Taichine–
A New Way to Learn Taiji

18-500 ECE Capstone Project, Team B4
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Picture from: http://taichisnob.blogspot.com/2013/03/an-introduction-to-24-posture-yang-tai.html

Use Case

The Problem:

- Many people self-learned Taiji, but doing Taiji incorrectly will not achieve the desired health benefits.

The Solution:

- Provide behavioral analysis through video processing using machine learning to compare against reference gesture.
  - Golden Rule – 24 Gesture from the basic Yang’s Taichi exercise
- Provide the flexibility for users to create instructions on their own gesture video

Use Case Requirement

- Need to provide verbal instruction for gesture adjustment
  - 90% accuracy for error joint detection, 10 degree tolerance for angle difference
  - 90% accuracy for correct posture detection
- Enable users to upload custom reference and provide automatic processing necessary for the app
- Ensure that the latency of software is reasonable for users to get real-time feedback when practicing
  - 10 frames per second, cool down time of 2 seconds for wrong postures
- Easy to use once app installed

Solution Approach

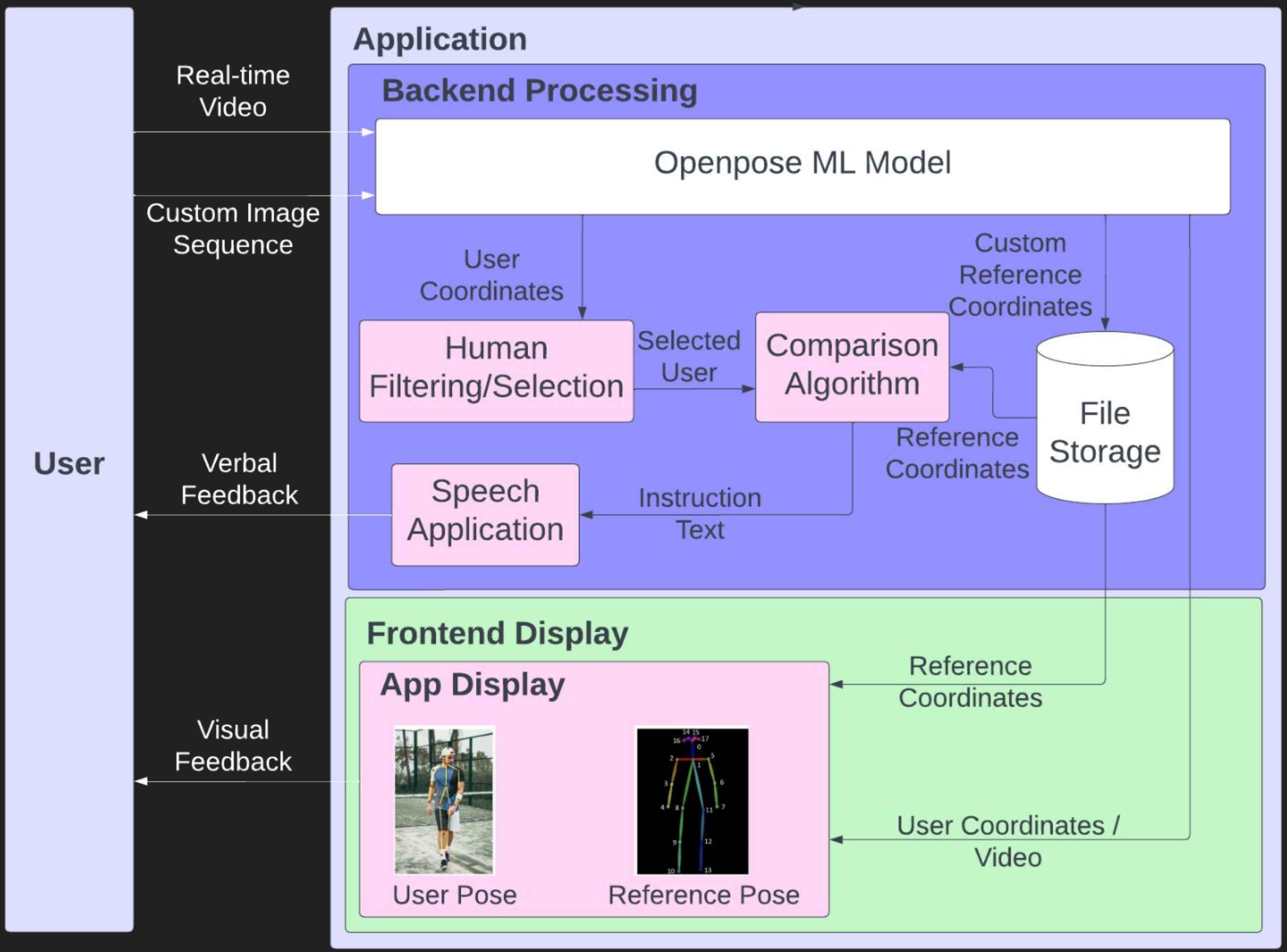
- **Real-time Instruction Pipeline**
  - Allows user to practice Taichi/Custom Pose in front of camera
  - Real-time user input -> Pose Processing -> Reference Comparison -> Verbal Instruction

