McMaster University

SmartServe

Software & Mechatronics Capstone

Verification and Validation

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Contents

1 Executive Summary of Testing **2**

2 Introduction **2**
2.1 Project Overview 2
2.2 Document Overview 2
2.3 Naming Conventions and Terminology 2

3 Testing Philosophy **3**
3.1 Approach 3
3.2 Schedule 4
3.3 Environment 4

4 Test Cases **5**
4.1 Electromechanical Subsystems 5
4.1.1 Shooting Mechanism 5
4.2 Software Subsystems 5
4.2.1 Computer Vision 5
4.2.2 ShotRecommender 10
4.2.3 Shooting Model 13
4.2.4 Data Storage 14
4.2.5 User Interface 14
4.2.6 SmartServe 14

5 Test Case-Requirement Traceability Matrix **25**

List of Figures

1 Revision History 1

Date	Revision	Comments	Author(s)
Feb 1, 2018	1.0	Document structure and Headings	Christopher MCDonald

Figure 1: Revision History

1 Executive Summary of Testing

2 Introduction

2.1 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.

2.2 Document Overview

This document will provide details of all formal testing methods and results performed on the SmartServe system. The first part of testing includes detailing how it will be performed and the details of the system on which it is run. This matters due to details which can affect the testing outcomes like operating system, lighting or performance of hardware. The schedule for the test will also be detailed alongside the major deliverables to have clear outcomes to explain to stakeholders. The testing will be preformed off of the *master* branch as it stands during the beginning of the testing phase.

The actual testing will then be detailed as test cases based on what subsystem they are testing. As needed, the communication will be tested in between the subsystems to ensure communication is working as intended. Lastly, a test case-requirement matrix will be provided which maps what test cases test which requirement. This will give the reader a simple way to check if a requirement is fully satisfied.

2.3 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

- **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 **??** 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 **??** for visual illustration
- **TCP:** transmission control protocol
- **Team**: all team members of the core capstone project, as noted in the list of Authors
- **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

3 Testing Philosophy

3.1 Approach

The approach to testing will be to separate the subsystems as much as possible and test them accordingly. Every subsystem will be unit tested in JUnit or PyUnit if implemented in Java or Python respectively. The shooting mechanism will be tested manually to ensure it is functional properly. Stubbing a service or dependancy can be done to return consistent, reliable and predictable results. For instance, the SmartServe system may use a stub for the CV subsystem to return a predefined sequence of pass/fail flags.

3.2 Schedule

Table 1: Testing Schedule

Testing Schedule		
Task	**Date**	**Notes**
Complete Test Cases	February 13, 2018	N/A
Run Tests (First)	February 16, 2018	N/A
Edit Test Cases	March 9, 2018	N/A
Run Tests (Second)	March 16, 2018	N/A

3.3 Environment

The SmartServe system uses heavy computation power due to the CV and ML models, so the system which runs the test will have the following details. The system will be a 15-inch Macbook Pro (Late 2016) running macOS High Sierra (10.13). The Macbook Pro has an 2.6 GHz Intel Core i7 CPU and a Radeon Pro 450 2GB GPU. The location will be in Thode Makerspace where the CV will be adjusted as necessary for those lighting conditions.

4 Test Cases

4.1 Electromechanical Subsystems

4.1.1 Shooting Mechanism

4.2 Software Subsystems

4.2.1 Computer Vision

Test ID: CV1	**ball detection Test**	Status: ????
Description: Test to see if cv module detects the ball		
Pass/Fail Condition: fails if false is returned while ball is in frame		
Pre-Conditions: cvmodule successfully connects to camera and smartserve Input: N/A		
Expected Results: returns true while ball is in frame	Actual Results: ????	
Post-Conditions: N/A		

Table 2: ball detection Test

Test ID: CV2	**ball upward detection Test**	Status: ????
Description: Test to see if cv module detects the ball moving upwards		
Pass/Fail Condition: fails if false is returned while ball is moving upwards		
Pre-Conditions: cvmodule successfully connects to camera and smartserve, ball is being detected Input: N/A		
Expected Results: returns true while ball is moving upwards	Actual Results: ????	
Post-Conditions: N/A		

