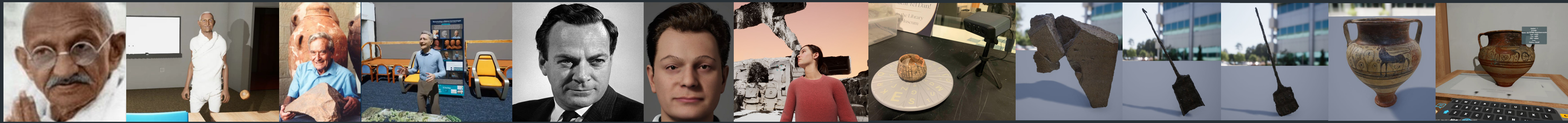


# Historic Metahumans: Avatars, Artifacts and Biblical Archaeology

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## Introduction

The Historic Metahumans project is a novel approach to respectfully preserving the essence of a historical figure and make this data perpetually accessible to future generations. There is great value in having a host/guide Avatar to direct users towards learning and even more when they are a historical figure that embodies a level of respect and connection with the past. These avatars can serve as a gateway to all the scientific data stored digitally for an archaeological site. Using LLMs (Large Language Models) we are able to create natural conversations between investigators and the avatar to study the archaeological site. As an experiment, we chose the famous Biblical archaeologist Avraham Biran, excavator of Tel Dan in the Galilee. With permission from the Biran family and support from the Scheuer - Sofaer family (Palo Alto, CA), we created a Historic Metahuman avatar of Prof. Biran. After the success of this project, we decided to expand our approach to other famous historical figures, including Mahatma Gandhi. We have developed a pipeline to drive multiple lifelike AI avatars like Biran, Gandhi and Richard Feynman. This includes an identical replication of voice, language, emotion, and appearance supplemented with face and body animations. With this pipeline, we will be able to add metahumans into a variety of projects to enhance the educational capabilities of virtual experiences.

### Our key contributions include:

- A pipeline for lifelike AI avatars to enhance education in virtual environments.
- An LLM for personalized responses linked with emotion values and actions.
- A plugin to synchronize AI voice, text, and animation data with avatars.
- Resurrected archaeologist Avraham Biran and Mahatma Gandhi as digital historic metahumans.
- HM GestureGen, a multimodal AI model, to generate facial/body animation from speech.
- A system for switching avatars and associated trained AI models.

