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Creating an Automated Parking System Enabled by IoT Technology

https://sddec25-09.sd.ece.iastate.edu

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sddec25-09: Thomas Olson, Joseph Schmidt, Harley Peacher, Sullivan Hart

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About Us

Team Members

Harley Peacher SE - Frontend

Thomas Olson SE - Frontend

Joseph Schmidt CprE - Backend

Sullivan Hart CprE - Hardware

Md Maruf Ahamed - Client & Advisor

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Agenda

- Project Overview
  - Problem and Context (background)
  - Requirements
- Design
  - Implementation
- Testing
  - Plan and challenges
- Iterations
  - Things that didn’t work
  - Lessons learned
- Results
  - Significance and value

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Project Overview

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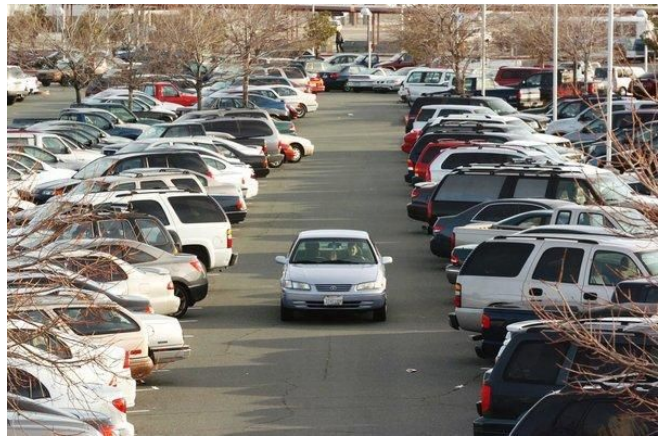
Problem Statement

- Drivers waste valuable time trying to find open parking spaces, often circling crowded lots without direction.
- This inefficiency leads to frustration, congestion, and poor use of available parking.
- UniPark addresses these challenges by simplifying the process, reducing search times, and optimizing how parking spaces are managed.



Requirements

Functional Requirements

- Display capacity of parking lots.
- Incorporate secure payment
- Allow for reservation of spots
- High-Resolution camera to track parking occupancy

Non-Functional Requirements

- Easy-to-use mobile interface
- Consistent behavior
- Modular Hardware

Design

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Project Breakdown

Raspberry Pi w/ Camera(s)

