

McMASTER UNIVERSITY

SMARTSERVE

SOFTWARE & MECHATRONICS CAPSTONE

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# Low Level System Design

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<b>Date</b>	<b>Revision</b>	<b>Comments</b>	<b>Author(s)</b>
Dec 29, 2017	1.0	Structure made for document including headings	Christopher McDonald
Jan 11, 2018	1.1	Added content for ShotRecommendation and SmartServe systems, and Communication Protocols Sections	Christopher McDonald
Jan 11, 2018	1.2	Added content for Document Overview	Christopher McDonald
Jan 12, 2018	1.3	Added Data Storage and User Interface modules	Sharon Platkin
Jan 13, 2018	1.4	Added details for Shooting Mech, CV, Shot Optimizer, Shooting Model subsystems	Harit Patel & Sam Hamel

Figure 1: Revision History

# 1 Introduction

## 1.1 Project Overview

SmartServe is an autonomous table tennis training system for table tennis players with various skill levels. SmartServe aids in diagnosing and improving a player's performance over time. The system trains table tennis players by shooting table tennis balls towards the player and detects successful returns from the player. The system can further adapt to the player's weaknesses and help them overcome it through further training. Importantly, SmartServe alleviates the problems of finding and working with a coach for players, as well as coaches trying to train multiple players simultaneously. The system will be deemed a success if the table tennis players and coaches can enjoy and see some value added by using SmartServe.

The project started at the beginning of the Fall 2017 academic term and will conclude at the end of the Winter 2018 term. In addition, the core project team consists of final year Software and Mechatronics Engineering students who are enrolled in the MECHTRON 4TB6/SFWRENG 4G06 capstone project course.

## 1.2 Document Overview

This document will add more detail into the subsystems introduced in the High-Level System Design document (HLSD) found [here](#). The HLSD omitted details such as how the subsystems would work, how they are built and how communication will be handled between them. This document will cover all of those details and introduce how each subsystem will be programmed by defining the language and libraries required.

All software developers on the development team should read this document when building the subsystems to ensure the correct data is being sent and communication portals are set up correctly. Each subsystem will hold one to many modules and each module will contain one to many methods or variables. A detailed class diagram will organize all the subsystems and their modules with arrows indicating which module uses another one.

## 1.3 Naming Conventions and Terminology

The following terms and definitions will be used throughout this document:

- **ACID**: a database transaction which is atomic, consistent, isolated and durable
- **ADT**: abstract data type
- **CV**: computer vision
- **FPS**: frames per second

- **FSM:** finite state machine, shows transitions between states
- **GUI:** graphical user interface
- **IPO:** input process output
- **Pitch:** rotation along the y-axis; this rotation angle primarily dictates the range of the ball from the net to the edge of the table on the user side
- **Roll:** rotation along the x-axis
- **Shooting Mechanism:** refers to the part of the system that shoots the table tennis balls towards the user side (player) Please refer to Figure 2 for visual illustration
- **System:** encompasses both the hardware and software parts of SmartServe
- **System Side:** the side of the table where the electromechanical system is placed; it is the opposite side of the User Side Please refer to Figure 2 for visual illustration
- **TCP:** transmission control protocol
- **Team:** all team members of the core capstone project, as noted in the list of Authors
- **UI:** user interface
- **User Side:** the side of the table where the user (player) is standing
- **Yaw:** rotation along the z-axis; this rotation angle primarily dictates the panning functionality of the shooting mechanism from the right side to the left side of the table

