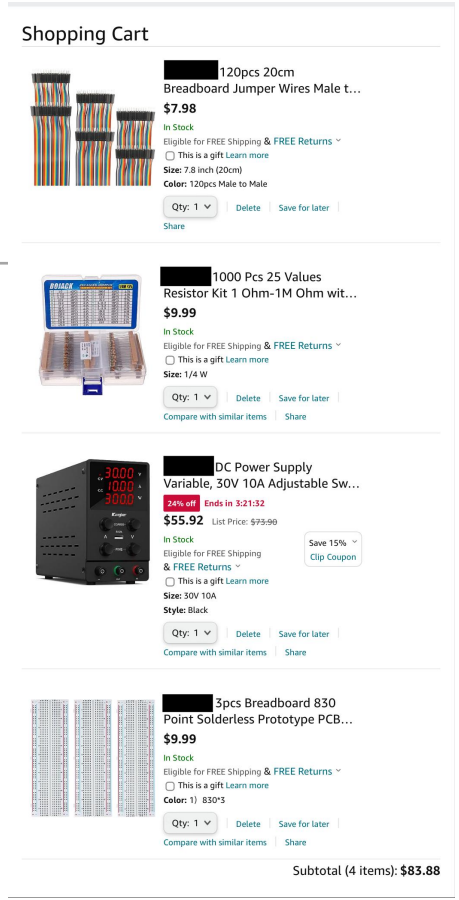
Use Case

- Electronic circuits are **potentially dangerous** and **lack accessibility**
- **Benefits to drawing circuits** on paper
  - Good to connect symbols to components
  - Kids like to draw!
- Solution: build a system that **takes a picture** of a drawn circuit, **simulates circuit**, and **renders annotated schematic**
  - Learning and verification tool
- ECE Areas: Software, Circuits

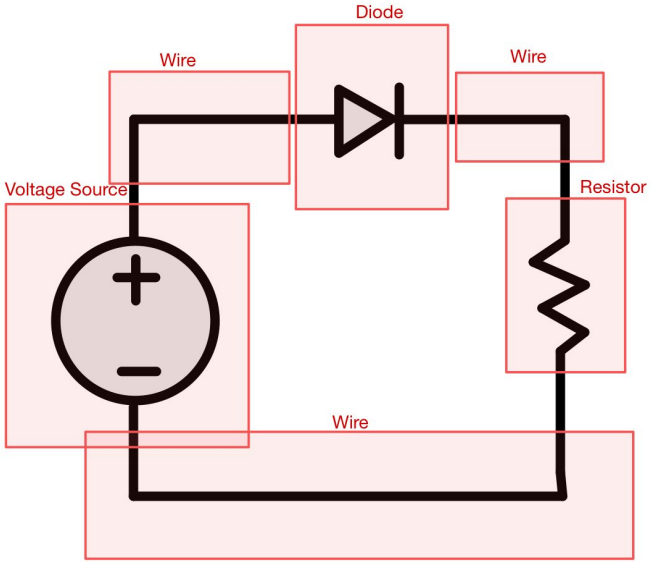
Requirement 1: Ease of Use

- Accessibility
  - More hardware = more expensive
  - Users **only need internet access** and **camera**
  - **No additional purchases** needed
- Usage
  - Minimal interaction
    - Draw, take picture, wait



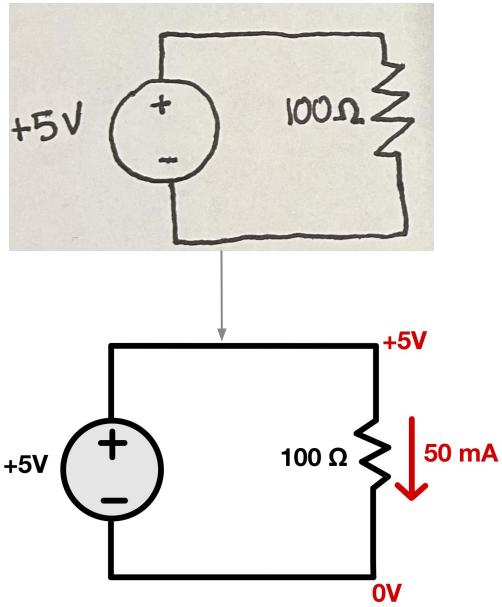
Requirement 2: Circuit Detection Accuracy

- Individual component accuracy
  - **90%**
- Full circuit detection accuracy
  - **80%**
- Poor drawings can always be redrawn