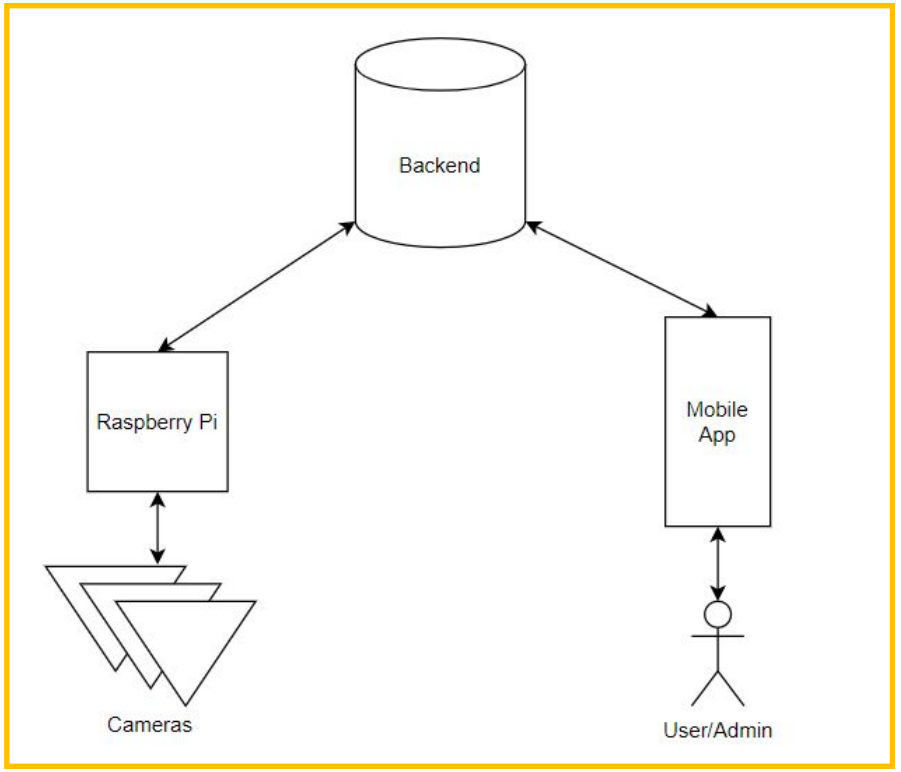
- Data Capturing

Backend Server

- Hold user and parking data

Mobile App

- Users find and reserve spots



Frontend Design

- **Application Built With:**
  - **React Native** - Cross-platform framework with native components
  - **Axios** - HTTP(S) client for API requests
  - **Stripe** - Handles secure in-app payments
- **Application Structure:**
  - **Login/Register page** - Auth via POST requests
  - **Map (Home) page** - Map, location, and availability
  - **Reserve page** - Lot info/blocks displayed, reservation/payment
  - **Profile page** - Logout and preferences

