

Carnegie
Mellon
University



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Thomas Kang, Jason Stentz, David Peng

** 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



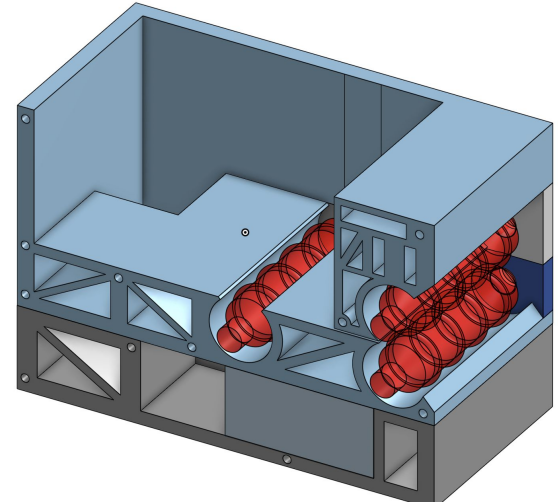
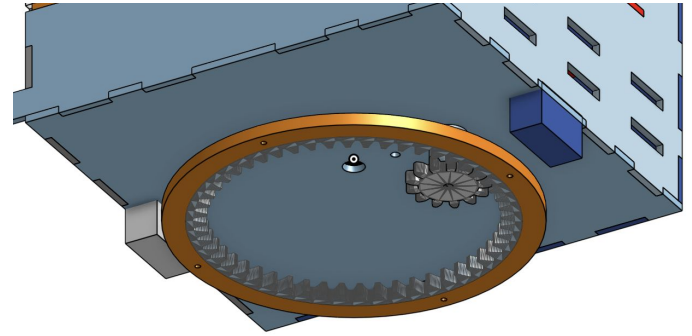
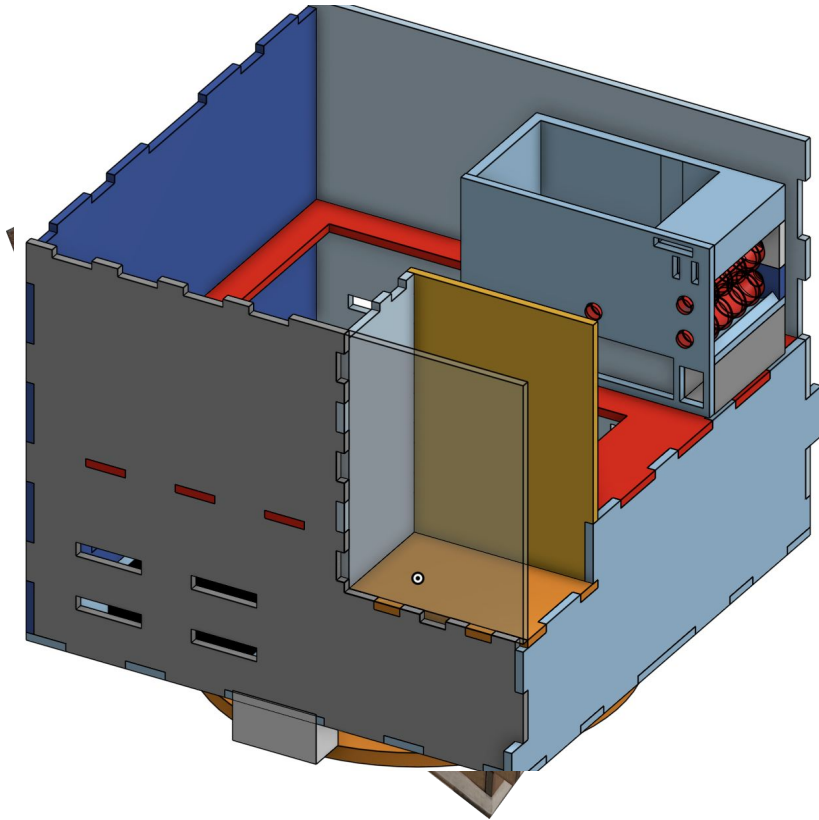
Solution Approach