- **Customization Pipeline**
  - Allows user to store postures as new reference in the app that could be used in the above instruction pipeline

System Diagram

Diagram Key

- □ Off the Shelf Library/Framework
- ▨ New Design
- 🟦 Backend Module
- 🟩 Frontend Module



User

Real-time Video

Custom Image Sequence

Verbal Feedback

Visual Feedback

Application

Backend Processing

Openpose ML Model

User Coordinates

Custom Reference Coordinates

Human Filtering/Selection

Selected User

Comparison Algorithm

File Storage

Reference Coordinates

Speech Application

Instruction Text

Frontend Display

App Display

Reference Coordinates

User Coordinates / Video

User Pose

Reference Pose

Implementation & Design Choices

- **OpenPose (Open source)**
  - Real-time human posture detection application
  - General Internal Logic
    - CNN based with Python/C++ support
    - Detects body parts from all “human” in the image
    - Compute affinity between parts
    - Delete low-affinity connections between body parts
  - Design Choice
    - Output coordinates that is easy to use for angle computation
    - Potential 3D estimation functionality to better support posture comparison and real-world modeling

Implementation & Design Choices

- **App Infrastructure**
    - Language of Implementation: Python
    - Visual Display Package: Python TKinter
    - Storage Model:
        - Folder 1: Reference Posture Image
        - Folder 2: Body Part Coordinates as JSON file
            - Purpose: Save Computation
            - Structure:
                - Name of the pose
                - List of pairs of body parts corresponding to their coordinates

Implementation & Design Choices

- **Comparison Algorithm (Python)**
    - Cosine Similarity Scoring
        - Based on posture instead of absolute position
    - Select correct user when more than one person detected in frame
        - Similarity Threshold: 70%+ (modifiable) to recognize user

- **Text to Speech Translation (Mozilla TTS on Python)**
    - Support multiple languages
    - Support high quality voice offline

Testing, Verification and Metrics

- **Gesture Comparison and Instruction Testing**
    - Ensure the requirements of accuracy is achieved
        - (80% - error detection, 80% - angle accuracy)
    - Angles – Elbow angle, Knee angle, Calf-Floor angle, Arm-body angle, Thigh-body angle, Head-body angle
- **Pipeline Testing**
    - Ensure the two pipeline are well connected from input to all backends
- **Latency Testing**
    - Ensure that the feedback is given with approximately 1 second latency after the input

Testing, Verification and Metrics

- **Input**
  - Real-time recognition – Taichi Beginner poses with intentional errors
    - Poses come from team members; use videos as tests if time allows
  - Customization – Images selected with obvious poses
- **Output & Verification**
  - Real-time recognition – Check if intentional errors match instructions
  - Customization – Check if the necessary data for real-time pipeline to use exist and can be used in the verification process for above
- **Risk Factor**
  - If Test FAIL – recheck the system pipeline and connections, debug comparison algorithm, ensure working solution for most cases
  - Log the pipeline to know which part of the application breaks

