Boston University
Electrical & Computer Engineering
EC464 Capstone Senior Design Project

User's Manual

SwingOn

Submitted to

Professor Martin Herbordt
8 St. Mary's St Boston, MA 02215
Room 333
(617) 353-9850
herbordt@bu.edu

by

Team # 20
SwingOn

Team Members

Tingru Lian tinalian@bu.edu
Yoel Beyene yoelb@bu.edu
Jessica Martinez Marquez jessmtzm@bu.edu
Hanlin Mai hanlinm@bu.edu

Submitted: Apr 18, 2022

SwingOn User's Manual

Table of Contents

Executive Summary

Golf is a difficult sport to learn without proper or personalized training, which leads many beginner golfers to leave the sport. In addition, most golf swing training aids focus on the trajectory of the golf ball. Although these aids are helpful, they cannot help users improve their balance and consistency. SwingOn aims to give users a way to improve their swing in ways that other training aids fail to do.

SwingOn is a smartphone iOS-based app that tracks the motion of the golfers. Users of the app are able to receive feedback on their swing in real time as well as via videos uploaded to the app.

1 Introduction

Golf is expensive because it requires fees for golf courses. Especially for beginners, who require more time to learn the correct swing technique in practice sessions. Golf as a whole has become a “dying sport” in recent times, between 2003 and 2018, golf saw a decline of over 6.8 million players and more than 1,200 course closures. These numbers worsened severely once the Covid-19 pandemic began, as it led to many more courses being closed. For this reason, a simpler and more readily accessible option was needed. Most golf swing improvers in the market focus on the trajectory of the ball flight and the static elements of the golf swing such as the grip and basic golf stance. These approaches do not provide the necessary tools to improve a golfer’s fundamental skills — balance and consistency.

The SwingOn smartphone app tracks the motion of the golfers, so they can analyze their swing and receive feedback conveniently on the golf course or driving range. The analysis is performed in real-time on live and pre-recorded videos uploaded from the user’s Photo Library or iCloud Files. The SwingOn app uses pre-trained machine learning models to detect and draw the golfer’s body points. These points are used to compute their centroid and measure their balance. Instant feedback will also be provided after analysis to give the user better insight into improving their swing in the future. SwingOn was created to make golf more accessible for people of all backgrounds and experience levels.

This document is the detailed description of the SwingOn App, including its installation, user interface, and operation.

