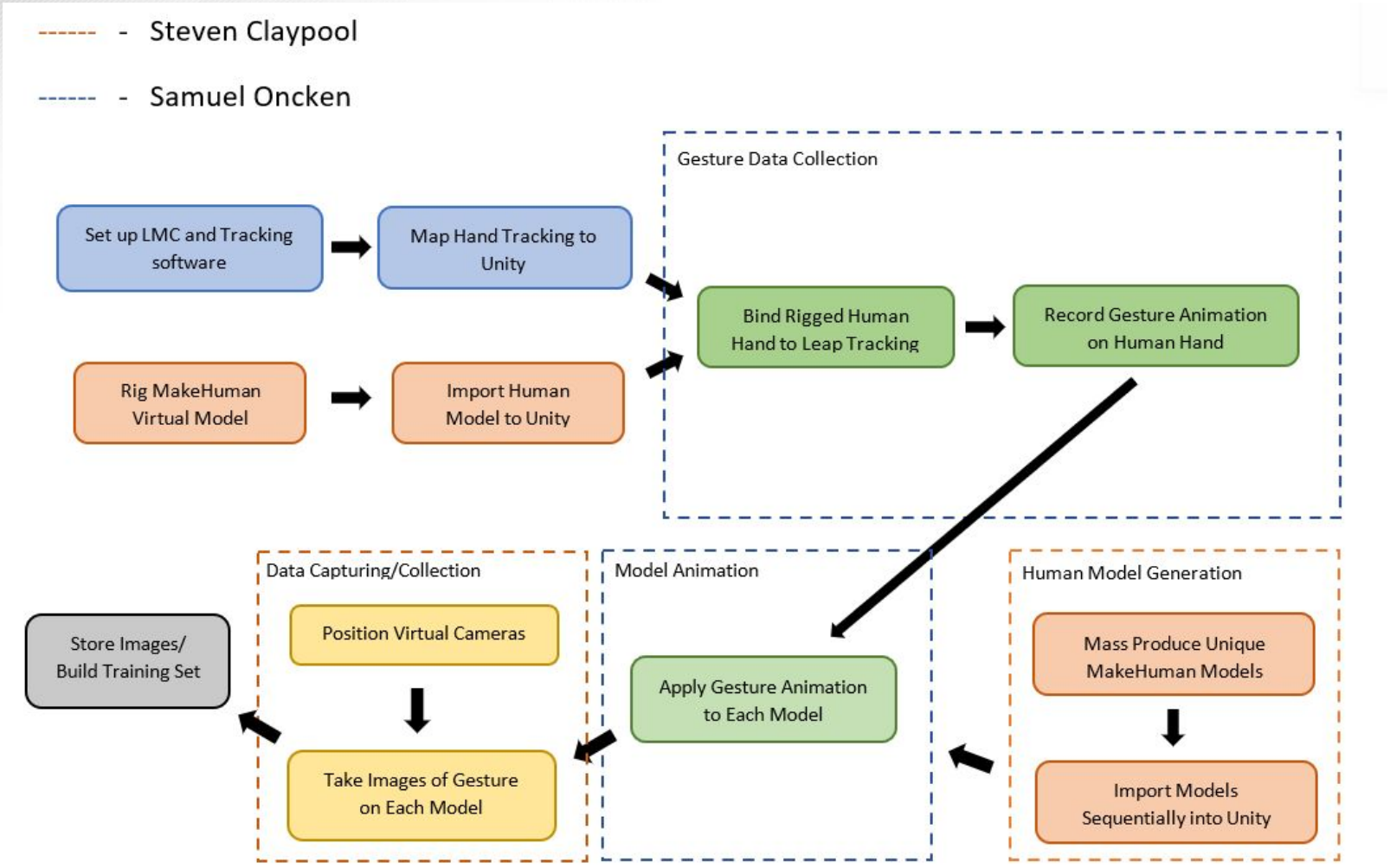
Our solution:

