BallBot - Finale

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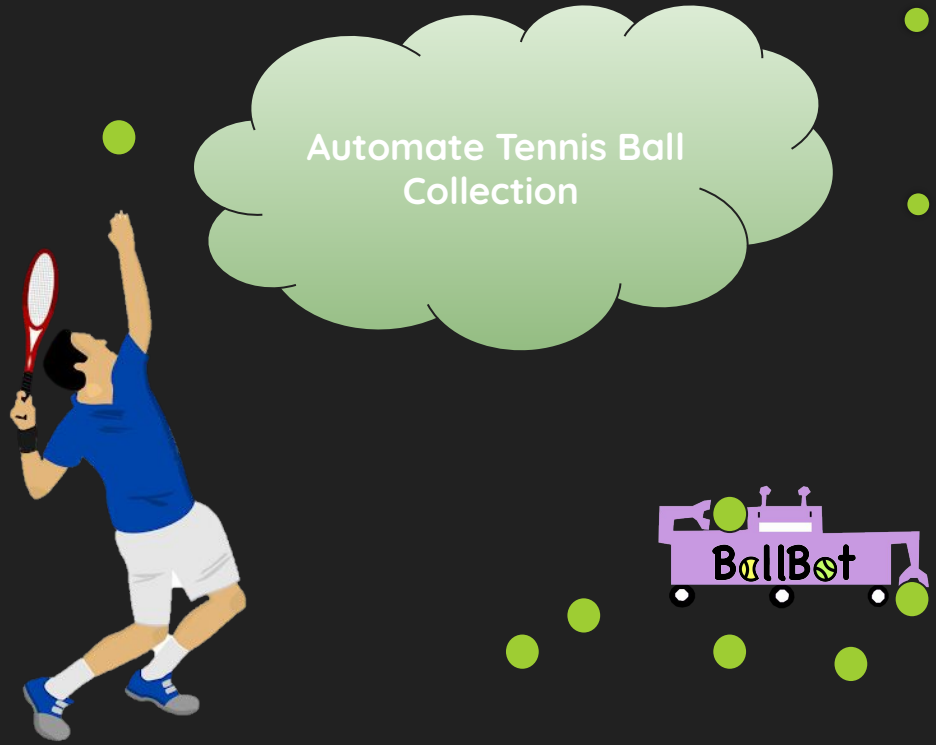
Application Area

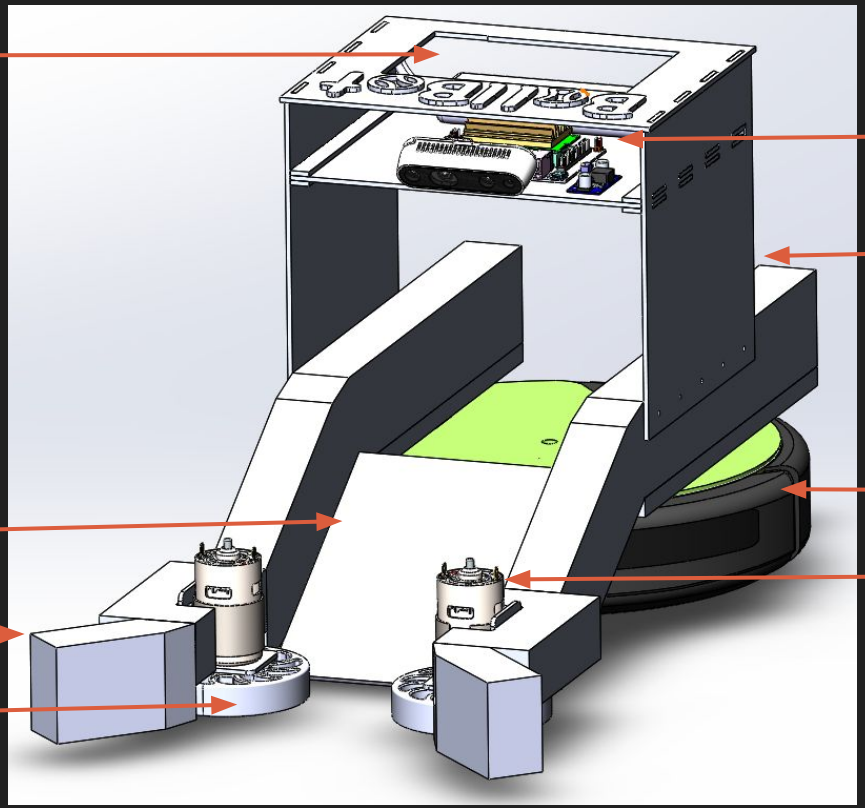
- In tennis equipment market, there exist very few advanced electronic devices assisting in the feeding and picking of tennis balls
- Tennis players often spend more time picking up balls after a serving practice session than hitting them
- Current approach - Ball Hopper
  - Can hold 70-80 balls
  - Heavy and Cumbersome
  - Takes away from practice time
  - Players are already exhausted after practice

