

SW Engineering CSC648/848

Mesekai

real-time full-body 3D avatar and virtual room web application

Section 04 Team 04

Caelen Wang (Team Lead)

Vasudevan Venugopal (Frontend Lead)

Matthew Madore (Backend Lead)

Jose Miguel Atienza (Scrum Master)

Eugene San Juan (Git Master)

Mohammad Abdelrahman

“Milestone 1”

October 4, 2021

Revision History Table

Executive Summary

The past year and a half introduced frequent, extended online interactions into our day-to-day lives. People of nearly all professions from all age groups switched their primary mode of teaching, learning, working, playing, and socializing to digital spaces. With this increase in demand for virtual modes of communication, comes the opportunity to redefine our perception of virtual experiences. Despite rapid development in online conferencing applications such as Zoom, Google Meet, and Microsoft Teams, the underlying premise of communicating through text, voice, and video chat has not changed since the early 2000s. Of course, gamers have long known the joy of extending communication to real-time interactions through online multiplayer videogames. Within these virtual worlds, players can do things and visit places as far as the boundaries of our imagination. However, gaming is still considered somewhat of a “niche” hobby by those who do not actively engage with the medium. Non-gamers view videogames as merely a form of entertainment that is entirely unrelated to themselves whatsoever. Our application, *Mesekai*, introduces the concept of a 3D, customizable, and interactive virtual avatar and world for the purpose of communicating and interacting with other individuals or a broader audience. *Mesekai* does not aim to replace traditional modes of communication and gaming, but instead introduces a new genre of virtual interactions entirely.

Users can access *Mesekai* through a computer with an internet browser and a webcam. Upon sign in, they are greeted with a 3D character model looking back at them through the monitor. This avatar will mimic the user’s facial expressions, along with full body and finger positions as detected from the webcam. The avatar inhabits its own virtual room with 3D models of furniture and other objects. Users can control their avatar to interact with the objects and the environment around them. Finally, users can invite others to their room or visit others’ rooms, and participate in shared activities. A specific use case for *Mesekai* is related to the recent trend of Vtubing, which is when YouTube and Twitch content creators use a virtual avatar instead of their real face when creating videos or interacting with their viewers. Our digital persona is a way to reinvent ourselves in a way that transcends physical constraints such as race, body type, and traditional standards of beauty. It is an opportunity to interact based purely on personality rather than perceived physical appearance. *Mesekai* serves as an escape from reality into another world, much like a videogame. However it does not entirely sever the connection between the user and the virtual persona, since avatar motion is still tethered to physical movement. This unique user input and interaction system offers a sense of “virtual physical presence” unseen in mainstream applications.

The *Mesekai* team comes from a diverse background of technical experience and passions. We are web, database, user interface, computer graphics, and videogame designers and developers. We are excited about the prospect of entering a fantasy world built by our own ingenuity and imagination. *Mesekai* aims to build a holistic experience that will convince users of the value of interactions within a virtual world. In the grand scheme, it is a first step towards the eventual symbiosis of physical and virtual identities, of biological and artificial sentience.

Personas and User Stories

Persona ID 01 - Elliot:

Elliot is a 27 year old cybersecurity engineer who has a hard time socializing. He is a very lonely person who doesn't have many friends. At least twice a week he comes home and cries all night because of how lonely he is, the other nights are spent fueling his opioid addiction. His sister is desperately trying to get him to go out there and socialize but his hate for society is just too strong. He realizes his anti-social issues as well but doesn't just start going out and interacting with people. His therapist also urges him to go out there and socialize in any way possible and to see that society is not all that bad.



Persona ID 02 - Brandon:



Brandon is a 34-year-old product manager who facilitates communication between many teams within the company. He and many of his colleagues spend multiple days a week working from home. Therefore Brandon and his teammates must conduct virtual meetings through online conferencing apps. Recently he is starting to notice a lack of energy and engagement in these entirely virtual meetings. Most of the time people are slouched in their chairs, working or browsing other things while talking in a

monotone voice. Specifically, it's difficult for teammates to motivate each other through gestures and body language. Brandon wants to establish a physical connection in these meetings to conduct more productive collaboration.

Persona ID 03 - Jessica:

Jessica is a 25-year-old who loves to dance and is constantly dancing when she's alone. However, she is shy and has stage fright. Every time she tries to perform in front of people she freezes up and can't focus on the routine. This is partly due to her insecurities about her body image. Jessica is actually quite talented. She aspires to be a background dancer for Ariana Grande one day and knows that her stage fright is a huge impediment. She continues to hone her dancing skills but knows she will never truly get over this hurdle unless she performs in front of a crowd. Jessica wishes there was a way she could show off her skills while remaining anonymous.



Persona 04 - Joseph:



Joseph “PsychoMantis” Deen, age 9, is the youngest professional Fortnite player, after signing with Team 33 in December last year. Between practicing and competing, Joseph streams his gameplay on Twitch to thousands of viewers. Besides Fortnite, Joseph also engages in variety streaming of other games that he enjoys. He has a loyal fan base that is mostly supportive. Due to his popularity, he attracts the attention of many critics and trolls. This results in constant derogatory comments in his Twitch chat commenting on his age and appearance, which has been hurting his self-esteem and confidence as a player.