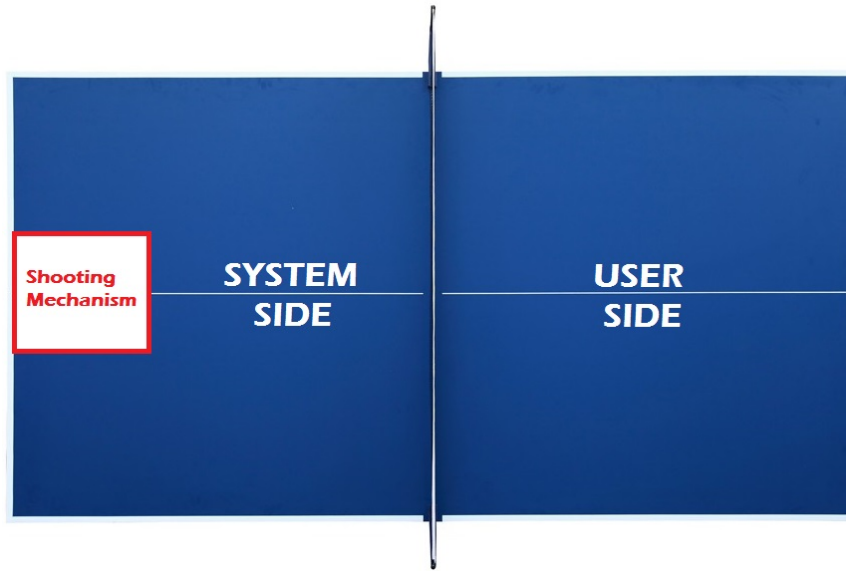


Figure 2: Top View of the Tennis Table

## 2 Detailed Class Diagram

## 3 Module Guide

### 3.1 SmartServe Modules

#### Controller

##### Responsibilities

The controller handles all the timing constraints and sequential events for shooting balls towards the player. It is the interface for the UI to allow the user to perform any and all actions.

##### Secrets

The sequence and timing constraints of the shooting procedure.

##### MID

- **boot** - none  
returns: *boolean*  
description: instantiates all dependencies and ensures services are working as expected

- **startTraining** - Mode m  
returns: *boolean*  
description: starts the shooting procedure given a certain training Mode
- **stopTraining** - none  
returns: *boolean*  
description: stops the training procedure
- **setShootingParameters** - ShootingParameters sp  
returns: *boolean*  
description: sets the shooting parameters for certain table sizes

## ArduinoConnector

### Responsibilities

This module is responsible for facilitating the communication with the Arduino which is part of the Shooting Mechanism subsystem. This includes sending and receiving messages as well as ensuring proper testing of the connection is preformed.

### Secrets

The connection to the Arduino.

## MID

- **test** - int port  
returns: *boolean*  
description: tests connection to the Arduino
- **shoot** - float pitch, float yaw, float angularVelocity  
returns: *none*  
description: instructs Arduino to shoot the ball in a certain way
- **position** - none  
returns: *Position*  
description: returns the position of the mechanism

## ShotRecommendationConnector

### Responsibilities

This module is responsible for facilitating the communication with the Shot Recommender subsystem. This includes sending and receiving messages as well as ensuring proper testing of the connection is preformed.

## Secrets

The connection to the Shot Recommender.

## MID

- **connect** - int port, [optional] String ip  
returns: *boolean*  
description: instantiates all dependancies and ensures services are working as expected
- **getRecommendation** - none  
returns: *Shot*  
description: returns the shot data to shoot towards the player
- **updateModel** - Shot shot, boolean returned  
returns: *none*  
description: sends data to ShotRecommender on whether a shot was returned or not

## CVConnector

### Responsibilities

This module is responsible for facilitating the communication with the CV (Computer Vision) subsystem. This includes sending and receiving messages as well as ensuring proper testing of the connection is preformed.

## Secrets

The connection to the CV system.

## MID

- **connect** - int port  
returns: *boolean*  
description: tests connection to CV subsystem
- **start** - none  
returns: *boolean*  
description: instructs CV to begin tracking and return data for shot

## SQLConnector

### Responsibilities

This module is responsible for facilitating the communication with the Data Storage subsystem. This includes sending and receiving messages as well as ensuring proper testing of



the connection is preformed.

### Secrets

The connection to the Data Storage system.

### MID

- **connect** - int port, [optional] String ip  
returns: *boolean*  
description: tests connection to Data Storage subsystem on port *port* at the IP Address *ip* or *localhost* if ip is unavailable
- **query** - String procedure, Map<String, String> values  
returns: *ResultSet*  
description: returns data from database based on procedure ran and values given
- **save** - String procedure, Map<String, String> values  
returns: *boolean*  
description: returns success information on write to database based on procedure ran and values given

## 3.2 Shot Recommendation Modules

### Controller

#### Responsibilities

This module will act as the API interface for the Shot Recommendation subsystem. As such, it will accept requests and return the appropriate data. It will also communicate with other modules should a user of this system need to do so.