2 System Overview and Installation

2.1 Block Diagram Overview

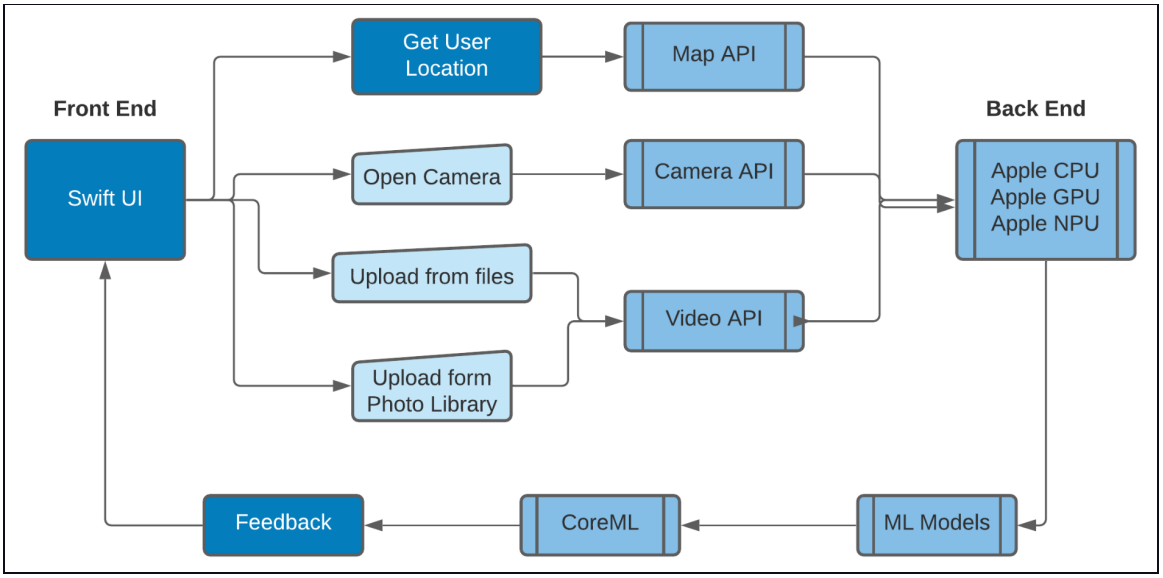

figure 2.1 System Overview of the SwingOn App

The app uses the programming language Swift because it can natively utilize the CPU, GPU, and NPU of Apple devices. It can also establish a stable and efficient connection between the user interface and machine learning models. Block diagram *Fig 2.1* illustrates the relationships of the app's principal modules and functions.

2.2 User Interface

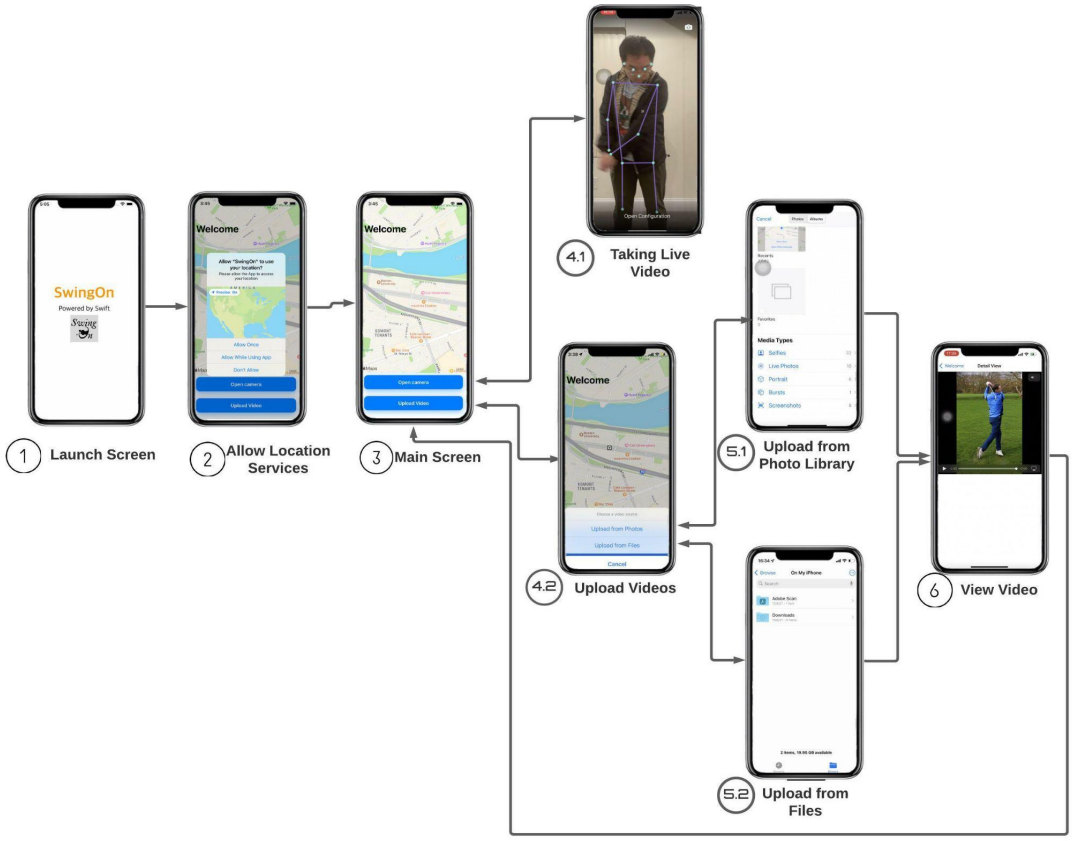

Figure 2.2 User Interface of the SwingOn App

Figure 2.2 shows the user interface consisting of 8 screens.