Table 3: ball upward detection Test

Test ID: CV3	**ball downward detection Test**	Status: ????
Description: Test to see if cv module detects the ball moving downwards		
Pass/Fail Condition: fails if false is returned while ball is moving downwards		
Pre-Conditions: cvmodule successfully connects to camera and smartserve, ball is being detected Input: N/A		
Expected Results: returns true while ball is moving downwards	Actual Results: ????	
Post-Conditions: N/A		

Table 4: ball downward detection Test

Test ID: CV4	**ball rightward detection Test**	Status: ????
Description: Test to see if cv module detects the ball moving rightwards		
Pass/Fail Condition: fails if false is returned while ball is moving rightwards		
Pre-Conditions: cvmodule successfully connects to camera and smartserve, ball is being detected Input: N/A		
Expected Results: returns true while ball is moving rightwards	Actual Results: ????	
Post-Conditions: N/A		

Table 5: ball rightward detection Test

Test ID: CV5	**ball leftward detection Test**	Status: ????
Description: Test to see if cv module detects the ball moving leftwards		
Pass/Fail Condition: fails if false is returned while ball is moving leftwards		
Pre-Conditions: cvmodule successfully connects to camera and smartserve, ball is being detected Input: N/A		
Expected Results: returns true while ball is moving leftwards	Actual Results: ????	
Post-Conditions: N/A		

Table 6: ball leftward detection Test

Test ID: CV6	**cvmodule timeout test**	Status: ????
Description: Test to see if cv module correctly times out		
Pass/Fail Condition: condition passes if fsm moves from state 1 to state 0 after 8 seconds		
Pre-Conditions: fsm is in state 1 Input: N/A		
Expected Results: sends bad signal to smart-serve, cvmodule stops running	Actual Results: ????	
Post-Conditions: cvmodule is closed		

Table 7: cvmodule timeout test

Test ID: CV7	**fsm transition: state 1 to 2**	Status: ????
Description:test if the fsm transitions to state 2 when ball is descending		
Pass/Fail Condition:fsm transitions to state 2 when ball is descending		
Pre-Conditions: fsm is in state 1 Input: N/A		
Expected Results: fsm transitions to state 2	Actual Results: ????	
Post-Conditions: fsm is in state 2		

Table 8: fsm transition: state 1 to 2

Test ID: CV8	**fsm transition: state 2 to 3**	Status: ????
Description:test if the fsm transitions from state 2 to state 3 when ball is ascending		
Pass/Fail Condition:fsm transitions to state 3 when ball is ascending		
Pre-Conditions: fsm is in state 2 Input: N/A		
Expected Results: fsm transitions to state 3	Actual Results: ????	
Post-Conditions: fsm is in state 3		

Table 9: fsm transition: state 2 to 3

Test ID: CV9	**good signal test**	Status: ????
Description:test if the cvmodule sends a good signal to smartserve		
Pass/Fail Condition:cvmodule successfully sends good signal when fsm is in state 3		
Pre-Conditions: fsm is in state 3 Input: N/A		
Expected Results: good signals successfully sent	Actual Results: ????	
Post-Conditions: fsm is in state 0		

Table 10: good signal test

Test ID: CV10	**cvmodule timeout test**	Status: ????
Description: Test to see if cv module correctly times out		
Pass/Fail Condition: condition passes if fsm moves from state 1 to state 0 after 8 seconds		
Pre-Conditions: fsm is in state 1 Input: N/A		
Expected Results: sends bad signal to smart-serve, cvmodule stops running	Actual Results: ????	
Post-Conditions: cvmodule is closed		

Table 11: cvmodule timeout test

4.2.2 ShotRecommender

Test ID: SR1	**ShotRecommender Listen Test**	Status: ????
Description: The ShotRecommender service responds to HTTP calls on port 8080.		
Pass/Fail Condition: The system waits until a request.		
Pre-Conditions: N/A Input: None		
Expected Results: N/A	Actual Results: ????	
Post-Conditions: N/A		