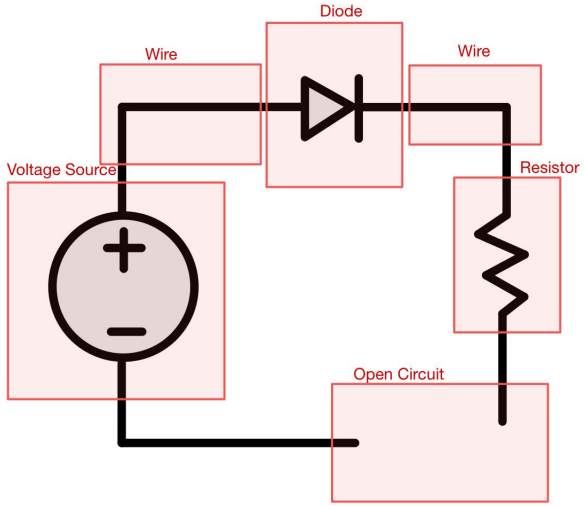


Requirement 3 - Simulation Accuracy

- Identifying the circuit as **valid or invalid**
- Identifying **voltage and current** at every node
- We should **always be right** given the circuit was identified properly



Technical Challenges



- Computer Vision
  - Electrical component detection
    - **Value** aspect and **component** aspect
    - Different orientations, handwriting, lighting, sizes
  - Individual component detection -> combined circuit
- Representation of **schematic** as **data**
- **Recognition** of **malformed** circuits (many edge cases)
- **Algorithmic complexity** of circuit **simulation**

Solution Approach - Overview

- Only need a **camera** and **internet access**
- **Entirely software and web-based**
  - Requiring a Raspberry Pi = unnecessary costs
  - Budget covers cloud computing costs
- Support **basic electrical components** and **only DC analysis**
  - Voltage/current sources, wires, resistors, lightbulbs, switches, silicon diodes
- Unique **link** can be **accessed anytime**
  - Utilize a database
  - Good for educational settings

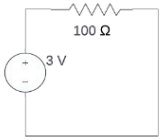


Image Upload

User Browser

simulpaper.com/upload

Here's your link:
simulpaper.com/url?id=...

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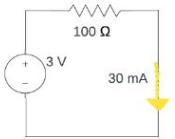


Post Request (axios)

URL Display HTML

GET Request For Circuit

Schematic UI

AWS EC2 Instance - Web Application (Node.js + React)

Generate simple page for displaying unique URL

Generate React components and UI for circuit schematic

Forwarded Post Request

POST Response With Unique URL

Forwarded GET Request

Circuit Data

AWS EC2 Instance - Backend

API Endpoint to Feed Image to CV System

CV System

Component detection & classification

Value detection & classification

Circuit building

Circuit Data Structure

Circuit Simulator

Labelled Circuit Data Structure

Generate unique URL and store labelled circuit data structure in database

Recieve GET request for circuit ID, query database for circuit, return circuit to frontend