Solution

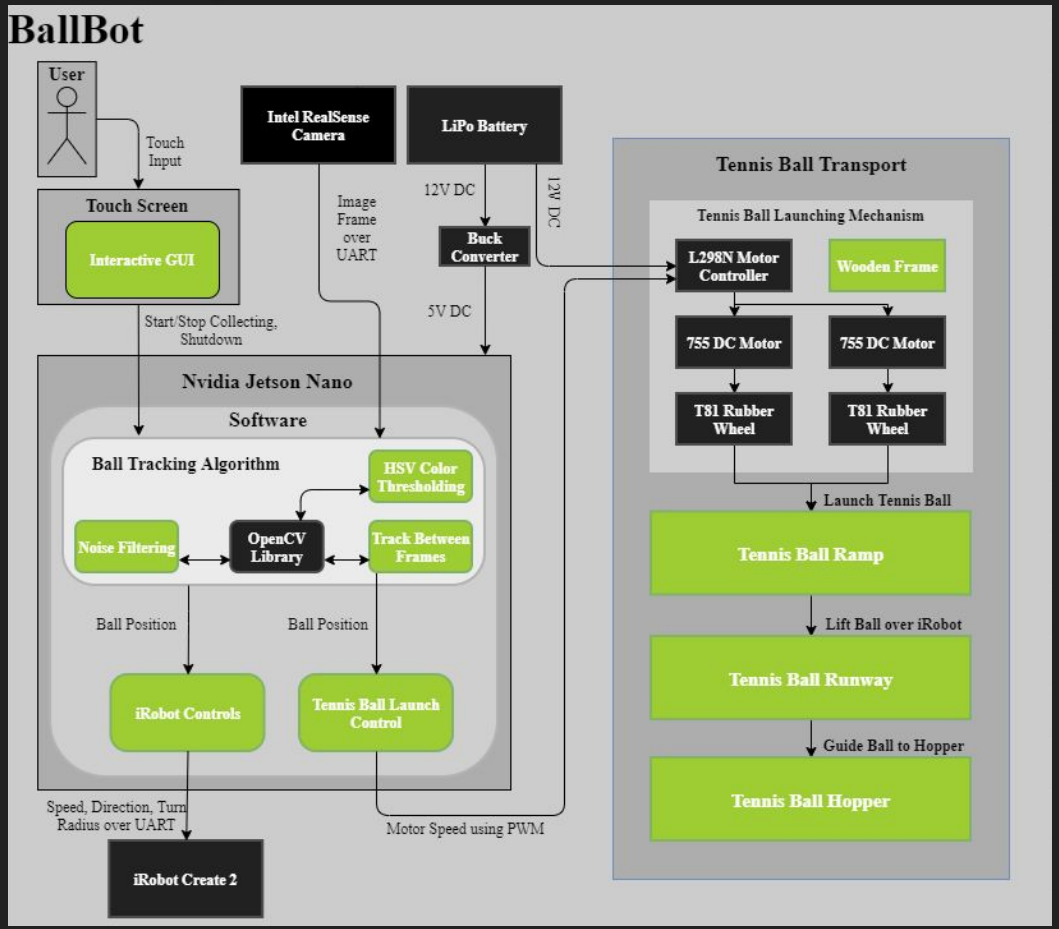


- BallBot - Robot that autonomously detects and collects tennis balls after **serving practice**
- There will be many balls on the court clustered together
  - Detects standard sized lime-green tennis balls
    - 20 - 30 ball capacity
  - Outdoor courts in daylight
  - Hard surface courts

