Carnegie Mellon University



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* all images are hyperlinked

Use Case / Application

- Problem
 - House rule variations
 - Time consuming scoring process
- Use Case
 - Accurate, quick, and automatic rule enforcement
 - Automatic scoring and card dealing
- Application
 - Competitive & home environment

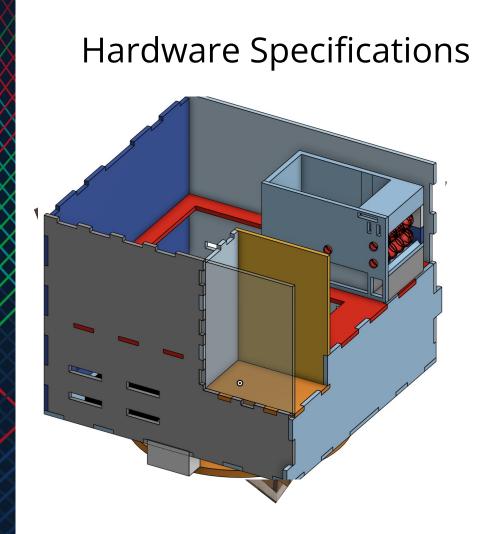


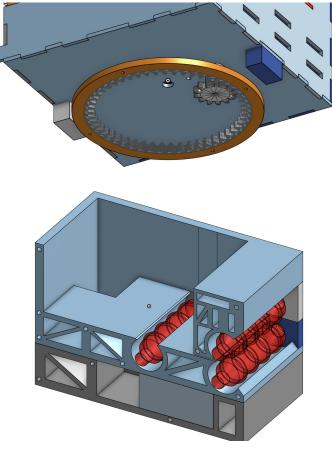
Solution Approach

- Game state tracking
 - Wide angle Pi camera for discard and draw pile
 - Crop out card's corner from surrounding
 - Convolutional network + color classification
 - Website with Flask backend for game updates
- Automatic card dealing
 - Stepper Motor with Internal gears for rotation
 - DC and servo motors for card dispenser

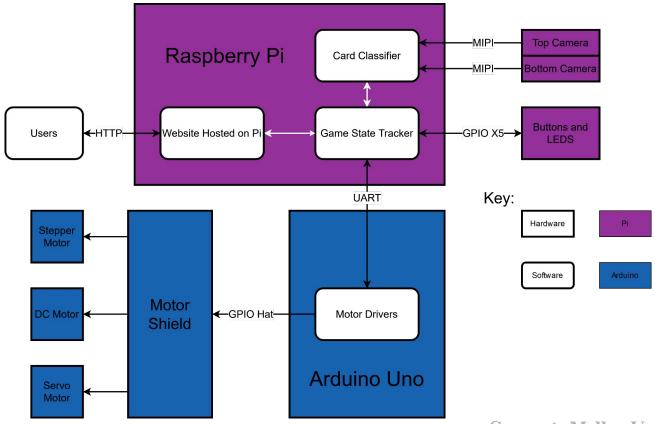
Design Requirements

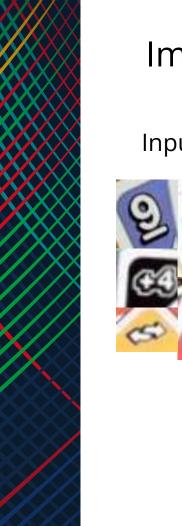
Area	Constraint											
Size	Fits comfortably in the center of small square table (around 3 ft in width)											
Battery life	> 1 hour (~ 6 games) 66.6 Wh battery in total, < 40 Watts Average											
Motor Power Draw	12V 1.2A per motor as limited by the motor shield											
Rotation	Rotate 7 ~ 8 lbs, ±10 degrees of player											
Classification	> 95 % accuracy, < 1 second latency											
Website	< 2 second latency for updates											





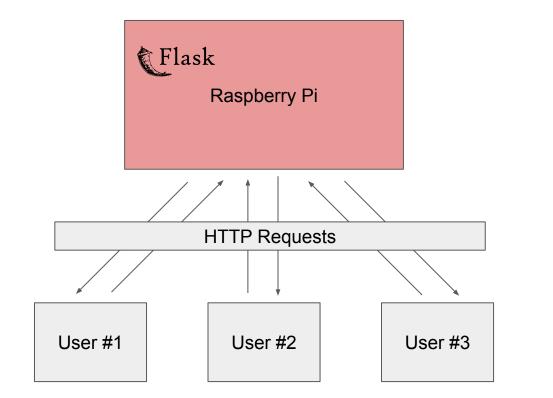
Top Level Design





Implementation - Classification Inputs Final CNN Shape Output Architecture If not wild or plus4 Classify Color