AWS RDS Database

Testing and Verification

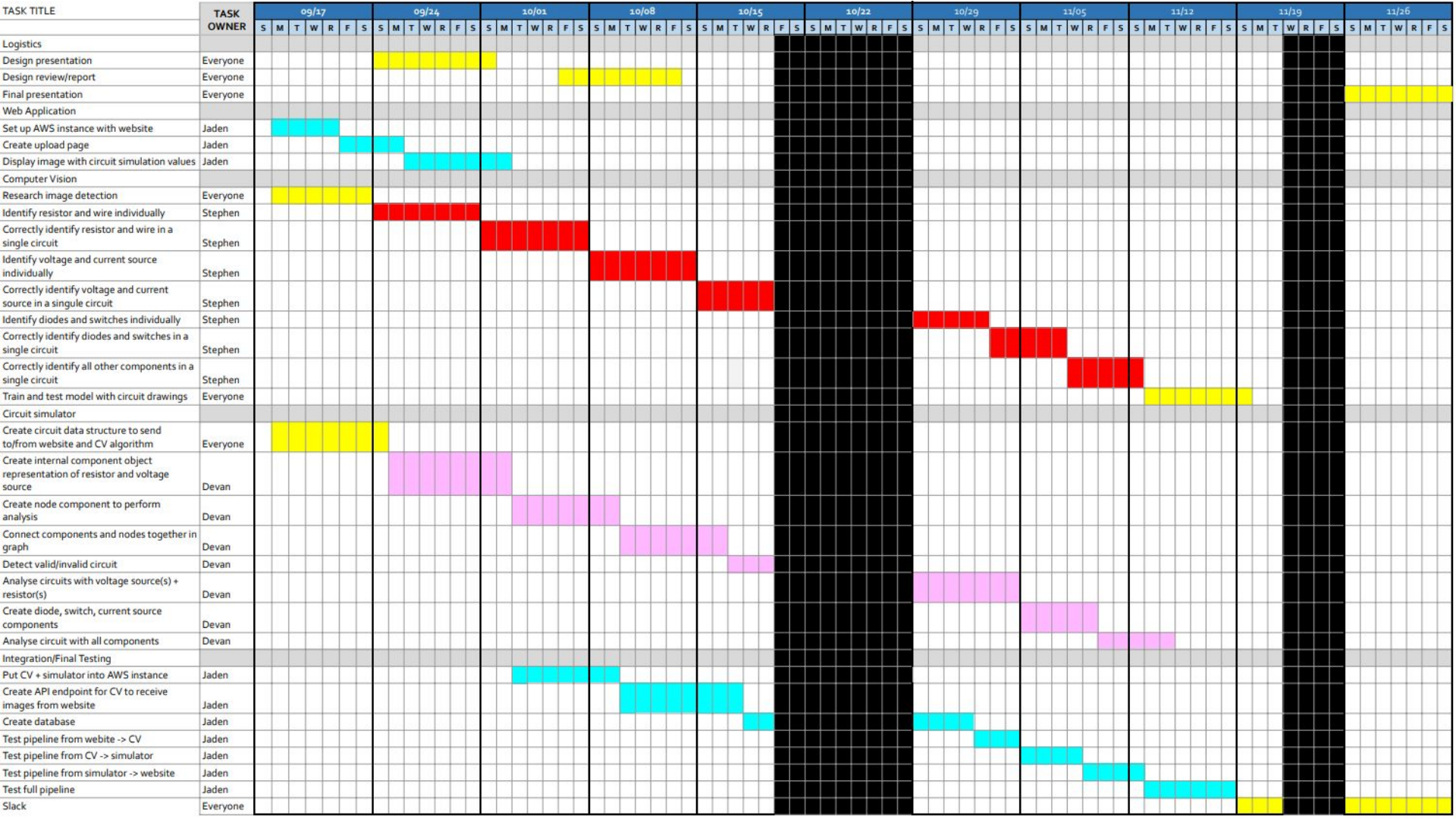
- CV functionality
  - **Unit tests on each component** to ensure 90% accuracy
  - Test with full circuits with 80% accuracy
    - **Draw circuits (valid + invalid)** and compare with created data structures
- Circuit simulator functionality
  - **Identify validity** of circuits with 100% accuracy
  - Correctly **calculate different electrical values** given a circuit with 100% accuracy
    - Test by hand calculating values / pre-calculated circuits

Testing and Verification

- Website functionality
  - Validate schematic UI
    - **Cross-check labelled values** with backend-calculated values
  - Verify circuits are saved in database with unique URL
  - Ensure intuitive UI for all users
    - **Qualitative testing** with human users
- Integration Testing
  - Validate each **step in pipeline**
    - Image upload -> CV -> circuit simulator -> website UI

Task Distribution

- Computer Vision
  - Individual component detection (**Stephen, Jaden**)
  - Complete circuit detection (**Stephen**)
  - Training and testing models (**All**)
- Web Application
  - CV + image endpoint APIs (**Jaden**)
  - Website schematic UI (**Jaden**)
- Circuit Simulator
  - Circuit data structure for CV + website (**All**)
  - Circuit/component analysis (**Devan**)
- Integration + Testing (**All**)


TASK TITLE
TASK OWNER
09/17
09/24
10/01
10/08
10/15
10/22
10/29
11/05
11/12
11/19
11/26
S M T W R F S
Logistics
Design presentation Everyone
Design review/report Everyone
Final presentation Everyone
Web Application
Set up AWS instance with website Jaden
Create upload page Jaden
Display image with circuit simulation values Jaden
Computer Vision
Research image detection Everyone
Identify resistor and wire individually Stephen
Correctly identify resistor and wire in a single circuit Stephen
Identify voltage and current source individually Stephen
Correctly identify voltage and current source in a singule circuit Stephen
Identify diodes and switches individually Stephen
Correctly identify diodes and switches in a single circuit Stephen
Correctly identify all other components in a single circuit Stephen
Train and test model with circuit drawings Everyone
Circuit simulator
Create circuit data structure to send to/from website and CV algorithm Everyone
Create internal component object representation of resistor and voltage source Devan
Create node component to perform analysis Devan
Connect components and nodes together in graph Devan
Detect valid/invalid circuit Devan
Analyse circuits with voltage source(s) + resistor(s) Devan
Create diode, switch, current source components Devan
Analyse circuit with all components Devan
Integration/Final Testing
Put CV + simulator into AWS instance Jaden
Create API endpoint for CV to receive images from website Jaden
Create database Jaden
Test pipeline from webite -> CV Jaden
Test pipeline from CV -> simulator Jaden
Test pipeline from simulator -> website Jaden
Test full pipeline Jaden
Slack Everyone

Conclusion

- Use-case: **lack of accessibility** for learning basic electronic circuits
- MVP
  - CV algorithm that can detect circuits and components
  - Fully functional DC circuit simulator with limited components
  - Web UI to display simulated circuit