Solution Approach – Updated Mechanical Model

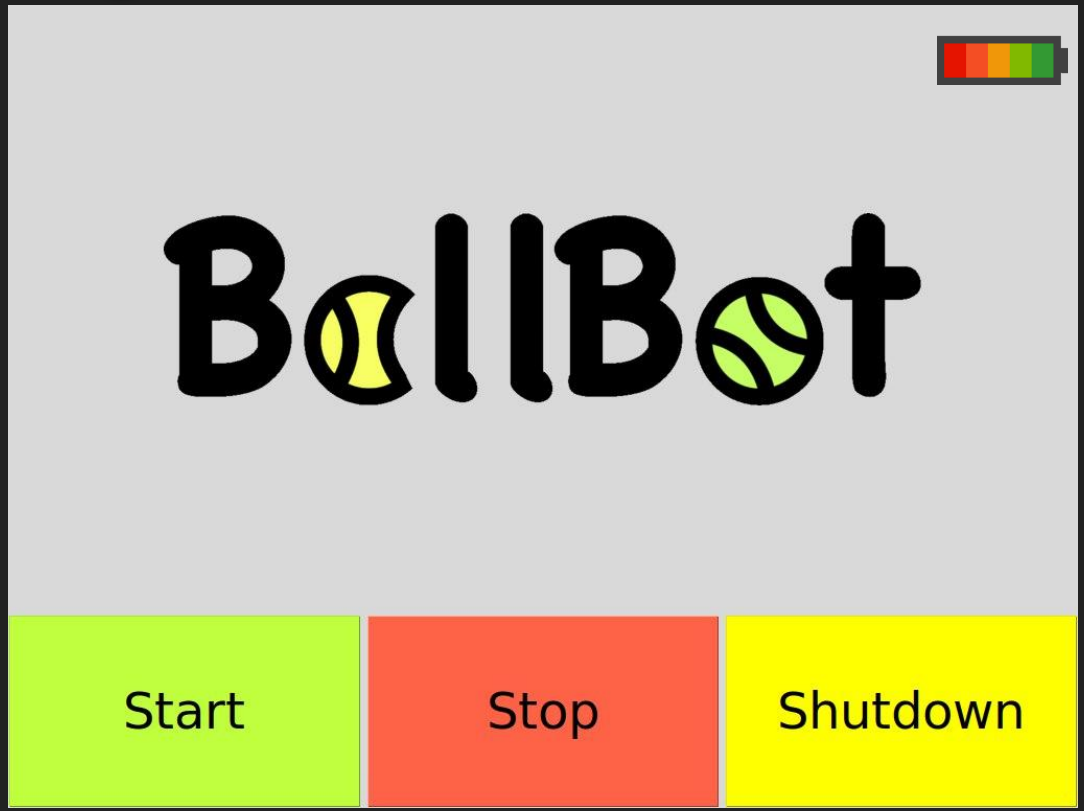


System Specification



BallBot Design

BallBot Design - UI



Lights Camera Action!