- Provide a similar if not improved metric of performance using **virtual (synthetic) data**
- Only **one user** required to perform gestures
- Only requires a Leap Motion Controller (LMC) (relatively **cheap**) and Ultraleap tracking software
- Uses **free** software (Unity and MakeHuman)



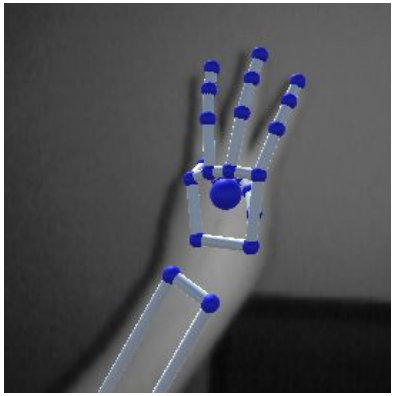


Subsystem Overview

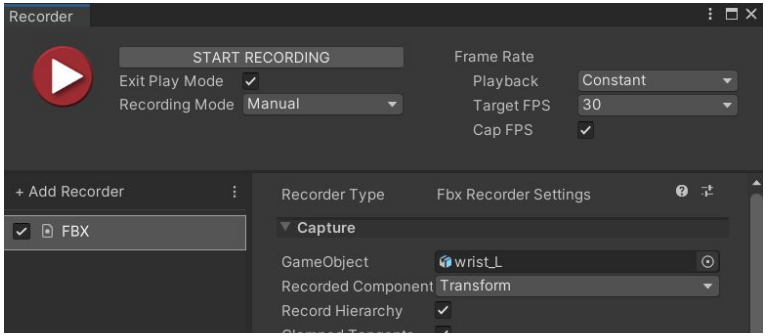


Gesture Data Collection Subsystem

- Hand gesture is **performed** on an imported MakeHuman model by the user
  - Using “Hand Binder” script to match hand tracking data to the model’s rigged bones



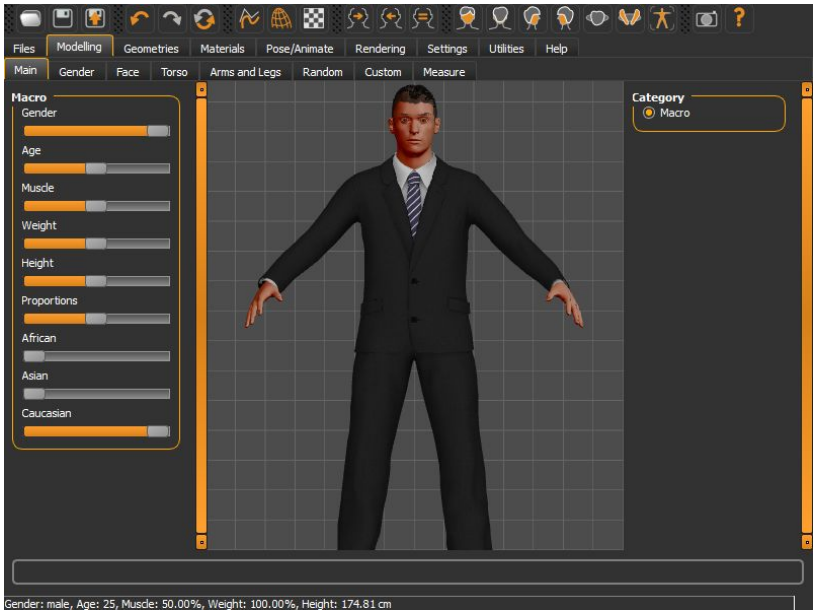
- Hand gesture is **recorded** and **exported** as a .fbx file
  - Using Unity Recorder and FBX Exporter
  - Must set the wrist as root node to record transformation data of child bones



Human Model Generation Subsystem

- Virtual human models are **generated** in MakeHuman and **exported** (as .fbx file)
  - Export folder is in Unity environment Assets folder
  - Diverse body structure, skin color, clothing, etc.

