

# Module Interface Specification for SFWRENG 4G06

## Capstone Design Project

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# 1 Revision History

Date	Notes
Jan 12	Add MIS for UI components
Jan 13	Add MIS for Media Control components, RTC Control components
Jan 14	Add MIS for Backend components
Jan 17	Revise before submission

## 2 Symbols, Abbreviations and Acronyms

Symbol	Description
MG	Module Guide
M	Module
MIS	Module Interface Specification
HTTP	Hypertext Transfer Protocol
OS	Operating System
STUN	Session Traversal Utilities for NAT - a type of server needed for setting up peer-to-peer connections
RTC	Real-Time Communication
SFU	Selective Forwarding Unit - A software unit that can selectively forward video streams
API	Application Programming Interface
SDP	Session Description Protocol
WebRTC	Web Real-Time Communication
CM	Center of Mass Annotation Module
HPE	Human Pose Estimation Annotation Module

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## 3 Introduction

The following document details the Module Interface Specifications for the MotionMingle application. Complementary documents include the Module Guide.

The full documentation and implementation can be found at [MotionMingle.git](https://github.com/MotionMingle/MotionMingle).

## 4 Notation

The following tables summarize the primitive data types, derived data types, and other derived data types from aiortc, av, aiohttp, React and Web APIs libraries that are used by MotionMingle.

The structure of the MIS for modules comes from [Hoffman and Strooper \(1995\)](#), with the addition that template modules have been adapted from [Ghezzi et al. \(2003\)](#). The mathematical notation comes from Chapter 3 of [Hoffman and Strooper \(1995\)](#). For instance, the symbol  $:=$  is used for a multiple assignment statement and conditional rules follow the form  $(c_1 \Rightarrow r_1 | c_2 \Rightarrow r_2 | \dots | c_n \Rightarrow r_n)$ .

### 4.1 Primitive Data Types

The following table summarizes the primitive data types used by MotionMingle.

Data Type	Notation	Description
character	char	a single symbol or digit
integer	$\mathbb{Z}$	a number without a fractional component in $(-\infty, \infty)$
natural number	$\mathbb{N}$	a number without a fractional component in $[1, \infty)$
real	$\mathbb{R}$	any number in $(-\infty, \infty)$
boolean	$\mathbb{B}$	a value of either True or False

The specification of MotionMingle uses some derived data types: sequences, strings, and tuples. Sequences are lists filled with elements of the same data type. Strings are sequences of characters. Tuples contain a list of values, potentially of different types. In addition, MotionMingle uses functions, which are defined by the data types of their inputs and outputs. Local functions are described by giving their type signature followed by their specification.

### 4.2 Data Types from Libraries

The following table summarizes the data types provided by external libraries and used by MotionMingle.

<b>Data Type</b>	<b>Notation</b>	<b>Description</b>
VideoStreamTrack	VideoStreamTrack	A dummy video track that reads green frames.
MediaRelay	MediaRelay	A media source that relays one or more tracks to multiple consumers.
RTCPeerConnection	RTCPeerConnection	An interface represents a WebRTC connection between the local computer and a remote peer.
MediaStreamTrack	MediaStreamTrack	A single media track within a media stream.
RTCSessionDescription	RTCSessionDescription	An interface describes the potential connection and how it's configured. Each RTCSessionDescription consists of a description type indicating which part of the offer or answer negotiation process it describes and of the SDP descriptor of the session
JSON	JSON	JavaScript Object Notation, it is a text-based open standard data interchange setup and only provides a data encoding specification.
RTCTrackEvent	RTCTrackEvent	An event triggered by adding a MediaStreamTrack
MediaStream	MediaStream	A stream of data that usually carries media data
HTMLVideoElement	HTMLVideoElement	A react type representation of the video element in Hypertext Markup Language
React.component	React.component	A independent and reusable bits of react code that outputs HTML elements

Table 1: Data types from libraries

## 5 Module Decomposition

The following table is taken directly from the Module Guide document for this project.