BallBot

Metrics, Testing & Verification

Requirements	Testing	Metrics	P/F	Performance
Quickly and autonomously collect tennis balls	Time robot picking up 30 balls	Picks up 20-30 ball at an average of 6 balls per minute		Picked up 22 balls at 10 balls per minute
Battery lasts a serving session	Run robot until battery dies	Battery lasts at least 30 minutes.		Battery lasts around 2 hours
Lightweight and portable	Weigh robot on scale	Weighs less than 20 pounds		Robot weighs ~15 pounds
Fast image processing	Run ball tracking algorithm on Jetson Nano	Tracking algorithm runs at > 10 frames per second		Tracking algorithm runs at 30 frames per second

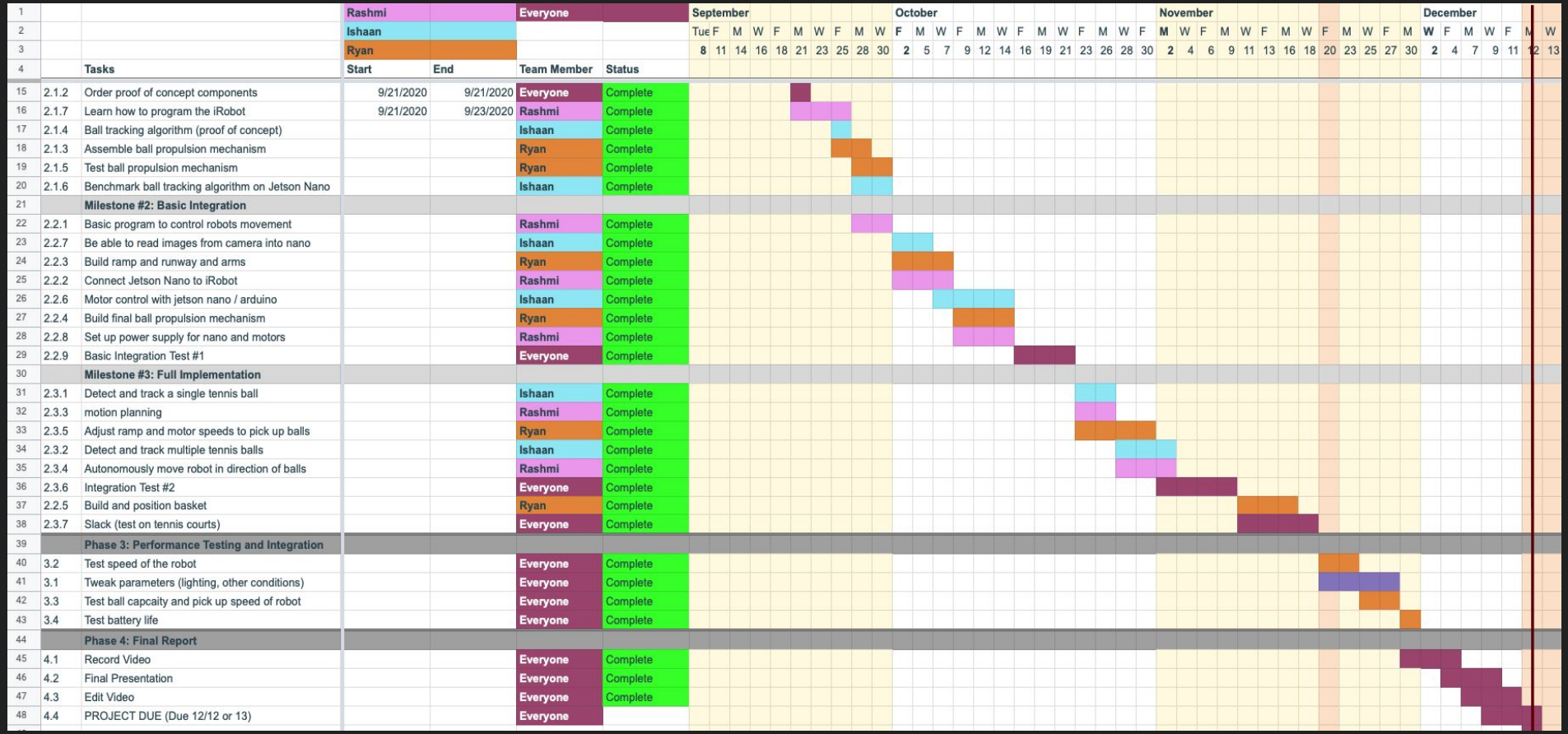
Metrics, Testing & Verification

Requirements	Testing	Metrics	P/F	Performance
Robot does not often move towards non existent balls	Drive robot around empty tennis court and check output	Less than 5% false positive rate in tennis ball detection		Less than 1% false positive rate under good lighting conditions (indoors / clear weather). Around 10% false positive rate under drastic changes in lighting
Rarely misses existing ball	Place multiple balls in robot FOV and check output	Less than 5% false negative rate for tennis ball detection		Less than 1% false negative rate
Can pick up tennis balls into basket	Run robot picking up 30 balls	Balls get launched by wheels at 2.2 meters/second and land inside the basket		Balls never miss the basket

Design Trade-Offs

- Basket size:
  - To meet ball capacity requirement and requirement for all launched balls to enter basket, we made the basket wide and shallow instead of tall.
  - But this made it harder for the Ballbot to turn and the overall Robot larger/heavier.
- Computer Vision:
  - We loosened the thresholds in our ball detection algorithm to ensure tennis balls were detected in varied lighting condition
  - Caused higher false positive rate, ok since we have high battery capacity
- Material:
  - We planned on using acrylic in BallBot's frame construction but eventually switched to wood to support the weight of our motors and increase robustness
  - This also increased the weight of the robot and lowered our resistance to weather