- **Mass produce** models for data collection of large training sets
  - Requires MakeHuman's Mass Produce plugin
  - Must ensure sequential spawning in Unity environment



Model Animation Subsystem

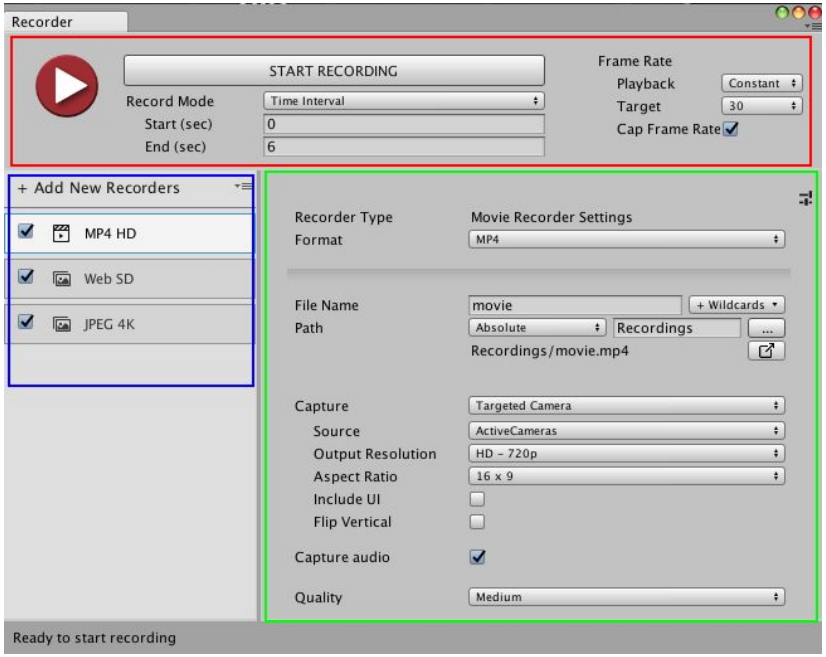
- Recorded hand gesture animation (.fbx file) is **applied** to each imported MakeHuman model
  - Requires an animator component in the wrist (root node)
  - Requires an animation controller to specify animation behavior

- Additional scripting necessary
  - Placement of animator on proper bone for each imported model
  - Specification of applied gesture animation on each imported model

Data Capturing/Collection Subsystem

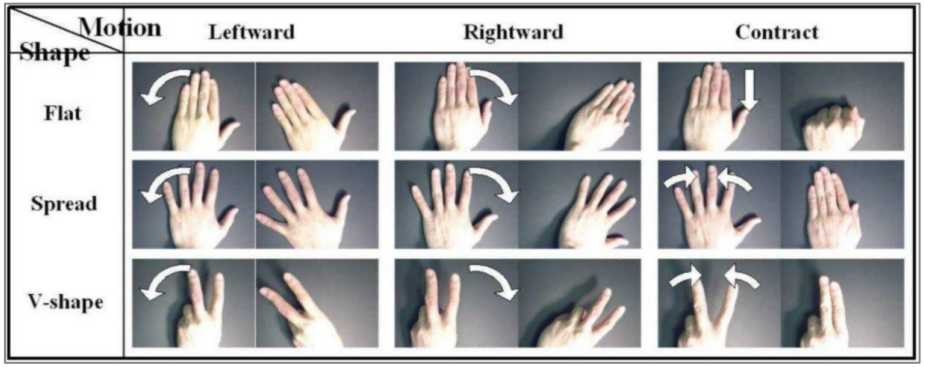
- Multiple Unity cameras for taking images or videos are **placed** in the Unity environment
  - Using Unity Recorder plugin
  - Requires scripting for controlling image or video timing
  - Save the files matching the file type of the benchmark data
  - Uses Image Synthesis for image/video annotation