Table 12: ShotRecommender Listen Test

Test ID: SR2	**ShotRecommender Query Test**	Status: ????
Description: The ShotRecommender calls the "query" method for user data.		
Pass/Fail Condition: The call returns a table of user performance data.		
Pre-Conditions: The SQL database is running on port 3306. Input: a valid user id for the "performance" procedure		
Expected Results: table of data	Actual Results: ????	
Post-Conditions: N/A		

Table 13: ShotRecommender Query Test

Test ID: SR3	**ShotRecommender Random Shot Test**	Status: ????
Description: The ShotRecommender receives a request for a shot.		
Pass/Fail Condition: The service generates a random shot.		
Pre-Conditions: The service is running on port 8080. Input: an HTTP request with "Random" as the mode parameter		
Expected Results: a random shot which adheres to requirements	Actual Results: ????	
Post-Conditions: N/A		

Table 14: ShotRecommender Random Shot Test

Test ID: SR4	**ShotRecommender Training Shot Test**	Status: ????
Description: The ShotRecommender receives a request for a shot.		
Pass/Fail Condition: The service generates a shot.		
Pre-Conditions: The service is running on port 8080. Input: an HTTP request with "Train" as the mode parameter		
Expected Results: a random shot which adheres to requirements	Actual Results: ????	
Post-Conditions: N/A		

Table 15: ShotRecommender Training Shot Test

Test ID: SR5	**ShotRecommender UpdateModel Test**	Status: ????
Description: The ShotRecommender receives a status update for a shot.		
Pass/Fail Condition: The service changes the model in response.		
Pre-Conditions: The service is running on port 8080. Input: an HTTP request with the shot id and returned boolean as parameters.		
Expected Results: the model is updated	Actual Results: ????	
Post-Conditions: N/A		

Table 16: ShotRecommender UpdateModel Test

4.2.3 Shooting Model

Test ID: SM1	**ShootingModel calculateYawAngle Test**	Status: ????
Description: The calculateYawAngle method returns an accurate yaw angle in degrees.		
Pass/Fail Condition: The method returns an angle in degrees accurate to a whole number.		
Pre-Conditions: N/A Input: xDist, yDist; distance to desired shot's x-coordinate and y-coordinate.		
Expected Results: A yaw angle in degrees, accurate to a whole number.	Actual Results: ????	
Post-Conditions: N/A		

Table 17: ShootingModel calculateYawAngle Test

Test ID: SM2	**ShootingModel calculateVelocity Test**	Status: ????
Description: The calculateVelocity method returns an accurate velocity in meters/second.		
Pass/Fail Condition: The method returns the velocity accurate to a whole number.		
Pre-Conditions: N/A Input: N/A		
Expected Results: Velocity in m/s, accurate to a whole number.	Actual Results: ????	
Post-Conditions: N/A		

Table 18: ShootingModel calculateVeolocty Test

Test ID: SM3	**ShootingModel netHeightChecker Test**	Status: ????
Description: ThenetHeightChecker method checks whether the desired shot will pass over the net.		
Pass/Fail Condition: The method returns the correct boolean indicating if the shot will pass over the net.		
Pre-Conditions: N/A Input: N/A.		
Expected Results: A boolean; True is shot will pass over the net, False otherwise.	Actual Results: ????	
Post-Conditions: N/A		

Table 19: ShootingModel netHeightChecker Test

4.2.4 Data Storage

4.2.5 User Interface

4.2.6 SmartServe

Test ID: SR1	**ShotRecommendation Connection Test - Pass**	Status: ????
Description: The ShotRecommendation class will call the *connect* method with port 8080 as a parameter.		
Pass/Fail Condition: The method should return true.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: 8080		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 20: ShotRecommendation Connection Test - Pass

Test ID: SR2	**ShotRecommendation Connection Test - Fail**	Status: ????
Description: The ShotRecommendation class will call the *connect* method with port 8090 as a parameter.		
Pass/Fail Condition: The method should return false.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: 8090		
Expected Results: false	Actual Results: ????	
Post-Conditions: N/A		