Server Design

Docker

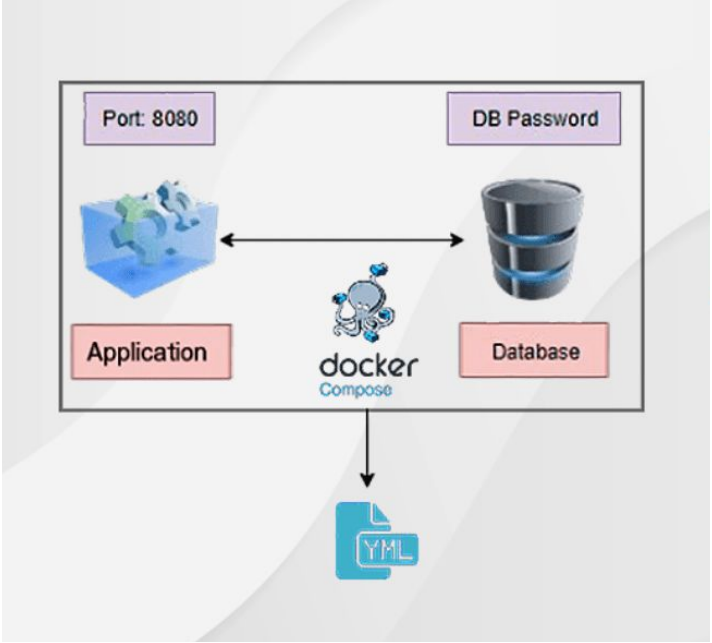
- Portability
- Scalability

Docker Compose

- Spring Boot container
- MySQL container

IASTATE Virtual Machine

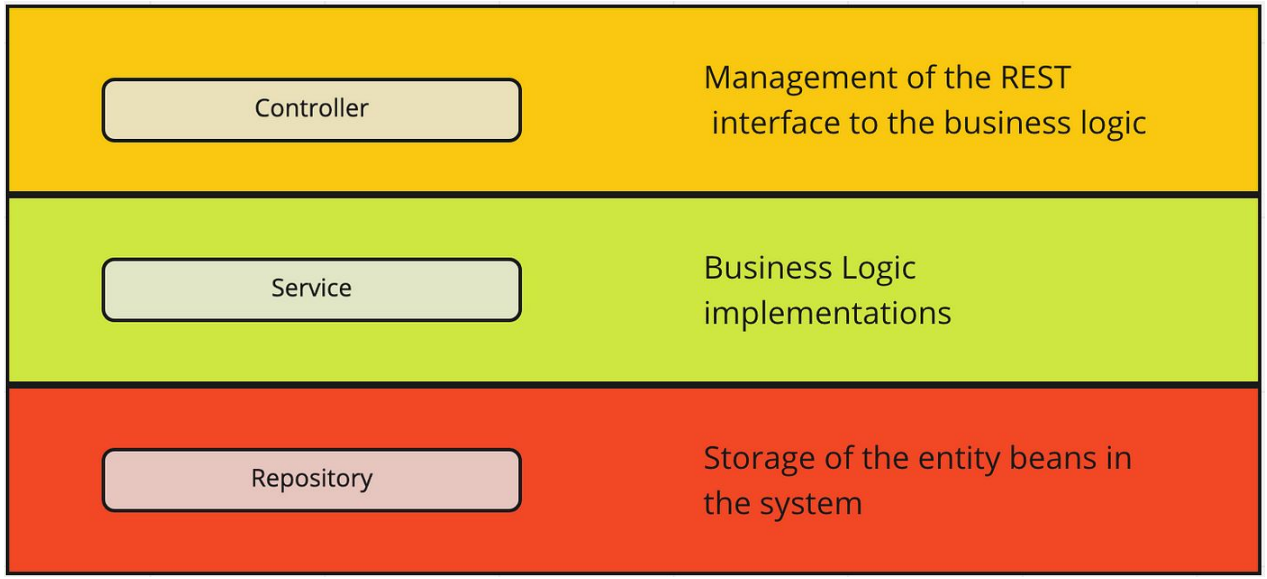
- Free and configurable
- Reverse Proxy



Backend Design

Spring Boot

- Manages complex data relationships
- Controller-service-repository architectural model
- RESTful APIs
- Scheduled events



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Hardware Design

Camera Module

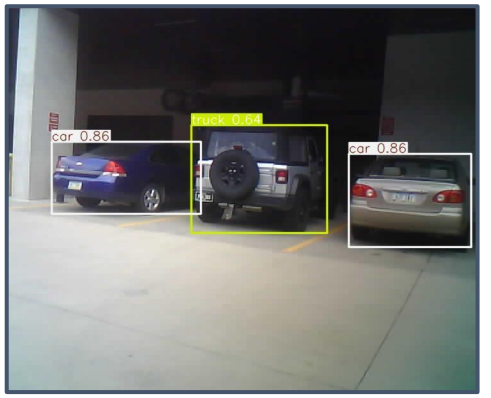
- ArduCam 16MP USB Camera

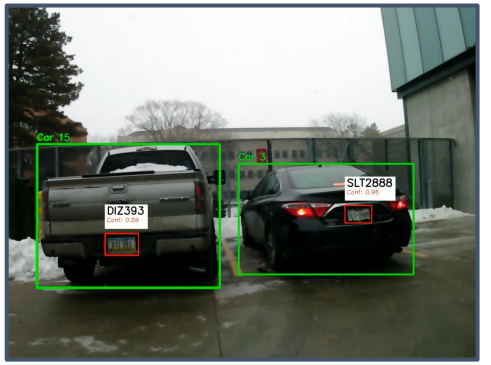
Raspberry Pi

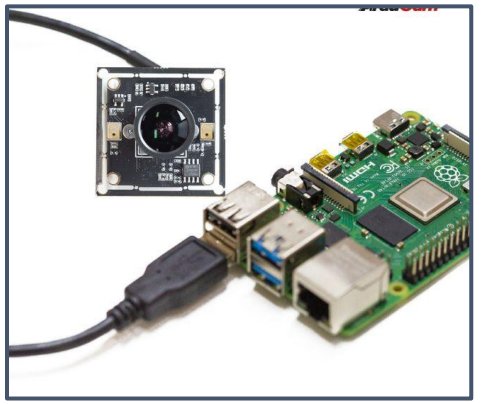
- Pi 5 8GB
- Docker Container with Watchtower
- AI Hat+ 26 TOPS