Level 1	Level 2
Hardware-Hiding Module	
	User Authentication Module
	Instructor View Module
	Practitioner View Module
Behaviour-Hiding Module	Annotation Configuration Module
	RTC Control Module
Software Decision Module	STUN Server Module
	App Module
	Video Transform Module
	Human Pose Estimation Annotation Module
	Center of Mass Annotation Module
	SFU Server Module

Table 2: Module Hierarchy

## 6 MIS of RTC Control Module

### 6.1 Module

RTCControl

### 6.2 Uses

Web APIs

STUN Server Module

### 6.3 Syntax

#### 6.3.1 Exported Constants

N/A

#### 6.3.2 Exported Access Programs

Name	In	Out	Exceptions
createPeerConnection	JSON	RTCPeerConnection	-
closeRemoteConnection	RTCPeerConnection	-	-
negotiate	RTCPeerConnection	-	-

### 6.4 Semantics

#### 6.4.1 State Variables

N/A

#### 6.4.2 Environment Variables

STUN\_SERVER\_ADDRESS: string — represents the address of the STUN server

SFU\_BROADCAST\_API: string — represents the API endpoint for SFU broadcast API

SFU\_CONSUME\_API: string — represents the API endpoint for SFU consume API

#### 6.4.3 Assumptions

SFU server and STUN servers are running in normal conditions.

#### 6.4.4 Access Routine Semantics

createPeerConnectionWith(config: JSON):

- transition: N/A

- output: `pc := RTCPeerConnection` — initializes a new `RTCPeerConnection` based on the given configuration.
- exception: N/A

`closeRemoteConneciton(pc: RTCPeerConnection):`

- transition: `pc.signalingState := closed` — closes peer connection and send a signal to the connected peer connection.
- output: N/A
- exception: N/A

`negotiate(pc: RTCPeerConnection):`

- transition:  
`pc.localDescription := RTCSessionDescriptionInit`  
`pc.remoteDescription := RTCSessionDescriptionInit`  
sets the local description of the peer connection to its generated SDP, and set the remote description of the peer connection to its received SDP from `SFU_BROADCAST_API`.
- output: N/A
- exception: N/A

`getRemoteStream(pc: RTCPeerConnection):`

- transition: `pc.event := getRemoteEvent(pc).streams`
- output: N/A
- exception: N/A

#### 6.4.5 Local Functions

`getRemoteEvent(pc: RTCPeerConnection):`

- transition: N/A
- output: `pc.event := RTCTrackEvent`
- exception: N/A

## 7 MIS of Media Control Module

### 7.1 Module

`MediaContorl`

## 7.2 Uses

Web APIs

## 7.3 Syntax

### 7.3.1 Exported Constants

N/A

### 7.3.2 Exported Access Programs

Name	In	Out	Exceptions
setMicEnabled	Boolean	-	-
setCameraEnabled	Boolean	-	-
getStream	-	MediaStream	-

## 7.4 Semantics

### 7.4.1 State Variables

isMicEnabled: Boolean

isCameraEnabled: Boolean

### 7.4.2 Environment Variables

Microphone

Camera

### 7.4.3 Assumptions

User's devices have a functioning screen, camera and microphone.

### 7.4.4 Access Routine Semantics

setMicEnabled(isEnabled: Boolean):

- transition: isMicEnabled := isEnabled
- output: N/A
- exception: N/A

## 8 MIS of Media Control Module

### 8.1 Module

MediaContorl

### 8.2 Uses

Web APIs

### 8.3 Syntax

#### 8.3.1 Exported Constants

N/A

#### 8.3.2 Exported Access Programs

Name	In	Out	Exceptions
setMicEnabled	Boolean	-	-
setCameraEnabled	Boolean	-	-
getStream	-	MediaStream	-

### 8.4 Semantics

#### 8.4.1 State Variables

isMicEnabled: Boolean

isCameraEnabled: Boolean

#### 8.4.2 Environment Variables

Microphone

Camera

#### 8.4.3 Assumptions

User's devices have a functioning screen, camera and microphone.

#### 8.4.4 Access Routine Semantics

setMicEnabled(isEnabled: Boolean):

- transition: isMicEnabled := isEnabled
- output: N/A

- exception: N/A

setCameraEnabled(isEnabled: Boolean):

- transition: isCameraEnabled := isEnabled
- output: N/A
- exception: N/A

getStream():

- transition: N/A
- output: returns the user media stream based on the state value isCameraEnabled and isMicEnabled
- exception: N/A

#### 8.4.5 Local Functions

N/A

## 9 MIS of Instructor View Module

### 9.1 Module

Instructor

### 9.2 Uses

Media Control Module

RTC Control Module

Annotation Configuration Module

React

Web APIs

### 9.3 Syntax

#### 9.3.1 Exported Constants

N/A

#### 9.3.2 Exported Access Programs

Name	In	Out	Exceptions
Instructor	-	React.component	-



## 9.4 Semantics

### 9.4.1 State Variables

remoteVideoRef: HTMLVideoElement

selfVideoRef: HTMLVideoElement

peerConnection: RTCPeerConnection

### 9.4.2 Environment Variables

Screen

### 9.4.3 Assumptions

User's devices have a functioning screen, camera and microphone.