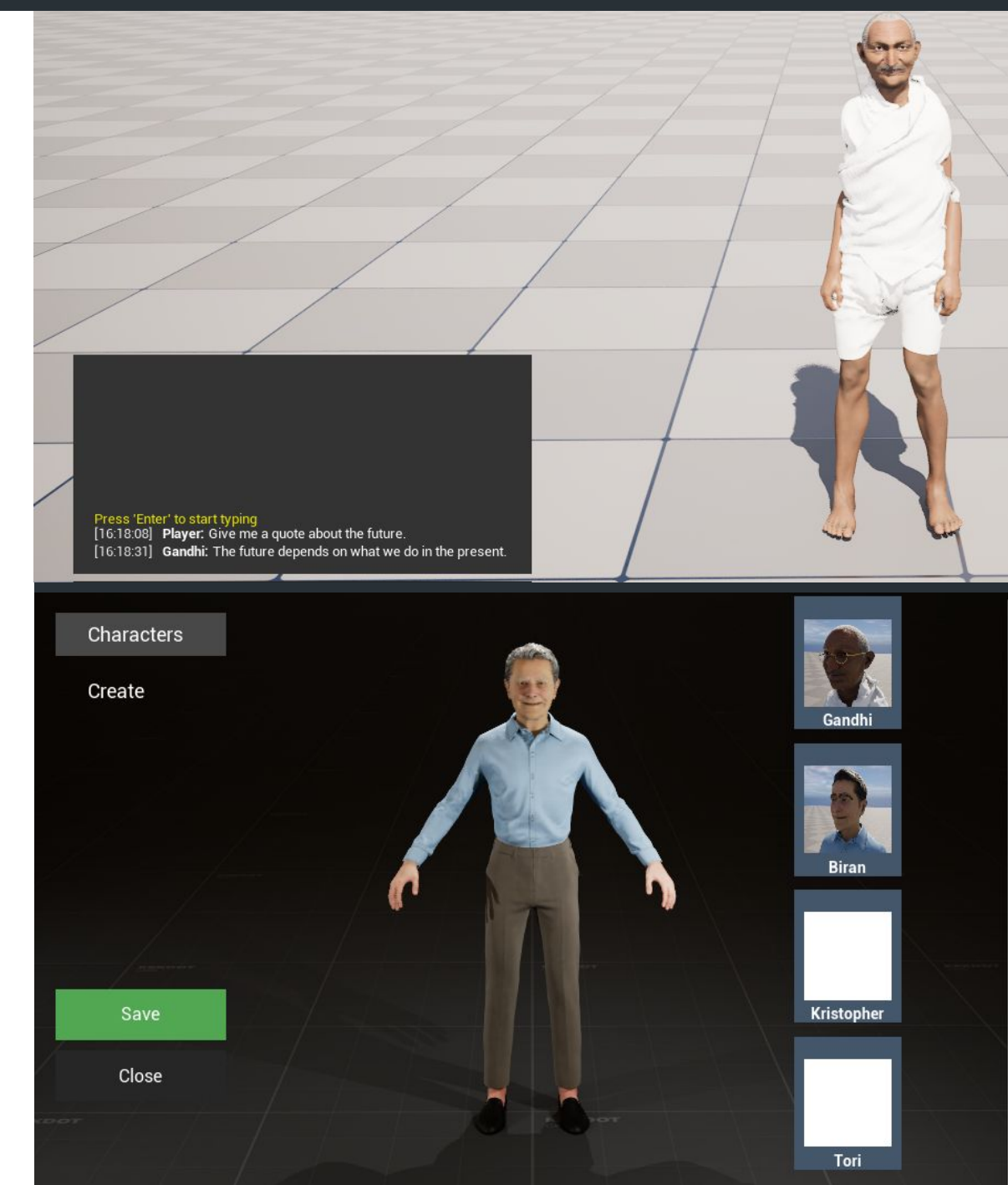
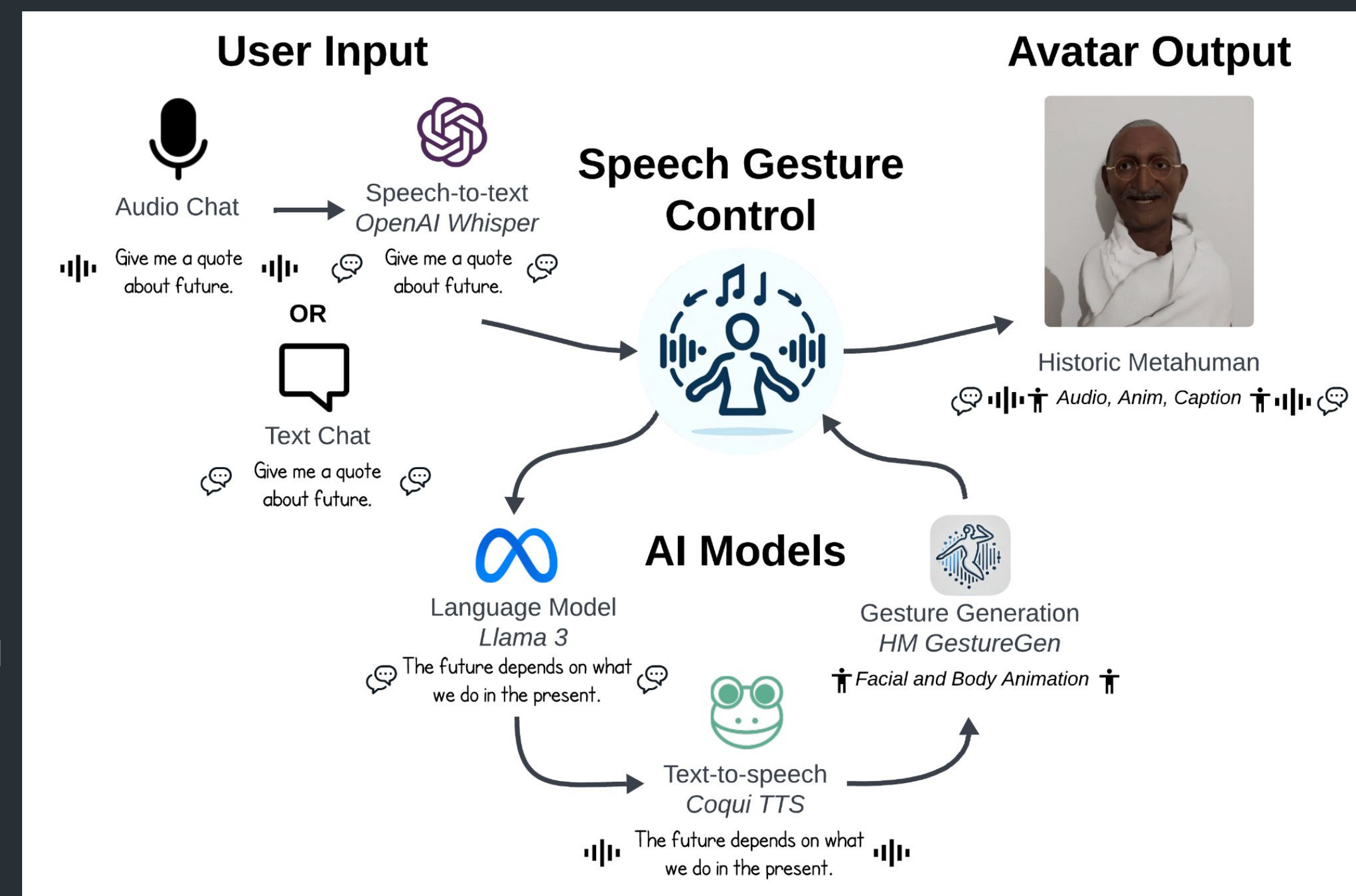
## Methodology