Machine Learning

- YOLOV8
- PaddleOCR







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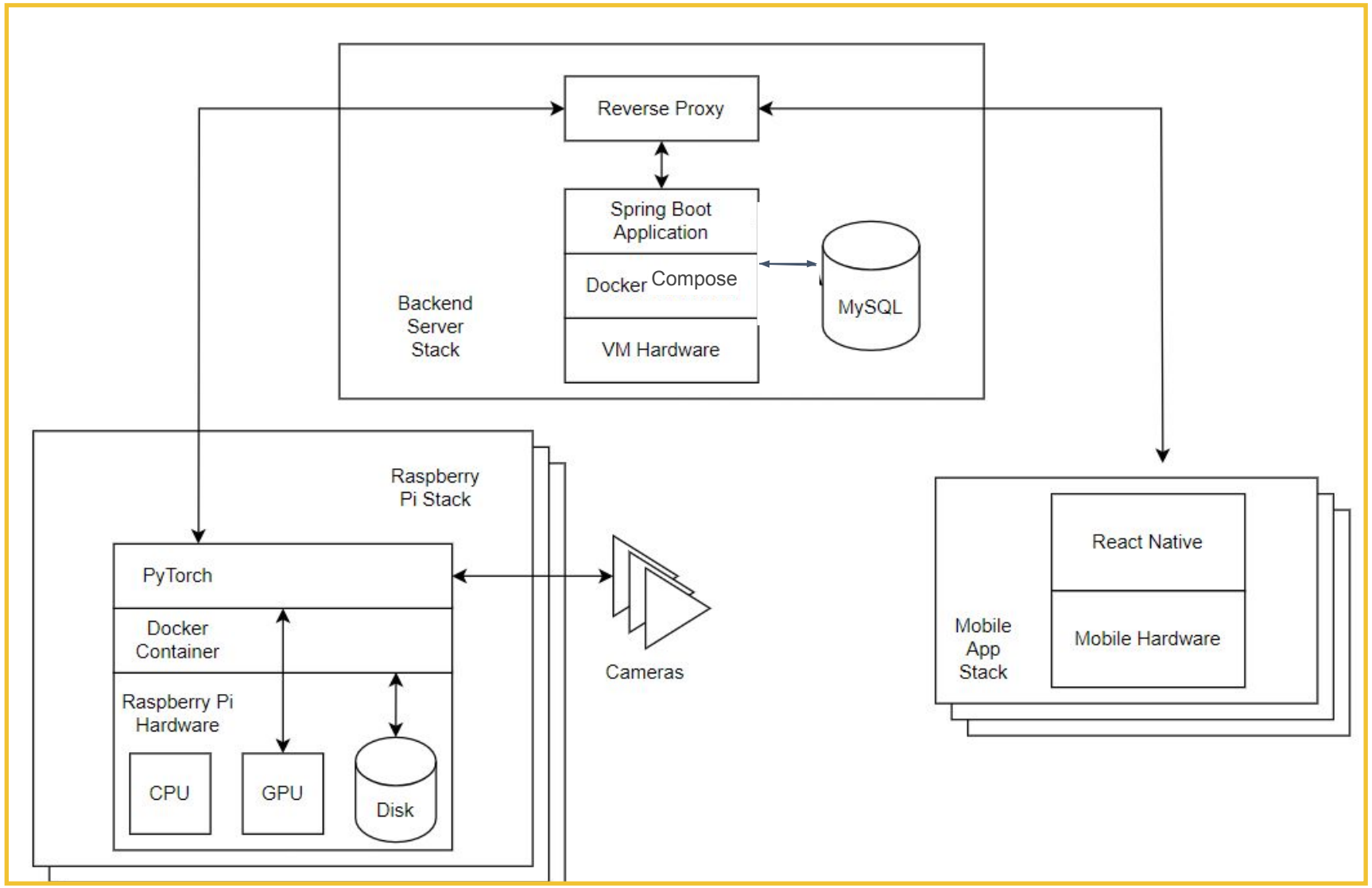