### 9.4.4 Access Routine Semantics

Instructor():

- transition: N/A
- output: renders a react component of the instructor view page
- exception: N/A

### 9.4.5 Local Functions

setPeerConnection(pc: RTCPeerConnection):

- transition: peerConnection := pc
- output: N/A
- exception: N/A

getSelfVideo():

- transition:  
selfVideoRef.current.video.srcObject:= MediaControl.getStream()  
render video stream from the local camera to screen
- output: N/A
- exception: N/A

startRemoteSharing():

- transition: `peerConnection.addTrack := MediaControl.getStream()`
- output: N/A
- exception: N/A

`stopRemoteSharing()`:

- transition:
  - `remoteVideoRef.current.video.srcObject = null`
  - `peerConnection.close:= true`
  - stops the remote video on the user's screen and close the `RTCPeerConnection`
- output: N/A
- exception: N/A

`getRemoteVideo()`:

- transition: get remote video coming from the SFU server and render it on the user's screen.
- output: N/A
- exception: N/A

## 10 MIS of Practitioner View Module

### 10.1 Module

Practitioner

### 10.2 Uses

Media Control Module

RTC Control Module

Annotation Configuration Module

React

Web APIs

### 10.3 Syntax

#### 10.3.1 Exported Constants

N/A

### 10.3.2 Exported Access Programs

Name	In	Out	Exceptions
Practitioner	-	React.component	-

## 10.4 Semantics

### 10.4.1 State Variables

remoteVideoRef: HTMLVideoElement

peerConnection: RTCPeerConnection

### 10.4.2 Environment Variables

Screen

### 10.4.3 Assumptions

User's devices have a functioning screen.

### 10.4.4 Access Routine Semantics

N/A

### 10.4.5 Local Functions

setPeerConnection(pc: RTCPeerConnection):

- transition: peerConnection := pc
- output: N/A
- exception: N/A

getRemoteVideo():

- transition: get remote video coming from the SFU server and render it on the user's screen.
- output: N/A
- exception: N/A

## 11 MIS of Annotation Configuration Module

### 11.1 Module

AnnotationConfig

## 11.2 Uses

RTC Control Module

React

## 11.3 Syntax

### 11.3.1 Exported Constants

N/A

### 11.3.2 Exported Access Programs

Name	In	Out	Exceptions
setIsSkeletonEnabled	Boolean	-	-
setIsCOMEnabled	Boolean	-	-
getIsSkeletonEnable	-	Boolean	-
getIsCOMEnable	-	Boolean	-

## 11.4 Semantics

### 11.4.1 State Variables

isSkeletonEnabled: Boolean

isCOMEnabled: Boolean

### 11.4.2 Environment Variables

N/A

### 11.4.3 Assumptions

N/A

### 11.4.4 Access Routine Semantics

setIsSkeletonEnabled(isEnabled: Boolean):

- transition: isSkeletonEnabled := isEnabled
- output: N/A
- exception: N/A

setIsCOMEnabled(isEnabled: Boolean):

- transition: isCOMEnabled := isEnabled

- output: N/A
- exception: N/A

getIsSkeletonEnabled():

- transition: N/A
- output: isSkeletonEnabled
- exception: N/A

getIsCOMEnabled():

- transition: N/A
- output: isCOMEnabled
- exception: N/A

#### **11.4.5 Local Functions**

N/A

## **12 MIS of App Module**

### **12.1 Module**

App

### **12.2 Uses**

RTC Control Module

Media Control Module

Instructor View Module

Practitioner View Module

Annotation Configuration Module

User Authentication Module

### **12.3 Syntax**

#### **12.3.1 Exported Constants**

None

<b>Name</b>	<b>In</b>	<b>Out</b>	<b>Exceptions</b>
App	-	React.component	-

### **12.3.2 Exported Access Programs**

## **12.4 Semantics**

### **12.4.1 State Variables**

N/A

### **12.4.2 Environment Variables**

N/A

### **12.4.3 Assumptions**

N/A

### **12.4.4 Access Routine Semantics**

App():

- transition: App:= React.component()  
starts React App and render it on the user's device
- output: N/A
- exception: N/A

