Grocery Store Checkout System

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Use Case

Grocery stores can have long wait times for their lines, and as customers, we find ourselves wanting to select the line that lets us wait the shortest amount of time before getting checked out.

- Have a system that selects the best line for you instead of picking (potentially) a suboptimal checkout line
- Areas: Software Systems, Hardware Systems

Use Case Requirements

- Compute the result for the fastest line and display it to the user in < 7.5 seconds
    - While speed isn’t the main priority, we still don’t want a user to wait too long to see the best checkout line to select.
- > 95% accuracy in determining the fastest checkout line
    - We care about accuracy because this is the most important aspect of the system: if inaccurate, we will have no users!
    - Metric for accuracy is “I start checking out before the people who went through the system after me”
- < 25% margin of error for detecting the number of items in someone’s cart
- < 25% margin of error with average time cashier takes to checkout each item

Scope

User

- Has a grocery cart or basket, no bags from home
- Assume users do not join the line without being seen by system
- Checking out items that are of similar size
- Each user checking out max 40 items
- Items must have a barcode

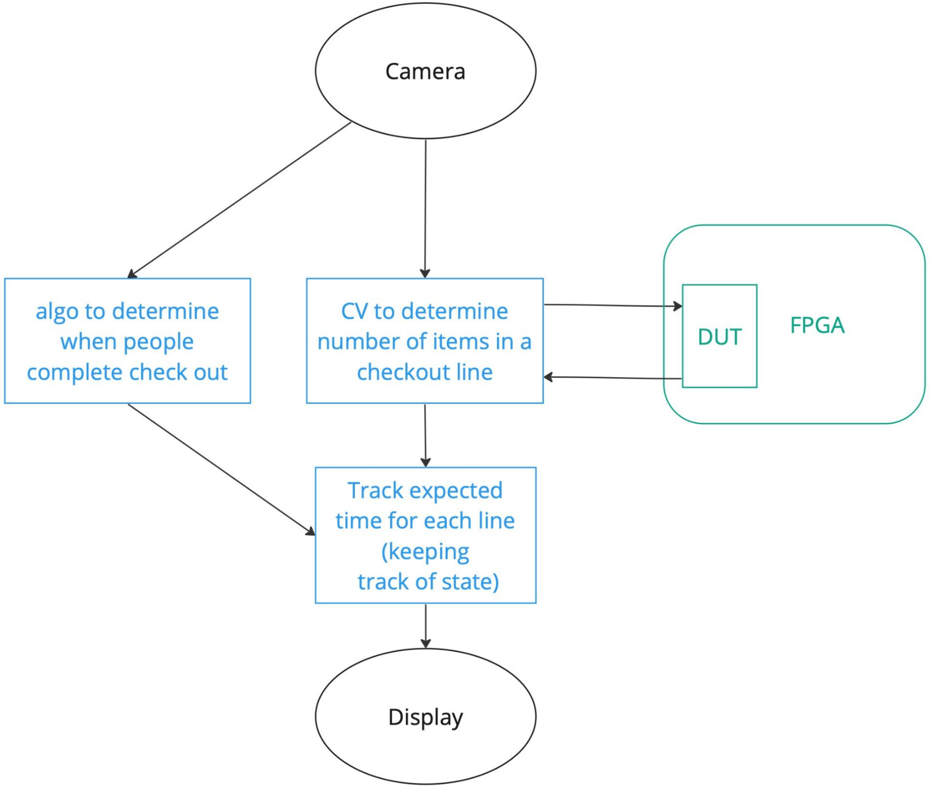
System

- Implemented at a grocery store
- Tracks ~4 checkout lines
- All users follow the system and join the line the system says to join

Technical Challenges

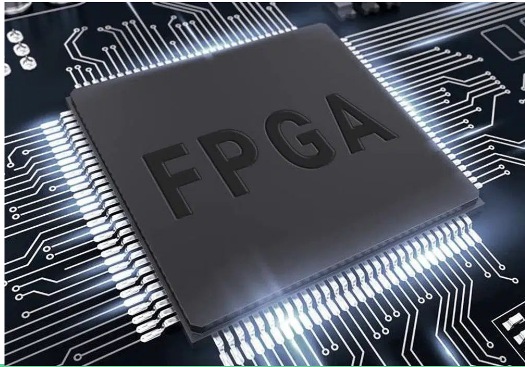
- Need to determine how many items a customer has in their shopping cart/basket
- Need to be able to detect when a customer has finished checking out
- Need to determine the expected time a customer takes depending on their items/number of items
- Keep track of state, which will be expected time for each line, number of people in a line, how fast cashier is working
- Need to consider the speed of each cashier at a checkout line