### Secrets

The process for handling Shot Recommendation requests.

### MID

- **listen** - none  
returns: *none*  
description: waits for a request made for a shot
- **query** - String procedure, dict values, [optional] int port, [optional] String ip  
returns: *Cursor*  
description: gets data from a stored procedure using some set of values for a MySQL instance on port *port* at the IP Address *ip*

## Model

### Responsibilities

This module will hold the data for each user in such a way information can be extracted. It will contain an internal model which is built from the data and use it to recommend a new shot.

### Secrets

The algorithm to build the model.

### MID

- **Model `model`** - representation of shot performance data for extracting information
- **`train`** - Cursor cur  
returns: *none*  
description: using some data from Cursor, this will train the model
- **`next`** - none  
returns: *Shot*  
description: returns a shot based on the user's past performance

## 3.3 Shooting Model Modules

### Shooting Details

#### Responsibilities

Specific details (such as yaw and speed) that are required to take the desired shot are stored within this abstract data type module.

#### Secrets

None

#### MID

- **`shootingDetails`** - double yaw, double velocity  
returns: *none*  
description: constructor to store the shooting model details in an abstract data type.
- **`toString`** - none  
returns: *String*  
description: Returns shooting details in a printable string format.

## Shooting Model

### Responsibilities

Responsible for mapping a desired shot to the details needed to take the shot.

### Secrets

Methods and formulas being used to identify the required details needed to take the desired shot.

### MID

- **shootingModel** - double initialHeight, double xInitialHeight, double pitch  
returns: *none*  
description: instantiates the shooting model subsystem.
- **getShootingDetails** - double landingXCoord, double landingYCoord  
returns: *ShootingDetails*  
description: calculates details to take the desired shot and stores them within the ADT.

## 3.4 Shot Optimizer Modules

### Controller

#### Responsibilities

This module is responsible for facilitating the communication with the Shot Optimizer system. This includes sending and receiving messages as well as ensuring proper testing of the connection is performed.

#### Secrets

The connection to the Shot Optimizer system.

### MID

- **connect** - int port, [optional] String ip  
returns: *boolean*  
description: instantiates all dependancies and ensures services are working as expected.
- **getOrientation** - Position position  
returns: *Orientation*  
description: returns the optimal orientation data to orient the shooting mechanism.

### 3.5 Computer Vision Modules

#### Detect

##### Responsibilities

This module detects successful returns from the user, and sends that data to smartserve

##### Secrets

Success criteria of returns

How the camera feed is analyzed

##### MID

- **Detect** - Camera Capture cap  
returns: *none*  
description: Detects if the ball was successfully returned by the user and calls the Send function
- **Send** - none  
returns: *none*  
description: Sends a signal to Smartserve indicating that a successful return was made

### 3.6 Data Storage Modules

#### Global

##### Responsibilities

Communicates with the database to create, delete and update rows in various tables.

##### Secrets

All connection information between the sub-systems, table contents.

##### MID

- User **user** - String user\_name, String password, int user\_id  
description: representation of a user
- Shot **shotType** - int zone\_id, int omega\_id, int shot\_id  
description: representation of a shot type
- Zone **user** - int zone\_id, double x\_loc, double y\_loc  
description: representation of a zone on the table, used as a look up table
- Omega **user** - int omega\_id, double angle, double velocity  
description: representation of angular velocity of the ball, used as a look up table

- **ReturnRate** **return\_rate** - int user\_id, int shot\_id, Timestamp timeStamp, boolean returned  
description: return statistics for each user
- **signUp** - String userName, String password  
returns: *none*  
description: adds a user row to the *User* table
- **nextShot** - int zone  
returns: *Shot*  
description: determines which shot type to perform
- **returned** - Timestamp timeStamp, User user, Shot shot  
returns: *none*  
description: updates returnRate table for user for performance statistics

### 3.7 Shooting Mechanism Modules

This module will be specified in the hardware component design of the shooting mechanism.

### 3.8 User Interface Modules

#### Controller

#### Responsibilities

Responsible for translating the desired action of the user from the View module to the SmartServe module.

#### Secrets

Connection between modules and sub-systems.

