E7: IntelliRack

Final Presentation

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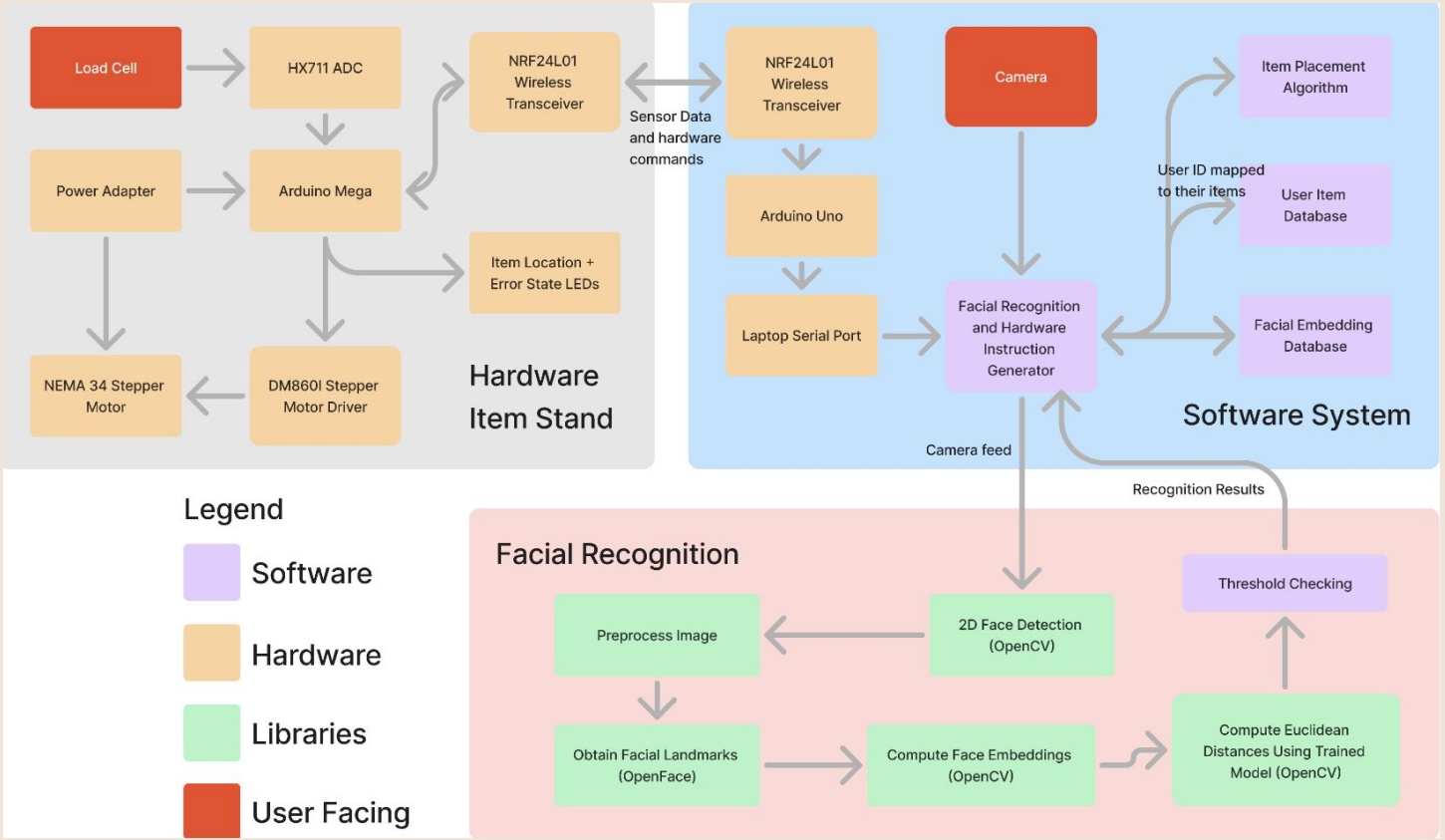
Use-Case + Design Requirements

Goal: Streamline the item/coat checking process using a facial recognition system integrated with a physical hardware item stand.

Facial Detection and Recognition	• Detect faces within a range of **0.5 meters** with a recognition time of within **5 seconds** • Achieve **95% accuracy** for facial recognition
Item Deposit/Retrieval	• Detect the addition or removal of an item within **1 second** • Indicate the position of the user's hook within **7 seconds** by rotating to the correct position and flashing the LED.
Item/Coat Stand Integrity	• Support **20 pounds** on each of 6 hooks • Support **maximum load of 120 pounds** distributed across 6 hooks