The Historic Metahumans project harnesses multiple AI tools to create life like Avatars. We use Hierarchical Representation Network (HRN) to extract the facial structure of historic figures as a 3D mesh. The mesh is then passed through Unreal's Metahumans tool where a fully rigged avatar is produced with the ability to adjust body and facial details. For avatar conversation, we use a refined Llama 3 model to create characterized text responses, as well as associated emotions and actions to produce realistic interactions. We then use a refined Coqui TTS (VITS) model trained on historical figure's voice to transcribe the text responses into realistic audio. Finally, we pass the previous outputs to our HM GestureGen model to generate synchronized facial and body animation.

We initially gather various speeches and letters from the target historical figure to train the Llama3 and TTS model. However, in order to portray emotions more accurately, we create a website that allows volunteers to label audio clips of the historical figures using the pleasure arousal dominance model for emotion tagging. We then fine tuned the Llama 3 model using LlamaFactory with the emotion tagged transcribed audio. Additionally, we train the model to produce a set of actions that relate to the text response. To accomplish this, we created a small dataset of sample responses for training and the model's output improves overtime to produce accurate and correctly formatted responses. For gesture generation, we base our HM GestureGen on the Cascaded Motion Network (CaMN), improving it to output holistic body motion. Finally, we implement our Speech Gesture Control (SGC) plugin in Unreal to coordinate the external AI models with multiplayer gameplay.

## Full Pipeline & Applications

The diagram below shows how we link the full pipeline together to enable multiple players to speak to a Historic Metahuman. In Unreal, a player can talk to Historic Metahuman via in-game text chat or microphone that is transliterated using WhisperAI. The player's input is then relayed to the server through our Speech Gesture Control (SGC) plugin. At the server, the player input is sent to external AI models to generate the response in speech audio, facial/body animation, caption, and action. The response is then sent back to Unreal and SGC, replicated to all players, and animated in our historic metahuman with spatial audio, text caption, and action.

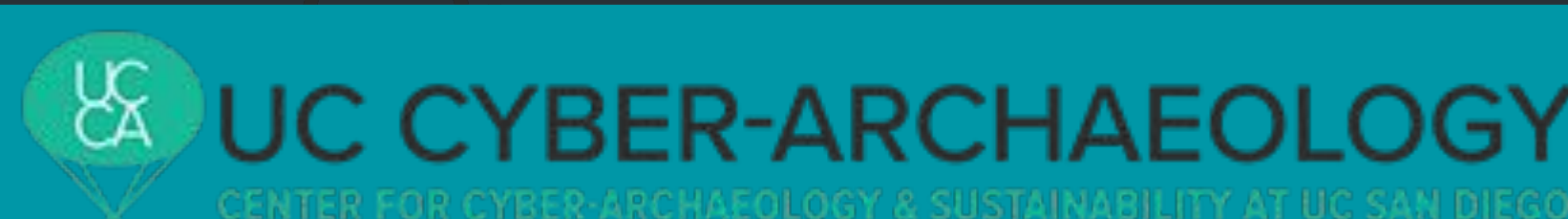


With our completed pipeline, we have successfully built trained AI models and avatars for both Gandhi and Biran. To quickly switch between our preset metahumans at runtime and customize their appearance, we employ a character customization system to apply these avatars to a variety of virtual environments. In the past, we used the Biran metahuman to give a virtual tour of the Hebrew Union College Museum. Currently we are looking to use our pipeline and system for other projects such as the Climate Games to build interactive educational experiences and to allow historical figures give tours of other digital twined environments.

Similar to the digital recreation of Historical figures, we are able to employ low cost structured light scanning devices to scan in many of the associated artifacts with the famous archaeologist or archaeological site. We have had the unique privilege to scan the Tel Dan Inscription, Charioteer Vessel and the Incense Shovels all recovered from Biran's excavations of Tel Dan. These artifacts are true to scale and reach a precision of 0.01mm. Our avatars are able to use these artifacts as interactable props to further education and explain their relevance to archaeology and the biblical narrative.

## Future Work

We are researching methods to improve our pipeline for more accurate user interactions with metahumans. For future metahumans, we would like to recreate esteemed archeologists Thomas E. Levy and Assaf Yasur-Landau to be applied in a case study of Israel's Carmel Coast for better modeling of Tel Dor.



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