Solution Approach


Camera
algo to determine when people complete check out
CV to determine number of items in a checkout line
DUT
FPGA
Track expected time for each line (keeping track of state)
Display

Solution Approach (Hardware)

- Cameras for capturing footage
  - One for scanning carts, one for capturing checkout lines
  - Debating between Logitech Brio 4k, Intel Realsense
- LCD display to display the result
- FPGA for hardware acceleration to compute result faster, probably an Altera board
- No wireless protocols, just have everything plugged into each other



Solution Approach (Backend)

- OpenCV and object detection algorithms such as YOLO
- Keep track of average checkout time per line based on how fast the cashier scans items

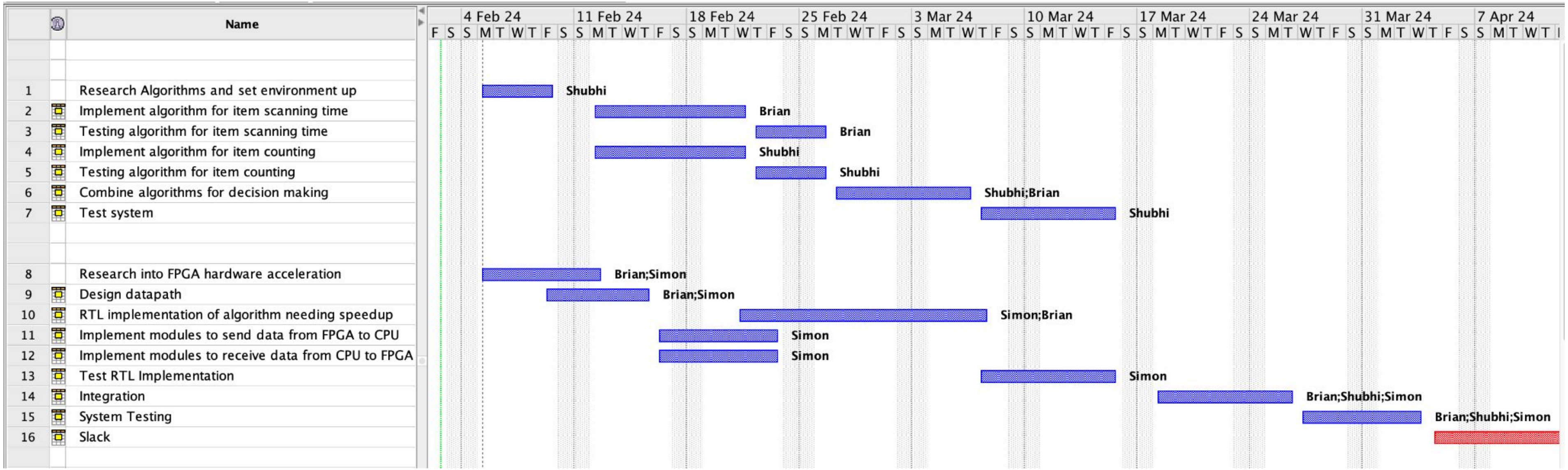
Testing and Verification

- Accuracy for determining lines **> 95%**
  - Run tests with different line variations and directions, and the line changing in real time
- Accuracy of the resulting checkout lines **> 95%**
  - Play out test scenarios with expected results
- Updates user with response in **< 7.5 seconds**
  - Run manual timer tests

Tasks and Division of Labor

- Brian
    - Implement and test cashier time detection
    - Help Simon with algorithm speedup on FPGA
    - Help Shubhi with combining item counting with cashier time detection
- Simon
    - Implement communication between FPGA and software
    - Speed up algorithm with help of FPGA
- Shubhi
    - Implement and test item counting
    - Testing backend system
- All
    - Integrating software and hardware together
    - Testing the entire system

Schedule



	Name
1	Research Algorithms and set environment up
2	Implement algorithm for item scanning time
3	Testing algorithm for item scanning time
4	Implement algorithm for item counting
5	Testing algorithm for item counting
6	Combine algorithms for decision making
7	Test system
8	Research into FPGA hardware acceleration
9	Design datapath
10	RTL implementation of algorithm needing speedup
11	Implement modules to send data from FPGA to CPU
12	Implement modules to receive data from CPU to FPGA
13	Test RTL Implementation
14	Integration
15	System Testing
16	Slack

Conclusion

- MVP: a system that informs a user which line to enter
  - System can use real time information about number of items in the line and average time for each cashier to make a decision
  - Fast, accurate decision making for the user