Persona 05 - Betsi:

Betsi is a senior citizen who is bound to a wheelchair due to her unreliable hips. Betsi’s condition does not stop her from enjoying the twilight of life. Betsi spends much of her time on the internet in chat rooms and stays close to the many friends she has acquired throughout her long life. Betsi was very involved in her local community through volunteer events though her mobility issues no longer allow her to attend those enjoyable functions. Betsi has now moved her joyful presence online and is excited to find a way to allow her to virtually walk around, interact with her friends, but yet still capture her lively and charming personality.



Persona 06 - Thomas:



Thomas is a 40 year old veteran who is still scarred from the things he’s experienced during his time in the military. There are nights where he can’t sleep and can still hear bullet fire and explosions going off in his head. During the day he forgets where he is sometimes and thinks he’s on the battlefield. Sometimes looking at women and children he remembers the innocents that were dragged into the war. He’s been holding onto his grief to himself for so long and has tried help groups but couldn’t bring himself to speak. He knows he has to let this off his chest in order to take back control of his life.

User Story ID #	Persona	Feature	Benefit	Constraints
1	Elliot	Reinvent himself online through fictional persona	He can alleviate his drug addiction	Variety of characters to choose from
2	Elliot	Socialize with other people	He can resolve his loneliness and mental illness	Online multiplayer in same room
3	Brandon	Conduct online conference with physical interactions	Keep energy high and meetings engaging	Virtual conference table and whiteboard
4	Jessica	Being able to show off her dance skills without showing her real body	She can gradually gain confidence in dancing in front of a crowd	Accurate motion detection and tracking
5	Jessica	A teacher to help her practice dance routine	Know that she is doing the dance properly	Pose correction feature
6	Joseph	Supplement his streaming presence with a virtual avatar	Create a persona to avoid personal attacks from Twitch chat	Optimized for streamer use: various camera angles, tabletop objects
7	Joseph	Create an appearance to his liking	Be whatever his little heart desires	User imported custom models
8	Betsi	Continue to interact with her friends despite walking difficulties	Maintain her life long friends	Upperbody only mode, use keyboard for movement
9	Betsi	Interact with local community through online events	Continue her passion for community building	Engaging and fun multiplayer activities
10	Thomas	Being able to anonymously talk about his experience	He can vent his traumas from his service in the military	Comforting environment and settings to choose from

Data Definitions

Name	Definition	Usage
Avatar	Player controlled 3D character	Facial expression, body and finger pose controlled through physical motion captured by webcam
World	3D environment that the Avatar resides in	Used as sandbox that user can customize and interact with
Object	3D asset in the World	Decoration of World, Interactive with Avatar
Face Landmark	Point on user's face in 3-dimensional space	Constructs a Face Mesh
Face Mesh	Array of 468 Face Landmarks, represents a face	Used to calculate facial expressions and gaze direction
Pose Landmark	Point on user's body in 3-dimensional space	Constructs a Pose
Pose	Array of 33 Pose Landmarks, represents a body	Used to track user's limbs
Hand Landmark	Point on user's hand in 3-dimensional space	Constructs a Hand Pose
Hand Pose	Array of 21 Hand Landmarks for each hand, represents hands	Used to track hand movements and gestures
Skinned Mesh	Modular piece of 3D model containing mesh vertices and texture UVs	Multiple Skinned Meshes make up a 3D character model of Avatar
Morph Target	Rigged and animated shape key of Skinned Mesh corresponding to Avatar face	Values set dynamically to animate Avatar facial expressions
Bone	Abstraction of a joint connection in the human skeletal structure	Nested with parent/children relations to construct a Skeleton
Skeleton	Nest bones representing the human skeletal structure	Positions set dynamically to animate Avatar body

Functional Requirements

1. Account creation
 - Use the user's provided information such as username, email, and password and store these data in our database
2. Log in and log out of account
 - Log in to account using credentials stored in our database provided during account creation or password reset
3. Reset password to account
 - Link on login page that lets them enter their email address, to which a password reset link will be sent
4. Select Avatar from presets
 - Based on user choice from side menu, different Avatar will be swapped in
5. Select World from presets
 - Based on user choice from side menu, different World will be set active
6. Select Objects from list
 - Based on user choice from side menu, different Objects will be spawned in
7. Avatar / Object Interaction
 - User can control avatar to pick up and collide with Objects
8. Move Objects around World in user interface
 - Click, drag, drop Objects to be placed in desired location
9. Custom Avatars
 - User can upload their own 3D character models
 - Tutorial to show how to create model to meet system requirements
10. Custom Objects
 - User can upload their own 3D assets
 - Tutorial to show how to create assets to meet system requirements
11. Adjust hardware settings
 - Choose among Level 0: CPU only, Level 1: mid-tier GPU, and Level 2: high-end GPU based on device specifications
 - Lower levels reduce quality of tracking and graphics but improve performance
12. Adjust tracking settings
 - Toggle on or off for 1) facial expressions, 2) body tracking, 3) finger tracking based on desired effect
13. Adjust body tracking settings
 - Toggle between full body or upper body only modes
14. Adjust movement settings
 - Toggle between real-time tracking or keyboard movement
15. Adjust perspective
 - Choose from 1) 3rd person mirrored (default), 2) 3rd person aligned, 3) 1st person