SwiftUI is the user interface framework for Swift which allows the app to present a stack of views in a navigation hierarchy. Buttons perform navigation by linking with a destination view. To traverse a collection of views, users can navigate to their desired destination by selecting different buttons on the screen as well as return to the previous screen.

When users open the app, a launch screen with the logo appears. MapKit is used to display a map and get the users' location. Users need to authorize location services in order for SwingOn to use their location when first entering the app. The location services must be enabled for the phone, which they can turn on in Settings > Privacy. Users can

also change their choices in Settings > Privacy > Location Services > SwingOn.

From the main screen, users have two options to choose from. The first option is “Open Camera,” which is connected to the Camera API that uses AVFoundation. AVFoundation is a Swift multimedia framework that allows access to all the media devices on the iPhone. It combines six major technology areas for capturing, processing, synthesizing, controlling, importing, and exporting audiovisual media on Apple platforms. AVCaptureSession is an object in the framework that allows management of capture activity as well as coordination of the flow of data from input devices to capture outputs. AVCaptureVideoDataOutput is another framework that allows access to video buffers from a live camera for processing.

The second option on the main page view is “Upload Video.” Users can choose whether they want to “Upload from Files” or “Upload from Photo Library.” Both buttons are connected to the Video API. The videos can be viewed using AVPlayerControl in portrait and landscape mode. AVPlayer can display the video content from a player object, which allows playback controls, such as playing and pausing the video.

All these APIs connect to the backend for video analysis. We use the PoseNet Tensorflow pre-trained model for human body pose detection. It takes a video buffer as the input and outputs a BodyPoseObservation with information about 17 key body points, each with a confidence score between 0.0 and 1.0 indicating the probability that a keypoint exists. Our algorithm calculated centroid based on the body points in order to see if a user is in balance. For better visualization, circles are drawn for the joints and the lines between the joints are then connected. The centroid of the golfer is drawn on both live and recorded videos.

2.3 Physical Description

The product only contains a software component and does not have a hardware component. For best results, it is recommended to use a tripod, not included, to steady the phone.

2.4 Installation, Setup, and Support

This app can only be used on iOS devices. The setup consists of connecting the iPhone to a macOS computer to install the App, building the SwingOn project on XCode13, and downloading it on the iPhone. In the future, the SwingOn app will be published on the App Store so it is easier for users to download. When first opening the App, permission will be asked to access location services, camera, photo library, and iCloud files. Customers can change the permission in Settings > Privacy.

3 Operation of the Project

3.1 Operating Mode 1: Normal Operation

In a normal operating mode, the user will run the SwingOn App on their iPhone.

1. The user places the iPhone on the tripod.
2. The SwingOn App opens a map, where the user will be asked to allow their location to be tracked.
3. The user chooses the “Open Camera” button, where they will be asked to allow the App to access their camera.
    3.1. The phone’s camera will open and the App will display the body points of golfers in real time.
4. The user chooses the “Upload Video” button, where they will be asked to allow the App to access their iCloud Files and Photo Library.
5. Once the video/swing is complete, the App will save the video to the user’s Photo Library or Files.

3.2 Operating Mode 2: Abnormal Operations

Abnormal operations include the map not displaying a location/correct location, the camera not opening, body points not being accurately placed, and swings not being recognized. To fix the map issue, ensure that location services are enabled in Settings > SwingOn > Location > While Using the App, and if needed restart the app. To fix the camera issue, a simple application restart will work (double-tap the home button and swipe up on the application screen), or go to Settings > SwingOn > Allow Camera.