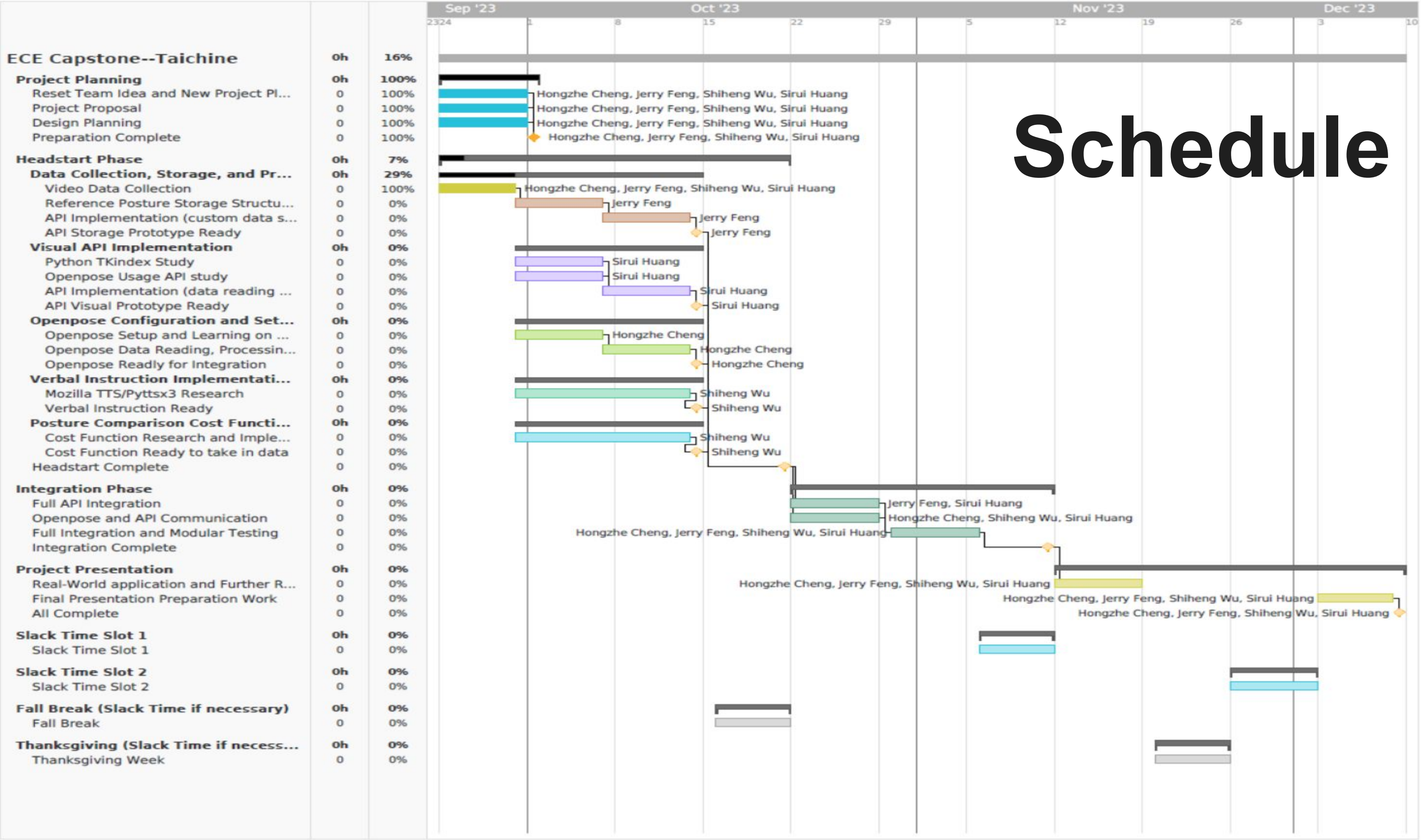
Tasks and Division of Labor

- **Hongzhe Cheng**
  - OpenPose Usage, Display setup
- **Sirui Huang**
  - Application Infrastructure on Posture Display, Data collection
- **Shiheng Wu**
  - Gesture comparison/Scoring algorithm, Verbal instruction
- **Jerry Feng**
  - Custom image’s pipeline and infrastructure, file storage system infrastructure

Stretch Goals:

- Dynamic Posture Instruction, 3D Openpose, Multi-Angle Integration, Cloud Storage

Schedule



ECE Capstone--Taichine	0h	16%
Project Planning	0h	100%
Reset Team Idea and New Project Pl...	0	100%
Project Proposal	0	100%
Design Planning	0	100%
Preparation Complete	0	100%
Headstart Phase	0h	7%
Data Collection, Storage, and Pr...	0h	29%
Video Data Collection	0	100%
Reference Posture Storage Structu...	0	0%
API Implementation (custom data s...	0	0%
API Storage Prototype Ready	0	0%
Visual API Implementation	0h	0%
Python TKindex Study	0	0%
Openpose Usage API study	0	0%
API Implementation (data reading ...	0	0%
API Visual Prototype Ready	0	0%
Openpose Configuration and Set...	0h	0%
Openpose Setup and Learning on ...	0	0%
Openpose Data Reading, Processin...	0	0%
Openpose Readly for Integration	0	0%
Verbal Instruction Implementati...	0h	0%
Mozilla TTS/Pyttsx3 Research	0	0%
Verbal Instruction Ready	0	0%
Posture Comparison Cost Functi...	0h	0%
Cost Function Research and Imple...	0	0%
Cost Function Ready to take in data	0	0%
Headstart Complete	0	0%
Integration Phase	0h	0%
Full API Integration	0	0%
Openpose and API Communication	0	0%
Full Integration and Modular Testing	0	0%
Integration Complete	0	0%
Project Presentation	0h	0%
Real-World application and Further R...	0	0%
Final Presentation Preparation Work	0	0%
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Fall Break (Slack Time if necessary)	0h	0%
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Thanksgiving (Slack Time if necess...	0h	0%
Thanksgiving Week	0	0%

Sep '23
Oct '23
Nov '23
Dec '23
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