Mines Field Session: SwingLens Video Capture System

Summer 2025

Company Background

SwingLens is an early stage startup focused on automatic analysis of tennis swings using machine learning approaches. It strives to make tennis more accessible to the masses by allowing athletes to improve their tennis swing using a simple mobile app. The company advisor is Peter Laird, an architect at Salesforce.

Project Description

SwingLens needs a team to build a video capture system. This system will capture video footage of model athletes performing tennis swings. The videos will be used to train the AI models, which is being worked on in a second field session.

Part 1: On Court Video Capture
Each swing is captured by up to 8 cameras placed on tripods on the tennis court. Each camera has a different angle relative to the athlete. The camera feeds are captured within [Open Broadcasting System](), a video capture application, as 8 rectangles in a single video feed. Capturing all angles in a single video feed ensures that the video feeds are aligned temporally and allows the operator's job easier. Using the OBS user interface, the operator verifies the camera feeds are working, and starts and stops the video recording. Within a single recording, many tennis swings of the same type will be recorded in a single video file.

Figure: athlete still frame from a single camera angle, with *pose estimation* lines drawn

The team will need to develop expertise in video capture hardware and the OBS software. Are the chosen cameras reliable? How can an operator be sure they are capturing video with sufficient frame rate and quality in OBS? Are there bugs in OBS that need to be avoided? Can 8 cameras overwhelm the USB 3.0 hub or laptop?

The output of this part will be a user manual for the operator and preset templates for OBS.

Part 2: On-Court Video Processing
Each swing video file will be post-processed and stored locally on the laptop while on-court. The operator will have a GUI application to process each video file after recording. The on-court application will support:
- Storing the metadata for the video file, such as player details (right-handed, intermediate ability, age, etc), swing details (top-spin, forehand, ground-stroke, etc), ball flight (top-spin, low height), footwork (both feet planted, right foot planted, etc) and other metadata.
- Splicing the raw video file in multiple ways.
  - First, each swing must be identified and split. This is typically done by using a microphone to detect the impact of the ball with the racquet, and then taking a predetermined amount of frames before and after the impact.
  - Second, the video feed will contain up to 8 camera angles as rectangles, each angle must be separated into an individual video file.
- For each swing video:
  - Run Pose Estimation on each video to add pose lines, and export human motion data as CSV files. This sounds difficult, but there is a packaged solution for this (MoveNet model in Tensorflow) that has proven effective.
- Additional processing may be implemented (as time allows in the Field Session), including:
  - Centering the athlete in the frame and cropping the video.
  - Creating downsampled lower resolution variants.
  - Masking the background (trees, fence, other people, etc)
- The on-court GUI tool will write the outputs to the local file system of the laptop.
- It will have automated tests (unit, functional)

Part 3: Off-Court Data Management
A second off-court software application will be written to upload the captured outputs of the on-court system. This will typically be done in batch, when the laptop is back home and connected to good wifi.
- This can be a simple command line application. It will iterate through all of the captured data and upload the videos to AWS S3 and record the metadata and CSV data in the cloud database.
- It will have features such as:
  - It must authenticate with AWS.
  - It must have good error handling capabilities, such that it will handle retries and alert the user if some data could not be uploaded.
  - It will be mindful and resilient to handle cases where the same data is being uploaded multiple times (replace, ignore, etc)
  - It will have automated tests (unit, functional, integration)

Part 4: Integration Testing
Once the three systems are built and tested, some real world testing will be done. The data collected during integration testing will not be "real". Meaning, the team will not need to

capture thousands of swings with different swing parameters. The goal of integration testing will be to verify the system works as expected, such that real data collection can begin after the field session ends.

Technologies

- Digital video capture hardware and software (OBS, USB connected cameras)
- Python software development
    - User interface design and implementation (e.g. React, Next.js)
    - Video stream processing
    - Database connectivity
- GUI design and implementation (React)
- Amazon Web Services (AWS)
- Database design and implementation (e.g. DynamoDB, S3)

Logistics

- This is a team project for up to four students.
- We will meet virtually multiple times per week to discuss progress, and in-person based on availability.
    - For some of the session, the project sponsor will be traveling abroad and will only be available remotely.
- SwingLens may have paid internships available after the Field Session completes.

This field session is one of two for SwingLens this summer. The other session will use the data captured in this field session to perform swing fault analysis. This creates a sequencing problem, as the other project will not have a complete set of data to work from at the start. Instead, the other project team will have a limited data set produced for the prototype. This data set contains 24 swings of each category (model swing, each swing fault), a single swing type, with a single camera angle.

As this project progresses, this team may be able to provide a more complete data set for use in the training of the models in the other field session. It will be helpful to keep in contact with the other team to arrange to ship more data to them as it becomes available.

Intellectual Property

Students will not be required to sign an NDA. Students will be able to showcase their work in future job applications. However, all intellectual property shall be retained by SwingLens LLC.