Because this app is based on human joint detection, having a background with many people will increase the error of wrong detection. So to fix the body point/swing issue, having a clear background that is not too busy/moving will help reduce the chance of a miscalculation/error.

3.3 Safety Issues

There are no data security issues found because all the data is stored locally in the iOS device. However, data loss is possible if the video has not been saved to the Photo Library or iCloud Files when the device runs out of battery. Since the project consists of software, there will not be any physical danger caused by the misuse of operators. However, be wary of surroundings when taking a swing, making sure no objects or people are nearby.

4 Technical Background

4.1 Software

SwingOn uses Xcode13 as its development tool and Swift for its programming language. The user interface is developed with SwiftUI, a declarative framework that allows the presentation of a vertical stack of views in a navigation hierarchy. Swift and SwiftUI allow the creation of applications with modern features and stable designs, since the system handles all possible interruptions.

4.2 PoseNet

PoseNet is a Tensorflow pre-trained model that performs pose estimation and detects 17 body key-points:

1. Nose
2. Left and right eye
3. Left and right ear
4. Left and right shoulder
5. Left and right elbow
6. Left and right wrist
7. Left and right hip
8. Left and right knee
9. Left and right ankle

For the purpose of this app, the left and right shoulders and the left and right hips are used to calculate the centroid and the degree hip rotation.

4.3 GPU

GPUs are the most widely available accelerators and provide a decent performance boost. They are very useful for analyzing high resolution videos as well as applying machine learning models.

4.4 AVFoundation

AVFoundation is an Apple framework that works with audiovisual assets, control device cameras, process audio, and configure system audio interactions.

4.5 AVPlayerControl

AVPlayerControl is an Apple framework that displays the video content from a player object, which allows playback controls, such as playing and pausing the video.

4.6 PhotoPickerModel

PhotoPickerModel is a framework that includes the view controllers updateUIViewController and makeCoordinator. The former updates the state of the specified view controller with new information from SwiftUI and the latter creates a custom instance that can communicate changes from our view controller to other parts of our user interface.

5 Relevant Engineering Standards

TABLE 1
ENGINEERING REQUIREMENTS

Requirement	Tasks
UI	Intuitive and user-friendly
Portability	A mobile APP for easier adoption by users
Video processing	User can take and upload videos
Body points	Body points being correctly detected
Balance	- Centroid of the golfer is correctly calculated. - Balanced swing is classified according to value threshold
Consistency	Detect whether golfers are consistent over time/number of swings
Give feedback	Feedback to the user are clearly displayed on the screen

6 Cost Breakdown

TABLE 2
COST BREAKDOWN

Project Costs for Production of Beta Version (Next Unit after Prototype)				
Item	Quantity	Description	Unit Cost	Extended Cost
App subscription fee	1	This subscription fee is for App maintenance and development.	$0.99/per month	$0
1 Tripod	1	Tripod to hold iPhone steady	$40	$40
			Beta Version-Total Cost	$0.99/per month

To use the App, users need to pay a monthly subscription fee of $0.99. This allows customers to cancel and resume their subscription at will. Users will get the first 3 months for free to try out the App. Afterward, they will be charged $0.99 on an auto-renewal service. The subscription fee does not include a tripod. However, users can purchase from us with the price of $40.

7 Appendices

7.1 Appendix A - Specifications

Requirement	Value, Range, Tolerance, Units
Device	iPhone 6s or newer
Software	iOS 15 or newer
Frame Rate	40fps

7.2 Appendix B – Team Information

Tina Lian - Senior at Boston University majoring in Computer Engineering and Psychology

Yoel Beyene - Senior at Boston University majoring in Electrical Engineering

Hanlin Mai - Senior at Boston University majoring in Computer Engineering

Jessica Martinez Marquez - Senior at Boston University majoring in Computer Engineering