### **12.4.5 Local Functions**

N/A

## **13 MIS of User Authentication Module**

### **13.1 Module**

Auth

### **13.2 Uses**

Instructor View Module

Practitioner View Module

## 13.3 Syntax

### 13.3.1 Exported Constants

N/A

### 13.3.2 Exported Access Programs

Name	In	Out	Exceptions
Auth	-	React.component	-

## 13.4 Semantics

### 13.4.1 State Variables

isUserInstructor: Boolean

### 13.4.2 Environment Variables

N/A

### 13.4.3 Assumptions

N/A

### 13.4.4 Access Routine Semantics

Auth():

- transition: Render the authentication page on the user's device, if the user clicks on the Instructor button, then jumps to the instructor view page, if the user clicks on the practitioner button, jumps to the practitioner view page.
- output: N/A
- exception: N/A

### 13.4.5 Local Functions

isUserInstructor  $\rightarrow$  Instructor view else Practitioner view  
setIsUserInstructor(isEnabled: Boolean):

- transition: isUserInstructor := isEnabled
- output: N/A
- exception: N/A

## 14 MIS of Video Transform Module

### 14.1 Module

VideoTransformTrack

### 14.2 Uses

HPE, CM

### 14.3 Syntax

#### 14.3.1 Exported Constants

kind = “video”

#### 14.3.2 Exported Access Programs

Routine name	In	Out	Exceptions
<code>__init__</code>	track, transform	-	-
<code>recv</code>	-	VideoFrame	-

### 14.4 Semantics

#### 14.4.1 State Variables

track: VideoStreamTrack

transform: string

#### 14.4.2 Environment Variables

N/A

#### 14.4.3 Assumptions

`__init__` is called before any other access program

#### 14.4.4 Access Routine Semantics

`__init__(track, transform):`

- transition: initiated by track and transform, `self.track = track`, `self.transform = transform`



- output: `out := self`
- exception: N/A

`recv(self):`

- transition: Processes a video frame (`frame`) received from a track. Depending on the value of `self.transform`, it applies one of the following transformations:
  - “HPE”: Converts the frame by applying the HPE module annotation.
  - “CM”: Converts the frame by applying the CM module annotation.
  - If `self.transform` is set to any other value, the frame is returned without any transformation.
- output: Returns a new `VideoFrame` object (`new_frame`) that has undergone the specified transformation, preserving the original frames timing information (timestamps and time base).
- exception: N/A

#### **14.4.5 Local Functions**

N/A

## **15 MIS of SFU Server Module**

### **15.1 Module**

`SfuServer`

### **15.2 Uses**

`VideoTransformTrack`

### **15.3 Syntax**

#### **15.3.1 Exported Constants**

N/A

#### **15.3.2 Exported Access Programs**

### **15.4 Semantics**

#### **15.4.1 State Variables**

N/A

<b>Routine name</b>	<b>In</b>	<b>Out</b>	<b>Exceptions</b>
consumer	request	-	-
broadcast	request	-	-

### 15.4.2 Environment Variables

relay: MediaRelay  
 consumer\_track: VideoStreamTrack

### 15.4.3 Assumptions

N/A

### 15.4.4 Access Routine Semantics

consumer(request):

- transition: Processes a WebRTC connection request. The function performs the following actions:
  - Parses the request to extract session description parameters.
  - Creates a new RTCPeerConnection object.
  - Logs the information about the sent track.
  - Adds a VideoTransformTrack to the peer connection, which includes subscribing to a consumer track and applying a specified video transformation.
  - Sets the remote description of the peer connection based on the received session description.
  - Creates and sets a local description for the peer connection by generating an answer to the received offer.
- output: Returns a web response in JSON format. This response contains the SDP data and the type of the local description set on the peer connection.
- exception: N/A

broadcast(request):

- transition: Manages the setup and handling of a WebRTC peer connection for broadcasting.
  - Parses the incoming request to extract the SDP data.
  - Initializes a new RTCPeerConnection.
  - Adds the peer connection to a global set and logs relevant information.

- Sets up event handlers for different peer connection events:
  1. Connection State Change: Monitors the connection state, logging changes and closing the connection if it fails.
  2. Track Reception: Handles received tracks, particularly video tracks, by setting a global consumer\_track for later use, and logs when tracks end.
  3. Processes the received offer by setting it as the remote description of the peer connection.
  4. Creates and sets a local description for the peer connection in response to the offer.
- output: Returns a web response in JSON format, containing the SDP data and the type of the local description set on the peer connection.
- exception: N/A