Table 21: ShotRecommendation Connection Test - Fail

Test ID: SR3	**ShotRecommendation Request Shot - Random**	Status: ????
Description: The ShotRecommendation class will call the *getRecommendation* method with Random mode as a parameter.		
Pass/Fail Condition: The method should a random shot of the form "X=A.BC,Y=A.BC,V=A.BC,W=A.BC" where the values are within the requirements of the system.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: Mode.Random		
Expected Results: A valid shot, in string form.	Actual Results: ????	
Post-Conditions: N/A		

Table 22: ShotRecommendation Request Shot - Random

Test ID: SR4	**ShotRecommendation Request Shot - Train**	Status: ????
Description: The ShotRecommendation class will call the *getRecommendation* method with Training mode as a parameter.		
Pass/Fail Condition: The method should a shot of the form "X=A.BC,Y=A.BC,V=A.BC,W=A.BC" where the values are within the requirements of the system.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: Mode.Train		
Expected Results: A valid shot, in string form.	Actual Results: ????	
Post-Conditions: N/A		

Table 23: ShotRecommendation Request Shot - Train

Test ID: SS1	**ShotRecommendation Request Shot - One-shot**	Status: ????
Description: The ShotRecommendation class will call the *getRecommendation* method with One-shot mode as a parameter.		
Pass/Fail Condition: The method should a shot of the form "X=A.BC,Y=A.BC,V=A.BC,W=A.BC" where the values are within the requirements of the system. Repeated requests should return the same shot.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: Mode.OneShot		
Expected Results: A valid shot, in string form.	Actual Results: ????	
Post-Conditions: N/A		

Table 24: ShotRecommendation Request Shot - One-shot

Test ID: SS2	**ShotRecommendation Model Update**	Status: ????
Description: The ShotRecommendation class will call the *updateModel* method.		
Pass/Fail Condition: The ShotRecommender does not throw an error and the model is updated.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: a previously request shot and false		
Expected Results: N/A	Actual Results: ????	
Post-Conditions: N/A		

Table 25: ShotRecommendation Model Update

Test ID: SS3	**ShotRecommendation Model Update**	Status: ????
Description: The ShotRecommendation class will call the *updateModel* method.		
Pass/Fail Condition: The ShotRecommender does not throw an error and the model is updated.		
Pre-Conditions: The ShotRecommendation server is running on port 8080. Input: a previously request shot and true		
Expected Results: N/A	Actual Results: ????	
Post-Conditions: N/A		

Table 26: ShotRecommendation Request Shot - One-shot

Test ID: SS4	**ComputerVisionController Connection Test - Pass**	Status: ????
Description: The CV class will call the *connection* method.		
Pass/Fail Condition: The method returns true.		
Pre-Conditions: The CV server is running on port 8000. Input: 8000		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 27: ComputerVisionController Connection Test - Pass

Test ID: SS5	**ComputerVisionController Connection Test - Fail**	Status: ????
Description: The CV class will call the *connection* method.		
Pass/Fail Condition: The method returns false.		
Pre-Conditions: The CV server is running on port 8001. Input: 8000		
Expected Results: false	Actual Results: ????	
Post-Conditions: N/A		

Table 28: ComputerVisionController Connection Test - Fail

Test ID: SS6	**ComputerVisionController Detect Test - Timeout**	Status: ????
Description: The CV class will call the *start* method and no ball is introduced into the frame.		
Pass/Fail Condition: The method returns false.		
Pre-Conditions: The CV server is running on port 8000. Input: N/A		
Expected Results: false	Actual Results: ????	
Post-Conditions: N/A		

Table 29: ComputerVisionController Detect Test - Timeout

Test ID: SS7	**ComputerVisionController Detect Test - Detect**	Status: ????
Description: The CV class will call the *start* method and a ball is introduced into the frame, emulating a successful shot.		
Pass/Fail Condition: The method returns true.		
Pre-Conditions: The CV server is running on port 8000. Input: N/A		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 30: ComputerVisionController Detect Test - Detect