Testing

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Frontend Testing

System Testing

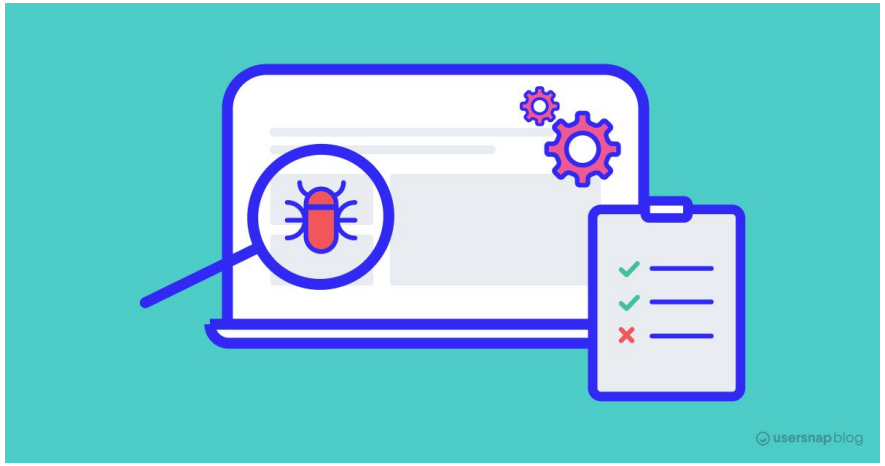
- End to end run
- Car to mobile app updates

Regression Testing

- Each feature functionality tested after every merge request

User Testing

- Application simulated by real users



Backend/Hardware Testing

Backend server:

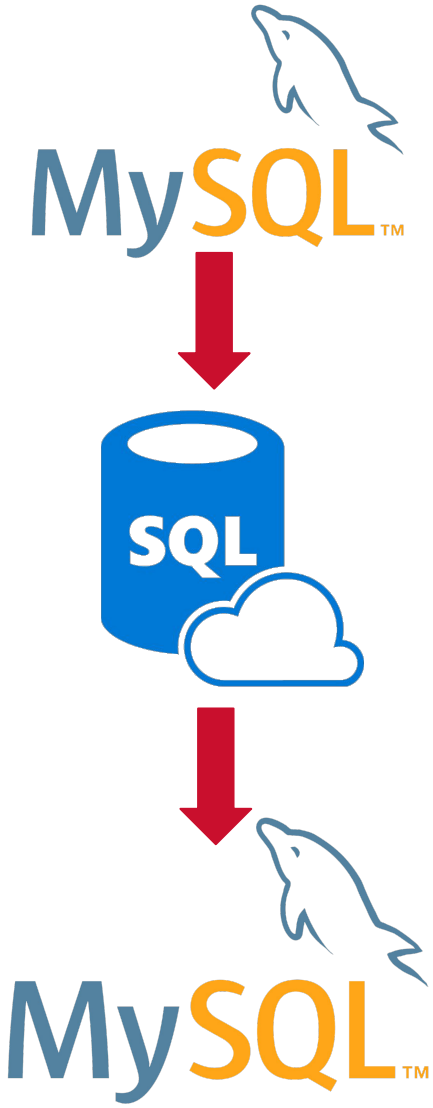
- Postman
- Opened debugging port in Docker container, VS code debugger

Hardware:

- Pi to camera
- Pi to server
- Monitoring a real car using the lot

Iterations

Cloud Migration



Migrated backend server to Azure

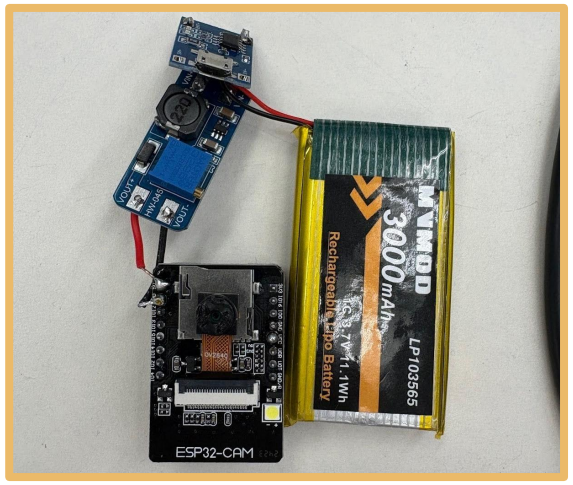
Motivation:

- Scalability
- Azure Service

Result:

- Worked initially
- Cost too high

ESP32 to ArduCam



ESP32:

- Wireless
- Low-power
- Low-resolution

ArduCam:

- USB
- High-resolution

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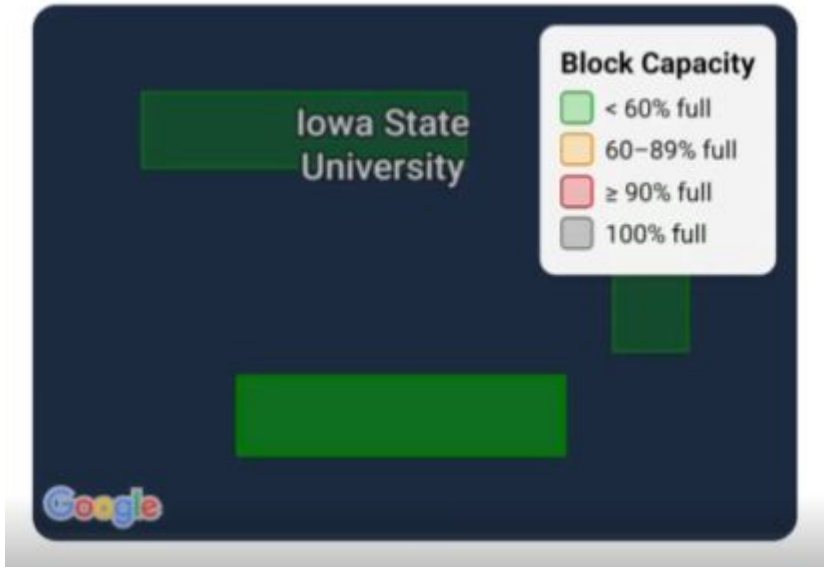
Moving to Parking Blocks



Motivation:

- Less overhead for moving reservations
- Simpler UI/Flow

Impact:

- Reworked reservation handling
- Reworked requests related to lots

Results

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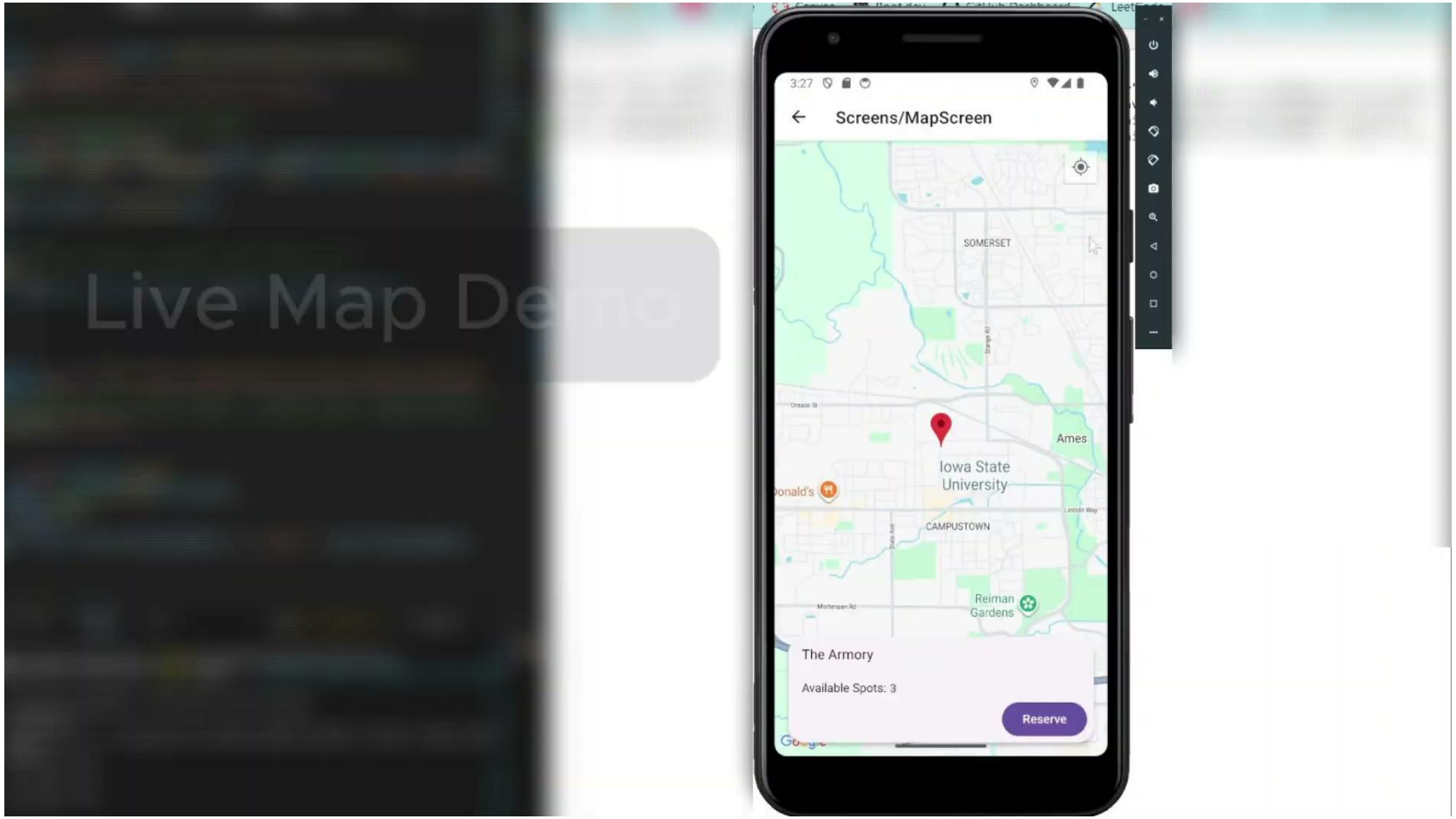
Live Map Demo



Summary of Progress

Improving User Flow

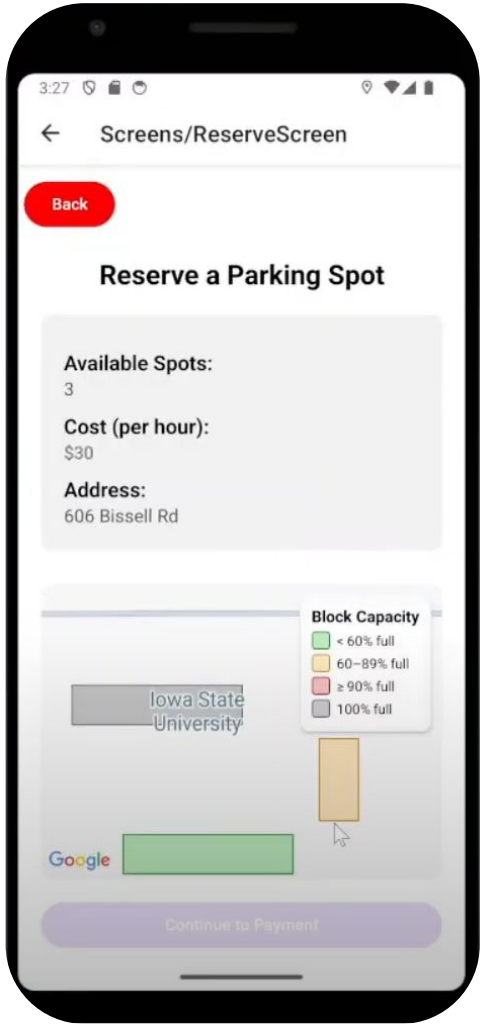
- Profile Screen from map
- Merging reservation and payment processes

Transitioning UI components to React Paper

- Dark mode
- Unified Styling

Live Map

- Color coded blocks based on occupancy
- Clear legend
- Block selection



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Summary of Progress (cont.)