System Block Diagram



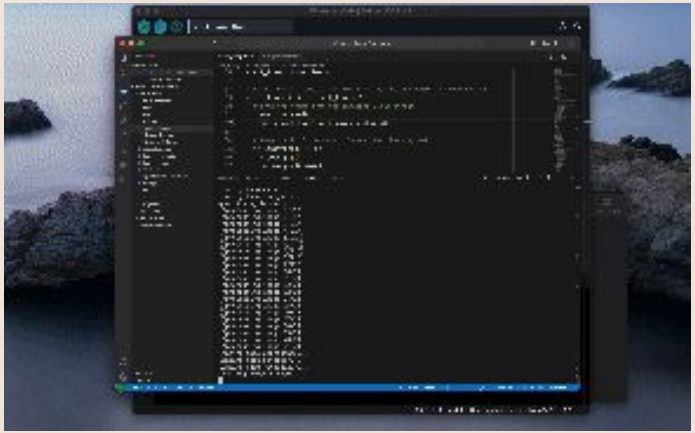
Solution Approach + Changes

Hardware Changes:

- Stepper Motor: Nema 17 (0.7Nm) - Nema 34 (4.8Nm)
  - Required 1.98Nm to satisfy use-case requirements
- Weight balancing algorithm
- Polling for item deposit/pickup
  - LEDs indicate timeout

Facial Recognition Changes:

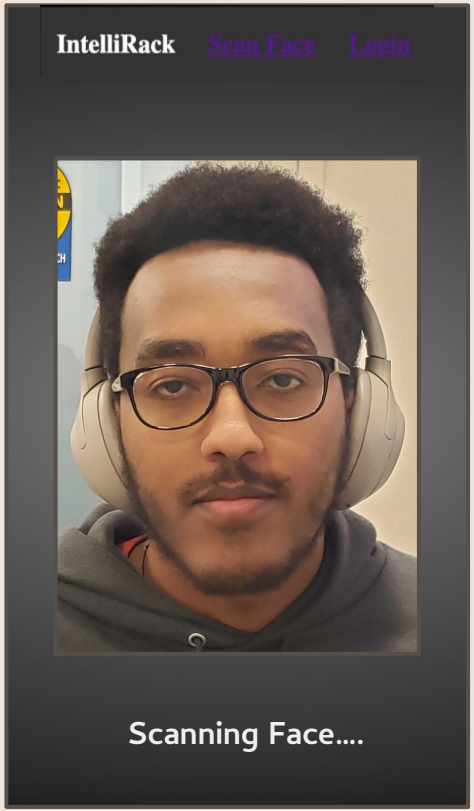
- Gaussian kernel SVM:
  - Used for classification tasks, when relationship between input features and class labels is non-linear
- Preprocessing:
  - Face alignment



Ethical Considerations

- **Economic Factors:**
  - Benefits for event organizers: reduce staffing costs and handle a higher volume of check-ins
- **Public Welfare:**
  - Streamlined check-in process to reduce attendee stress and frustration, promoting overall well-being
- **Privacy:**
  - Safeguard user privacy by deleting data after check-out
- **Security:**
  - Detect if attackers steal users' personal belongings stored on rack
    - Sound buzzer

Complete Solution + Demonstration



Testing: Item Stand

Durability:

- Test each hook can handle 20 pounds:
  - Place **20 pounds** on each hook only, one at a time, 0 pounds on other hooks. Rotate rack **360 degrees**
  - RESULT: Slight but expected bending of wood. Holds 20 pounds
- Imbalance test:
  - Place **60 lbs** on one side, **0 pounds** on opposite side. Check for rack stability and if rotation still works
  - RESULT: No instability in rack due to large base
- Max weight test:
  - While the rack is rotating, continuously place 20 pound weights on hooks until **max weight (120 pounds)** is reached
  - RESULT: Able to continuously rotate with max weight

Testing: Item Placement and Removal Times

Check-in (ms)	Check-out (ms)
610.51	607.40
607.55	608.28
612.48	608.36
606.54	609.30
AVG: 609.27	**AVG: 608.34**

Table 1: Check-in/Check-out System Propagation Time

Action	Recorded Time (in seconds)
Check-in: Position 0 - > Position 0	**AVG: <1**
Check-in: Position 0 - > Position 2	3.89, 3.88, 3.95, 3.67, **AVG: 3.85**
Check-in: Position 2 - > Position 4	4.27, 3.88, 4.00, 4.13, **AVG: 4.07**
Check-in: Position 4 - > Position 1	5.06, 5.18, 5.58, 5.57, **AVG: 5.35**
Check-in: Position 1 - > Position 3	3.88, 3.68, 3.88, 3.82, **AVG: 3.82**
Check-in: Position 3 - > Position 5	4.40, 3.48, 3.82, 4.07 **AVG: 3.94**
Check-out: Position 5	2.57, 3.95, 3.97, 5.13, **AVG: 3.91**
Check-out: Position 4	2.44, 5.00, 4.27, 5.13, **AVG: 4.21**
Check-out: Position 3	3.76, 3.75, 3.95, 4.33, **AVG: 3.95**
Check-out: Position 2	5.64, 3.88, 2.59, 5.64, **AVG: 4.44**
Check-out: Position 1	2.58, 2.45, 2.51, 4.34, **AVG: 2.97**
Check-out: Position 0	5.25, 7.92, 5.38, 6.89, **AVG: 6.36**