Test ID: SS8	**SQLConnector Connection Test - Pass**	Status: ????
Description: The SQLConnector class will call the *connect* method.		
Pass/Fail Condition: The method returns true.		
Pre-Conditions: The SQL server is running on port 3306. Input: 3306		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 31: SQLConnector Connection Test - Pass

Test ID: SS9	**SQLConnector Connection Test - Fail**	Status: ????
Description: The SQLConnector class will call the *connect* method.		
Pass/Fail Condition: The method returns false.		
Pre-Conditions: The SQL server is not running. Input: 3306		
Expected Results: false	Actual Results: ????	
Post-Conditions: N/A		

Table 32: SQLConnector Connection Test - Pass

Test ID: SS10	**SQLConnector Query Test - Signup**	Status: ????
Description: The SQLConnector class will call the *save* method.		
Pass/Fail Condition: The user is saved in the database.		
Pre-Conditions: The SQL server is running on port 3306. Input: Object[] with "Chris" and "password123" for the "sign_up" procedure		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 33: SQLConnector Query Test - Signup

Test ID: SS11	**SQLConnector Query Test - Returned**	Status: ????
Description: The SQLConnector class will call the *save* method.		
Pass/Fail Condition: The shot is saved in the database correctly.		
Pre-Conditions: The SQL server is running on port 3306. Input: Object[] with 25, 1, 1 and the current time for the "returned" procedure		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 34: SQLConnector Query Test - Returned

Test ID: SS12	**SQLConnector Query Test - Login**	Status: ????
Description: The SQLConnector class will call the *save* method.		
Pass/Fail Condition: The shot is saved in the database correctly.		
Pre-Conditions: The SQL server is running on port 3306. Input: Object[] with "Chris" and "password123" for the "login" procedure		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 35: SQLConnector Query Test - Returned

Test ID: SS13	**ArduinoController Connection Test - Pass**	Status: ????
Description: The ArduinoController class will call the *test* method, repeat for all arduinos.		
Pass/Fail Condition: The method returns true.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: the port for the Arduino(s)		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 36: ArduinoController Connection Test - Pass

Test ID: SS14	**ArduinoController Connection Test - Fail**	Status: ????
Description: The ArduinoController class will call the *test* method, repeat for all arduinos.		
Pass/Fail Condition: The method returns false.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: "some-test-string"		
Expected Results: false	Actual Results: ????	
Post-Conditions: N/A		

Table 37: ArduinoController Connection Test - Fail

Test ID: SS15	**ArduinoController Test - Pan**	Status: ????
Description: The ArduinoController class will call the *shoot* method.		
Pass/Fail Condition: The system pans to 75 degrees.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: a ShotDetail object with pan of 75 degrees		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 38: ArduinoController Test - Pan

Test ID: SS16	**ArduinoController Test - Pan**	Status: ????
Description: The ArduinoController class will call the *shoot* method.		
Pass/Fail Condition: The system pans to 120 degrees.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: a ShotDetail object with pan of 120 degrees		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 39: ArduinoController Test - Pan

Test ID: SS17	**ArduinoController Test - Shoot**	Status: ????
Description: The ArduinoController class will call the *shoot* method.		
Pass/Fail Condition: The system shoots at 75% power.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: 75		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 40: ArduinoController Test - Shoot

Test ID: SS18	**ArduinoController Test - Shoot**	Status: ????
Description: The ArduinoController class will call the *shoot* method.		
Pass/Fail Condition: The system shoots at 100% power.		
Pre-Conditions: The Arduinos are plugged in via USB and loaded with the correct code. Input: 100		
Expected Results: true	Actual Results: ????	
Post-Conditions: N/A		

Table 41: ArduinoController Test - Shoot

5 Test Case-Requirement Traceability Matrix

Table 42: Matrix to Match Tests to Functional Requirements

Functional Requirement-Test Matrix																		
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18

Table 43: Matrix to Match Tests to Non-Functional Requirements

Non-Functional Requirement-Test Matrix																			
	LF1	UH1	UH2	P1	P2	P4	P5	OE2	MS1	MS2	S1	S2	P1	LC1	HS1	HS2	HS3	HS4	HS5
T1					X						X								