- Taken images or videos are **sorted** by model and gesture and **exported**
  - Requires scripting to properly sort data and export to specified destination folder

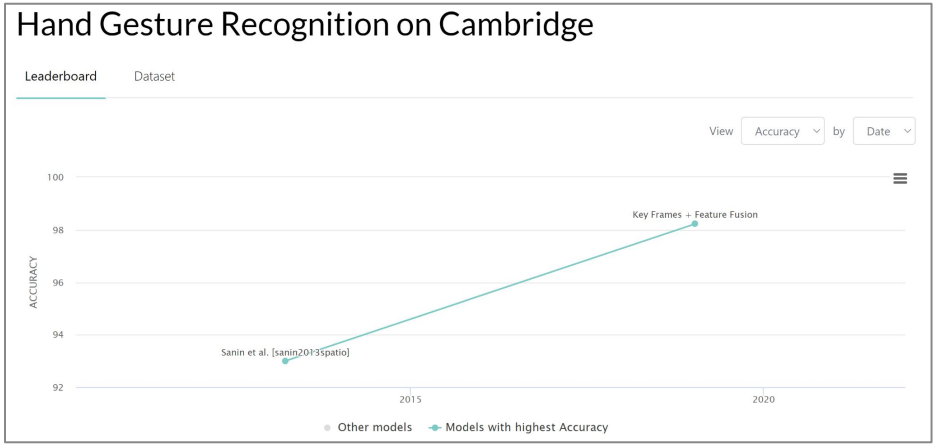


Post System Creation: Training Set Testing

- **Compare** generated virtual training sets to benchmark datasets
  - Ensure **similar** accuracy
  - Use benchmark CNNs and datasets from **well cited** sources



- Test and validate different training set compositions
  - Combine virtual training set with original benchmark dataset at different percent compositions of each



Task Partition

Subsystem	Responsibility
Gesture Data Collection	Samuel Oncken
Human Model Generation	Steven Claypool
Model Animation	Samuel Oncken
Data Capturing/Collection	Steven Claypool

Execution Plan

Progress to Date: Mounted LMC in optimal position, mapped real tracking data from LMC to MakeHuman model hands, recorded test animation for application on other models. Currently determining which real benchmark datasets we will be replicating along with the neural network they are tested against.

	October 12th	October 26th	November 9th	November 23rd	November 30th
Gesture Data Collection	- Choose real datasets to replicate - Complete hand mapping configurations	- Complete gesture animation recording according to chosen datasets to replicate			
Human Model Generation	- Produce 6 models into Unity for animation testing	- Mass produce models into Unity environment sequentially			
Model Animation	- Apply recorded test gesture to a single model	- Randomly apply a recorded gesture to any model			
Data Capture/Collection	- Place at least 5 virtual cameras in Unity environment to face model hand from multiple angles	- Record and store images of gesture performed on any model			
Training Set Completion/ Testing		- Completion of training set creation system. - Testing process begins	- Preprocess each training set - Create new training sets ranging in composition of real and synthetic data	- Train each neural network with new training sets and record the metric used in the real dataset paper for proper comparison	- Evaluate results after comparison and prepare system and outcomes for final presentation.

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Validation Plan

Test Name	Success Criteria	Methodology	Status	Responsible Engineer(s)
Gesture Recognition Accuracy	Accuracy is within 5% of benchmark accuracy using real dataset	Train gesture recognition neural network using real and synthetic sets and compare accuracy	UNTESTED	All
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.	IN PROGRESS	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.	UNTESTED	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.	UNTESTED	Samuel Oncken
Mass Produce Rigged MakeHuman Models to Unity	Minimum 100 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	UNTESTED	Steven Claypool
Data Capture Output and File Type	Virtual camera outputs image data as a .png file or video data as mp4 (TBD from neural networks used).	Record images/videos of gesture, validate that the data is stored, organized, and is of the desired file type.	UNTESTED	Steven Claypool