Table 2: Time to Display User's Position

Testing: Facial Recognition

Speed/Distance:

- Distance and Speed test:
  - Stand at varying distances (within and exceeding **0.5 meters**)
  - Check to see if the system attempts recognition only within **0.5 meters**
  - Time the recognition speed

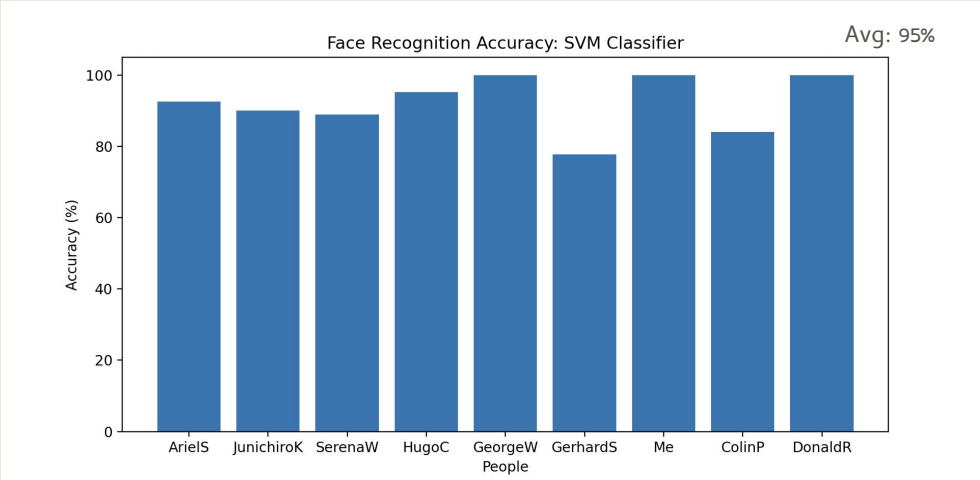
Distance	**0.25 m**	**0.5 m**	**1 m**	**1.5 m**
Round 1	Yes, 3.63	Yes, 4.21	No, -	No, -
Round 2	Yes, 3.95	Yes, 4.41	No, -	No, -
Round 3	Yes, 4.02	Yes, 4.09	No, -	No, -

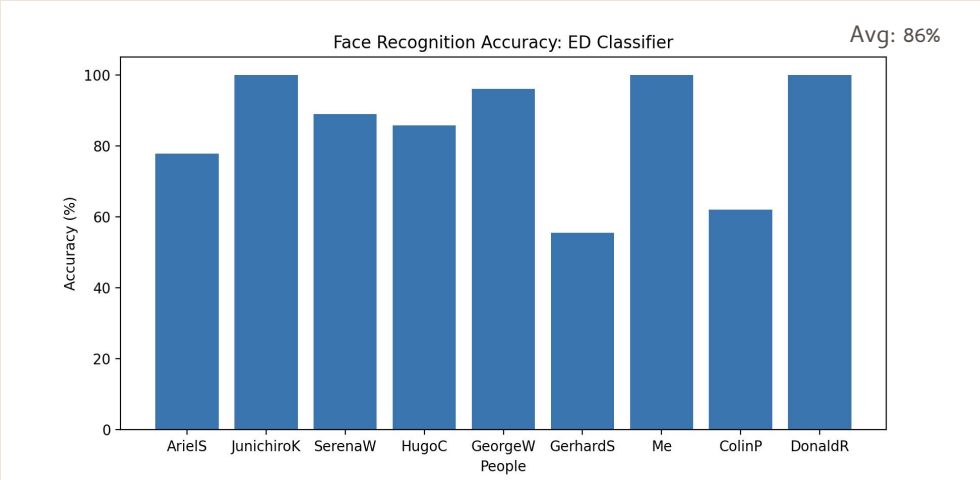
Table: Distance and Speed Results

Testing Facial Recognition: Results

Recognition Accuracy:

- Accuracy test:
  - Gather training and testing images of **20 people**
  - Train using training set and run the recognition system on the testing set
  - Record the testing accuracy and check to see if it exceeds 95% accuracy





Design Trade-Offs

	Raspberry Pi	Arduino
Pros	Could be used to integrate facial recognition into item stand directly	Easier to control and read from many sensors
Cons	Harder to use as a microcontroller	Unable to support onboard facial recognition

	Onboard Camera	Webapp Comm. with Item Stand
Pros	If interfaced with raspberry pi, could create self contained system	Reduces logic on item stand
Cons	Requires raspberry pi on item stand and larger slip ring	Requires transmission between webapp and item stand for system to work

Project Management