- 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

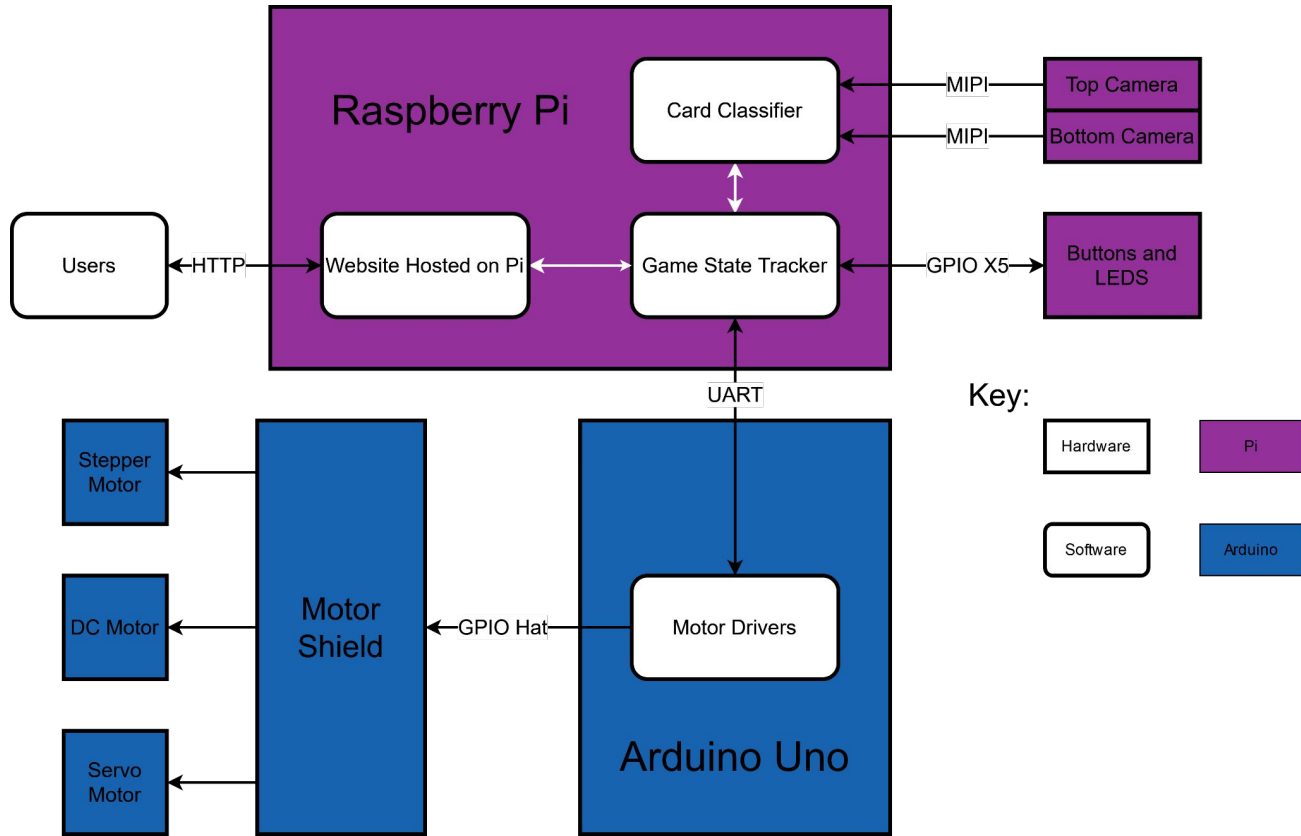
Design Requirements

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

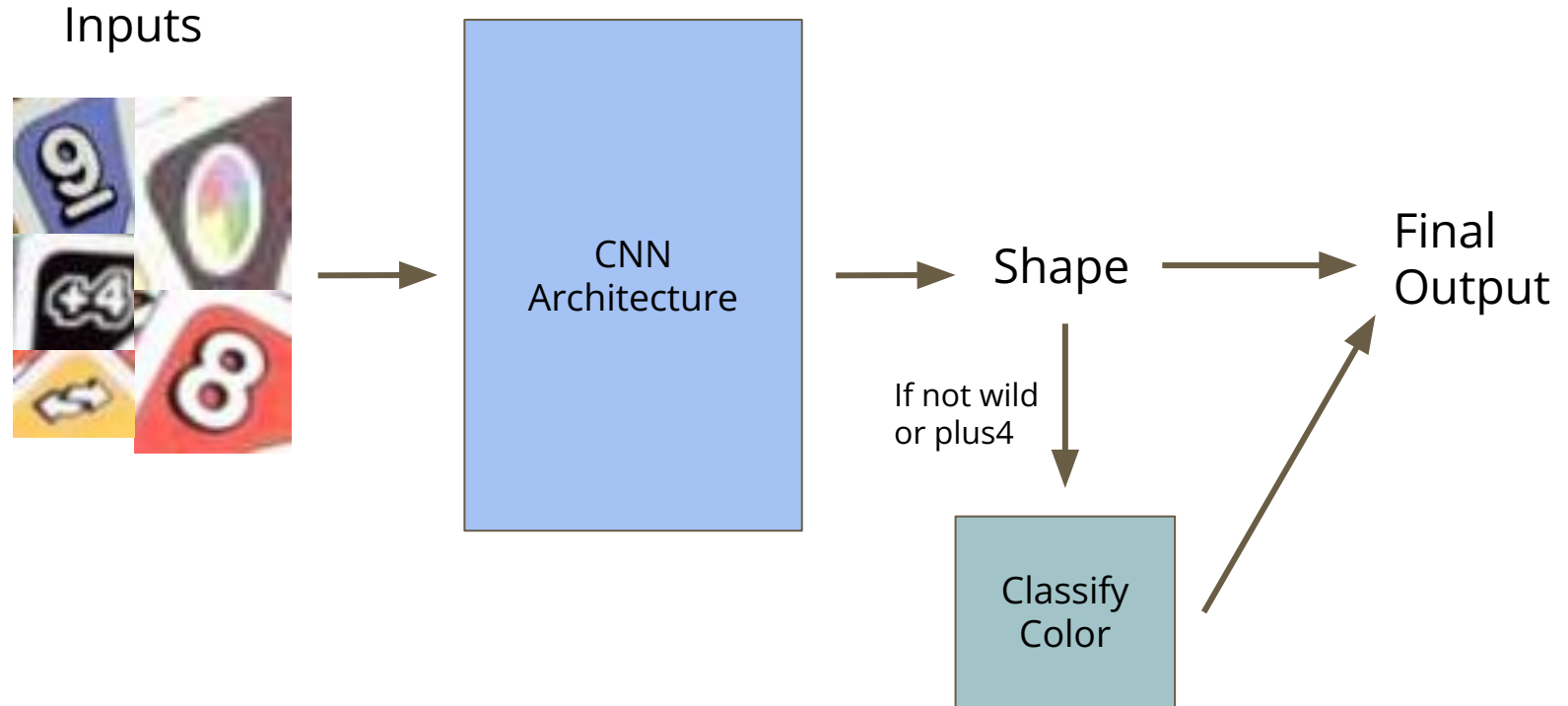
Hardware Specifications



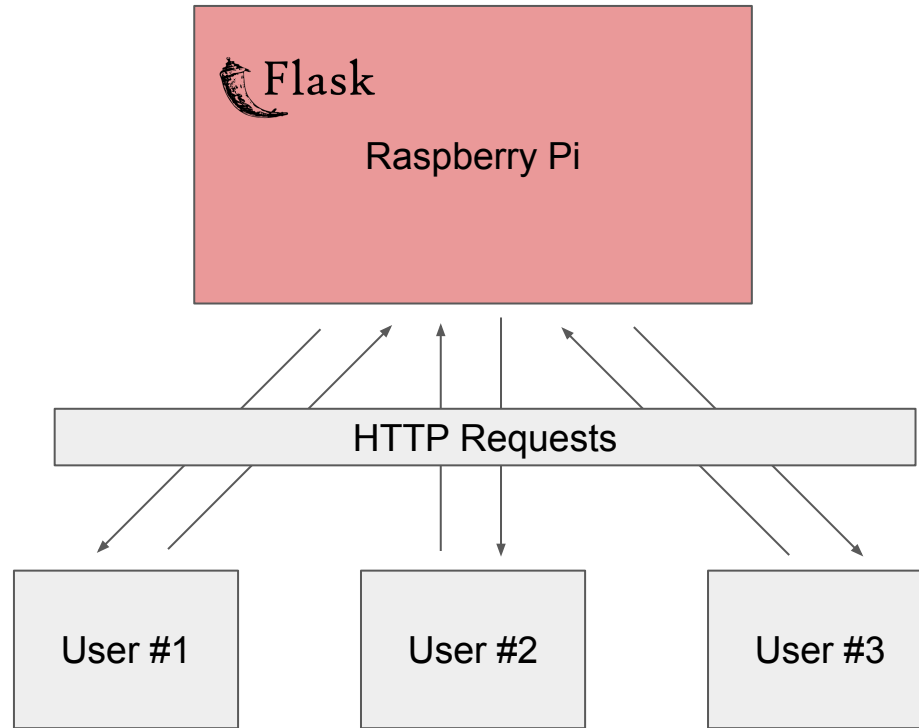
Top Level Design



Implementation - Classification



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	<ul style="list-style-type: none">● 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	<ul style="list-style-type: none">● Play UNO games for 5 battery cycles● > 1 hour battery life on average
Card Dispensing	<ul style="list-style-type: none">● Continuously dispense cards for 3+ decks● Dispense 1 card at once $> 95\%$ of the times

Testing & Verification

System Latency	<ul style="list-style-type: none">● Create a log file for each of the main events● Compute delta between required latencies<ul style="list-style-type: none">○ < 2 seconds for website updates○ < 1 second for card classification
Classification Accuracy	<ul style="list-style-type: none">● 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