#### MID

- **main** - String args[]  
returns: *none*  
description: calls the View module to initialize the UI
- **setTrainingMode** - Mode m  
returns: *none*  
description: sets mode from View module and sends it to SmartServe
- **setShootingParameters** - none  
returns: *ShootingParameters*  
description: sets shooting parameters from View module and sends it to SmartServe

- **setStatistics** - none  
returns: *StatisticsParameters*  
description: sets statistics parameters and sends them to View module
- **signUp** - User user  
returns *none*  
description: gets user information from view module and sends it to smartServe
- **login** - User user  
returns *boolean*  
description: gets user name and password from the View module and authenticates by calling SmartServe

## View

### Responsibilities

The view module will contain all the actual visual aspects of the system that the user will interact with. This includes text, pictures, buttons, etc.

### Secrets

The structure and implementation of the view.

## MID

- **start** - none  
returns: *none*  
description: general user interface code, called to initiate UI
- **selectMode** - MouseEvent  
returns: *Mode*  
description: listens for a mouse click on mode types, and returns that mode
- **calibrate** - none  
returns: *ShootingParameters*  
description: collects user input for table size in order to calibrate the system
- **startTrainingBtn** - MouseEvent  
returns: *boolean*  
description: listens for mouse click on start training button
- **stopTrainingBtn** - MouseEvent  
returns: *boolean*  
description: listens for mouse click on stop training button

- **viewStatsBtn** - MouseEvent  
returns: *none*  
description: listens for mouse click on statistics button and displays statistics to the user
- **signUpBtn** - MouseEvent  
returns: *User*  
description: listens for mouse click on sign up button and collects user information
- **loginBtn** - MouseEvent  
returns: *User*  
description: listens for mouse click on sign in button and displays profile if authenticated properly

## 4 Communication Protocols

### 4.1 Smart Serve to Shot Recommendation

The Shot Recommendation system (SR) will use Python to leverage machine learning libraries like SciKit Learn and the Smart Serve system (SS) will be implemented in Java. In order for the SS to communicate to the SR, it will make an HTTP request with some data and receive an HTTP response encoded using JSON. This allows the use of a reliable means of communication and flexibility to host the SR remotely if need be.

The SS will make a GET request to the SR for requesting a shot to use and can make POST request to give data regarding whether a shot was returned or not. In the event the HTTP request takes too long, the SS should handle it accordingly by timing out and using random shots or continuing the program.

HTTP libraries are standard in Java and a microframework for handling HTTP requests can be used for Python like flask.

### 4.2 Smart Serve to Shooting Mechanism

The Shooting Mechanism system (SM) will implement an interface using an Arduino. The SS will use libraries for communicating to the Arduino to communicate to the SM which can be found here for 64-bit Windows and Linux installations and here for 64-bit macOS installations. The SS does not need a response from the system, as it will tell the SM where to shoot and how to do so but does not need a response.

### **4.3 Smart Serve to Computer Vision**

The SS will communicate to the Computer Vision subsystem (CV) via sockets over the TCP protocol using the Java Networking libraries and the Python socket libraries. The SS will initiate the communication to start tracking and expect a return value based on whether it was returned or not. The SS will timeout in the event the CV does not return a value after 1.5 seconds.

### **4.4 Smart Serve to User Interface**

The SS and the User Interface system (UI) will both be programmed using Java. The UI system can interface with the SS by calling exposed public methods based on user input.

### **4.5 Smart Serve to Shot Optimizer**

The SS and the Shot Optimizer system (SO) will both be programmed using Java. The SS system can interface with the SO by calling exposed public methods based on user input.

### **4.6 Smart Serve to Shooting Model**

The SS and the Shooting Model system (SModel) will both be programmed using Java. The SS system can interface with the SModel by calling exposed public methods based on user input.

### **4.7 Smart Serve to Data Storage**

The SS is programmed in Java and the Data Storage system (DS) will be implemented using Stored Procedures held in a MySQL database instance. In order for the SS to use the DS, a SQLConnector can be used to do so.

### **4.8 Shot Recommendation to Data Storage**

The SR is programmed in Python and the Data Storage system (DS) will be implemented using Stored Procedures held in a MySQL database instance. In order for the SR to use the DS, a SQLConnector can be used to do so.