#### **15.4.5 Local Functions**

N/A

## **16 MIS of Human Pose Estimation Annotation Module**

### **16.1 Module**

HPE

### **16.2 Uses**

Numpy, CV2, OS, Sys, Time, Subprocess, Shutil, Socket

### **16.3 Syntax**

#### **16.3.1 Exported Constants**

server\_address, HPE\_address, K, pose, Rt1, R1, t1, P1, Identity, P2

#### **16.3.2 Exported Access Programs**

### **16.4 Semantics**

#### **16.4.1 State Variables**

N/A

Name	In	Out	Exceptions
get_kpts	Image	List	IOError, ValueError
measureJoint	List, List	Tuple	N/A
matchKpts	List	List	N/A
get3D	List, List	List	N/A

### 16.4.2 Environment Variables

N/A

### 16.4.3 Assumptions

External libraries are functioning as expected

### 16.4.4 Access Routine Semantics

get\_kpts(img):

- transition: Saves the input image to a designated path and calls OpenPose to generate keypoints, which are then saved to a JSON file.
- output: Returns a list of keypoints extracted from the input image.
- exception: IOError if image saving or reading fails, ValueError if keypoints processing fails.

measureJoint(kpts1, kpts2):

- transition: Computes the length of the spine in each set of keypoints and returns them ordered by length.
- output: Returns a tuple with the first element being the keypoints set with the longer spine.
- exception: N/A

matchKpts(mirror\_img):

- transition: Reflects the keypoints from the mirror image to match the real image.
- output: Returns the adjusted keypoints for the mirrored image.
- exception: N/A

get3D(real\_kpts, mirror\_kpts):

- transition: Uses the keypoints from the real and mirror images to triangulate 3D points.
- output: Returns the 3D coordinates of the keypoints.
- exception: N/A

### 16.4.5 Local Functions

N/A

## 17 MIS of Center of Mass Annotation Module

### 17.1 Module

CM

### 17.2 Uses

numpy: for numerical computations

params.bodySegParams: for body segmentation parameters

params.cameraParams: for camera parameters

### 17.3 Syntax

#### 17.3.1 Exported Constants

K, pose, P1, P2, R1, t1, R2, t2 - Camera intrinsic and extrinsic parameters, and projection matrices derived from them.

foot\_in\_air\_thresh - Threshold for determining if a foot is in the air. CoM\_foot\_thresh - Threshold for determining the supporting foot based on the center of mass.

#### 17.3.2 Exported Access Programs

Name	In	Out	Exceptions
getCoM	points_3D: 3D points array	CoM: Center of Mass point	-
feetStates	CoM: Center of Mass point points_3D: 3D points array	left_foot, right_foot: States of the feet	-

### 17.4 Semantics

#### 17.4.1 State Variables

N/A

#### 17.4.2 Environment Variables

N/A

### 17.4.3 Assumptions

The module assumes that body segment parameters and camera calibration data provided by the bodySegParams and cameraParams modules are accurate and reliable.

### 17.4.4 Access Routine Semantics

getCoM(points\_3D):

- transition: Calculates the center of mass based on the 3D points of body joints.
- output: Returns the 3D coordinates of the bodys center of mass.
- exception: N/A

feetStates(CoM, points\_3D):

- transition: Determines the state of each foot (left and right) based on their position relative to the center of mass and the vertical distance from the ground.
- output: Returns a tuple containing two dictionaries, left\_foot and right\_foot, each indicating whether the respective foot is on the ground and whether it is supporting body weight.
- exception: N/A

### 17.4.5 Local Functions

N/A

## 18 MIS of STUN Server Module

### 18.1 Module

STUN

### 18.2 Uses

N/A

### 18.3 Syntax

#### 18.3.1 Exported Constants

STUN\_SERVER\_ADDRESS

### **18.3.2 Exported Access Programs**

N/A

## **18.4 Semantics**

### **18.4.1 State Variables**

N/A

### **18.4.2 Environment Variables**

N/A

### **18.4.3 Assumptions**

The module assumes that a public STUN server is readily available.

### **18.4.4 Access Routine Semantics**

N/A

### **18.4.5 Local Functions**

N/A

## References

- Carlo Ghezzi, Mehdi Jazayeri, and Dino Mandrioli. *Fundamentals of Software Engineering*. Prentice Hall, Upper Saddle River, NJ, USA, 2nd edition, 2003.
- Daniel M. Hoffman and Paul A. Strooper. *Software Design, Automated Testing, and Maintenance: A Practical Approach*. International Thomson Computer Press, New York, NY, USA, 1995. URL <http://citeseer.ist.psu.edu/428727.html>.



## 19 Appendix

[Extra information if required —SS]