Non-Functional Requirements

A. Performance

- Loading time should be reasonable on all desktop browsers
- FPS should be 20+ on all desktop browsers
- Multiplayer should be in real-time with minimal lag

B. Scalability

- Database should scale horizontally as more users are using the application
- Database should scale vertically as more users join the same World

C. Recoverability

- All database operations are logged first before they are performed to ensure recovery upon system failure
- Users can recover accounts by resetting password

D. Security

- Password encryption to secure user private information in case of security breach

E. Additional Requirements

- All 3D models and assets should be aesthetically pleasing
- Avoid the Uncanny Valley

Competitive Analysis

Competitors' Features	Our Features
Memoji/Animoji (Free with iOS device) <ul style="list-style-type: none"> • Facial tracking head avatar • Avatar customization (Hair, Skin Color, Eye Color, etc.) that can be saved for later use • Send videos and photos of avatar via iMessage / text message 	Mesekai <ul style="list-style-type: none"> • Facial tracking as well as body and finger tracking full body avatar • Choose avatar from presets or upload your own • Interact with others in real time
VTubeStudio (Free) <ul style="list-style-type: none"> • Face and hand tracking • Upload own avatars • Customization through UI sliders 	<ul style="list-style-type: none"> • Web application supporting multiplayer and other online features
VRChat (Free-to-Play, requires VR Headset) <ul style="list-style-type: none"> • Full body tracking using VR headset, controllers, and hardware trackers • Join other users in multiplayer worlds. • Upload custom avatars 	<ul style="list-style-type: none"> • Full body tracking through webcam, no hardware accessories • Join other users in multiplayer worlds. • Upload custom avatars
Xbox Kinect (\$199, requires Xbox One) <ul style="list-style-type: none"> • Full body tracking for use in certain Xbox games/software that support Kinect functionality 	<ul style="list-style-type: none"> • Compatible with any webcam
XSens Motion Capture Suit (\$12,500 - \$30,000) <ul style="list-style-type: none"> • Accurate full body motion capture 	<ul style="list-style-type: none"> • Deep learning body tracking using webcam
Ultraleap Leap Motion Controller (~\$100) <ul style="list-style-type: none"> • Sensor to accurately track hands 	<ul style="list-style-type: none"> • Deep learning hand tracking using webcam

Mesekai is unique in that it combines the great features from competitors while avoiding the cumbersome ones into a single web application. Being entirely controlled by user movement means there are no additional hardware requirements that cause both money and physical toll. Being a web application allows *Mesekai* the versatility of facilitating online interactions. The summarized advantage of *Mesekai* over its competitors is that it's a lightweight, low barrier of entry, multiplayer interactive web application.

High Level System Requirements

Server Host	:	Google Cloud Platform: App Engine
Operating System	:	Windows 10, macOS, Linux
Database	:	Firebase NoSQL
Web Server	:	NGINX 1.12.2
Server-Side Language	:	Javascript
Web App Framework	:	React.js / Next.js
Front-end Additions	:	React Bootstraps, React Hooks, Ant Design
Prototyping	:	Figma
IDE	:	Visual Studio Code, IntelliJ
Web Analytics	:	Google Analytics
APIs	:	MediaPipe, Three.js

Team

Caelen Wang	Team Lead / Avatar team
Jose Miguel Atienza	Scrum Master / Avatar team
Vasudevan Venugopal	Frontend Lead / UI team
Eugene San Juan	Git Master / UI team
Matthew Madore	Backend Lead / Cloud team
Mohammad Abdelrahman	Backend / Cloud team

Checklist

- Team found a time slot to meet outside of the class
 - **Done**
- Scrum Master shares meeting minutes with everyone after each meeting.
 - **Done**
- Github master chosen
 - **Done**
- Everyone sets up their local development environment from the team's git repo
 - **Done**
- Team decided and agreed together on using the listed SW tools and deployment server
 - **Done**
- Team ready and able to use the chosen back and front end frameworks: **On Track**
 - React / Next: **Vasu, Eugene** - Refactored HTML about pages to React with Next.js framework. Need to work on incorporating Ant Design, pose detection page refactoring, and login/registration pages logic.
 - Google Cloud / Firestore: **Matthew, Mohammad** - Established a connection to the Google Cloud database (Firestore). Able to store data and retrieve it.
 - MediaPipe / Three.js: **Caelen, Jose** - Avatar head tilt, nod, and turn according to user gaze direction. Facial expressions animated according to the user's face.
- Team lead ensured that all team members read the final M1 and agree/understand it before submission
 - **Done**