Parking Blocks

- New representation that covers more edge cases
- Improves lot management

Reservations

- Moving reservations
- Checking car non-violator

Stripe API Payment

License Plate Detections

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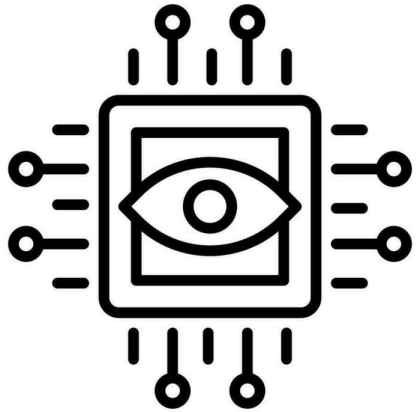
Value Added

Proof-of-Concept

- Showed a high-resolution camera can enable a parking capacity app

Design Decisions

- Frontend has been implemented in a feasible, ethical, and realistic way
- Backend / hardware implements modern computer vision technology to monitor lot capacity



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Next Steps

Admin Website

- Creating dynamic parking lots
- Assigning cameras to specific spots

More Reservation Control

- Modify, extend, or cancel reservations

LEDs to Enable Reservations

Work with ISU Parking for Trial

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Questions?

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THANK YOU

Ethical Considerations

- Handling sensitive user data (passwords, payment, location, etc.)
  - Encrypting data on backend
  - Adding HTTPS for all communications
  - Restrictions on Pi
- Privacy
  - Attackers could try to access parking lot images
  - Access to vehicle and person location (Flock Cameras)
- AI Model Concerns
  - AI Model could have bias
- App Use
  - Driving while on phone in parking lot

Frontend Dependency Issues

Frontend Dependency Issues

- Made testing more time consuming
- Tedious to update dependencies
- IOS device auto updated and project became deprecated on new version

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Edge Cases

Questions:

- User parks in invalid parking spot
- User parks poorly (takes up multiple spots)
- User parks without paying
- Someone takes a user's reserved spot

Solutions:

- Contact parking division
- Notify parking division after set duration
- Contact parking division
- Contact parking division, reassign the user to a new spot

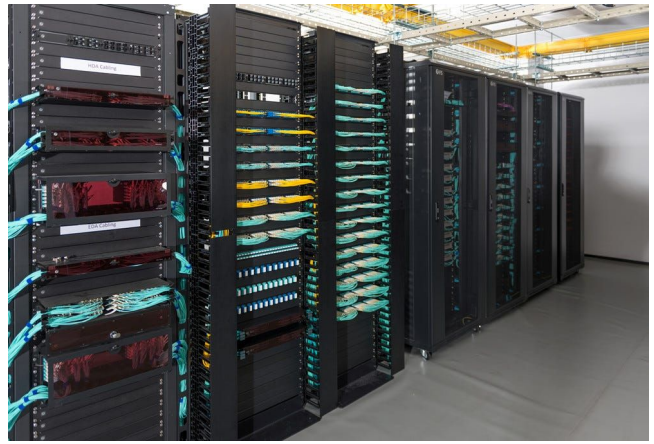
Cost

Camera Modules: $69.99

Raspberry Pi w/ AI Hat: $269.95

Server: Free through ISU

Price per lot: $269.95 + $69.99 per camera



Important Topics to Cover

Design problem and context

◦ Convey appropriate detail to contextualize your design work

◦ Convince audience of the importance of addressing the problem

Requirements

Overview of your design/collaboration process

◦ Explain the approach you took and why

Design

◦ Demonstrate quality of engineering problem-solving, decision-making, and judgment

◦ Communicate essential details of your solution (high level and key details)

Testing

◦ High level overview of process (to demonstrate quality of approach)

◦ Key testing details and outcomes (to demonstrate rigorous testing and convince of project outcomes)

Results

◦ Key takeaways regarding project progress

Iteration

◦ Lessons learned