Implementation - Website



Implementation plan

- Hardware
 - 3D print or Laser cut gears, dispenser, and chassis
 - Purchase batteries, motors, bearing, and motor shield
 - Integrate 3D printed gears and stepper for rotation
 - Use DC and servo motors for dispensing cards
- Software
 - Purchase Pi Cameras for classification
 - Design Game State Tracker and CNN classification model
 - Implement interface between Pi and Arduino
 - Implement drivers to control motors
 - Develop website using Flask

Testing & Verification

Rotation Accuracy & Latency	 Mark 90 degree intervals for a 4-player game Ensure each rotation is within ±10 degrees Manual rotation available < 3 seconds each rotation
Battery Life	 Play UNO games for 5 battery cycles > 1 hour battery life on average
Card Dispensing	 Continuously dispense cards for 3+ decks Dispense 1 card at once > 95% of the times

Testing & Verification

System Latency	 Create a log file for each of the main events Compute delta between required latencies < 2 seconds for website updates < 1 second for card classification
Classification Accuracy	 Evaluate trained model on test & validation set to find optimal hyperparameters > 95% accuracy on 5000 images of cards



Risk Factors & Unknowns

- Achieving high classification accuracy
 - Use majority vote of multiple models
 - Implement more image preprocessing
- Website latency on Pi
 - Host externally and treat Pi as a client
- Platform rotation
 - Decrease weight
 - Change gear characteristics
- Card dispensing
 - Vary roller and opening size
 - Increase clamping pressure on top

Gantt Chart

						02/05 - 02/11			02/	12 - 02/1	8	02,	/19 - 02	/25		02/26 -	03/03		03/0	4 - 03/1	0	0	3/11 - 0	3/17		03/	18 - 03/2	24		03/25 -	03/31		04/01	- 04/07		04/	/08 - 04/1	4		04/15 -	04/21		04/	22 - 04/2	28
TASK	TASK	TASK	START	DUE	DURATION		WEEK 1			WEEK 2			WEEK 3	1		WEEP	(4		Spri	ng breal	k		WEEK	6		1	WEEK 7			WEE	(8)		W	EK 9		V	WEEK 10			WEEK	.11		٧	WEEK 12	
ID TITLE		OWNER	DATE	DATE	IN DAYS	MTW	V R F	S SU	MTW	RF	S SU	MTV	WRI	F S SL	UMT	r w R	FS	SU M	T W	R F	S SU	MT	WR	FS	SU M	TW	RF	S SU	MT	WR	FS	SU M	TW	RF	S SU	MTW	RF	S SU	MT	WR	FS	SU M	T W	RF	S SU
1	Software	Jason																																											
1.1	UNO implementation	Jason	02/05/24	02/09/24	5																																								
1.2	Card Classification - Data Creation	Jason	02/10/24	02/16/24	7																																								
1.2.1	Card Classification - Preprocessing	Jason	02/15/24	02/22/24	8																																								
1.2.2	Card Classification - Main Algo	Jason	02/21/24	02/24/24	10																																								
1.2.3	Card Classification - Testing	Jason	03/11/24	03/17/24	7																																								
1.3	Website Creation - Frontend	Jason	03/18/24	03/24/24	7																																								
1.3.1	Website Creation - Back End	Jason	03/25/24	03/31/24	7																																								
2	Hardware	Thomas																																											
2.1	Lower Body Design in CAD	Thomas	02/05/24	02/11/24	7																																								
2.1.1	Lower Body Assembly	Thomas	02/19/24	02/25/24	7																																								
2.1.2	Lower Body motion testing	Thomas	02/23/24	02/29/24	7																																								
2.2	Upper Body Design in CAD	Thomas	2/12/24	02/18/24	7																																								
2.3	Card Dispenser Assembly	Thomas	02/28/24	03/12/24	7																																								
2.3.1	Card Dispensing Testing	Thomas	03/13/24	03/24/24	12																																								
3	Embedded	David																																											
3.1	Rotating platform drivers	David	02/05/24	02/18/24	14																																								
3.2	Camera drivers	David	02/16/24	02/22/24	7																																								
3.3	Card dispenser drivers	David	02/19/24	03/03/24	14																																								
3.4	Device Communication	David	03/11/24	03/17/24	7																																								
3.5	HW and SW integration	David	03/18/24	03/24/24	7																																								
4	Integration	Everyone																																											
4.1	Card Dispensing with CV integration	Everyone	03/25/24	03/28/24	4																																								
4.2	Stack structure with Camera Integration	Everyone	03/29/24	04/01/24	4																																								
4.3	Testing full system (slack)	Everyone	04/02/24	04/28/24	27																																								
4.4	Final Video Preparation	Everyone	04/08/24	04/21/24	14																																								
4.4.1	Final Presenatation Preparation	Everyone	04/08/24	04/21/24	14																																								
4.4.2	Final Report Preparation	Everyone	04/08/24	04/21/24	14																																								