Schedule / Gantt Chart



		Tasks	Start	End	Team Member	Status
			Rashmi		Everyone	
			Ishaan			
			Ryan			
15	2.1.2	Order proof of concept components	9/21/2020	9/21/2020	Everyone	Complete
16	2.1.7	Learn how to program the iRobot	9/21/2020	9/23/2020	Rashmi	Complete
17	2.1.4	Ball tracking algorithm (proof of concept)			Ishaan	Complete
18	2.1.3	Assemble ball propulsion mechanism			Ryan	Complete
19	2.1.5	Test ball propulsion mechanism			Ryan	Complete
20	2.1.6	Benchmark ball tracking algorithm on Jetson Nano			Ishaan	Complete
21		**Milestone #2: Basic Integration**				
22	2.2.1	Basic program to control robots movement			Rashmi	Complete
23	2.2.7	Be able to read images from camera into nano			Ishaan	Complete
24	2.2.3	Build ramp and runway and arms			Ryan	Complete
25	2.2.2	Connect Jetson Nano to iRobot			Rashmi	Complete
26	2.2.6	Motor control with jetson nano / arduino			Ishaan	Complete
27	2.2.4	Build final ball propulsion mechanism			Ryan	Complete
28	2.2.8	Set up power supply for nano and motors			Rashmi	Complete
29	2.2.9	Basic Integration Test #1			Everyone	Complete
30		**Milestone #3: Full Implementation**				
31	2.3.1	Detect and track a single tennis ball			Ishaan	Complete
32	2.3.3	motion planning			Rashmi	Complete
33	2.3.5	Adjust ramp and motor speeds to pick up balls			Ryan	Complete
34	2.3.2	Detect and track multiple tennis balls			Ishaan	Complete
35	2.3.4	Autonomously move robot in direction of balls			Rashmi	Complete
36	2.3.6	Integration Test #2			Everyone	Complete
37	2.2.5	Build and position basket			Ryan	Complete
38	2.3.7	Slack (test on tennis courts)			Everyone	Complete
39		**Phase 3: Performance Testing and Integration**				
40	3.2	Test speed of the robot			Everyone	Complete
41	3.1	Tweak parameters (lighting, other conditions)			Everyone	Complete
42	3.3	Test ball capcaity and pick up speed of robot			Everyone	Complete
43	3.4	Test battery life			Everyone	Complete
44		**Phase 4: Final Report**				
45	4.1	Record Video			Everyone	Complete
46	4.2	Final Presentation			Everyone	Complete
47	4.3	Edit Video			Everyone	Complete
48	4.4	PROJECT DUE (Due 12/12 or 13)			Everyone	