Wireless Charging Table Supporting Multiple Devices with Arbitrary Placement

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Wireless Charging Requires Alignment

- Wireless charging hotspots on tables
- At cafeterias and coffee shops
- Fixed coils restrict customers' positions
- Misalignment reduces charging efficiency

Image source: mobilefun.com

Our Solution: Move Coils Automatically

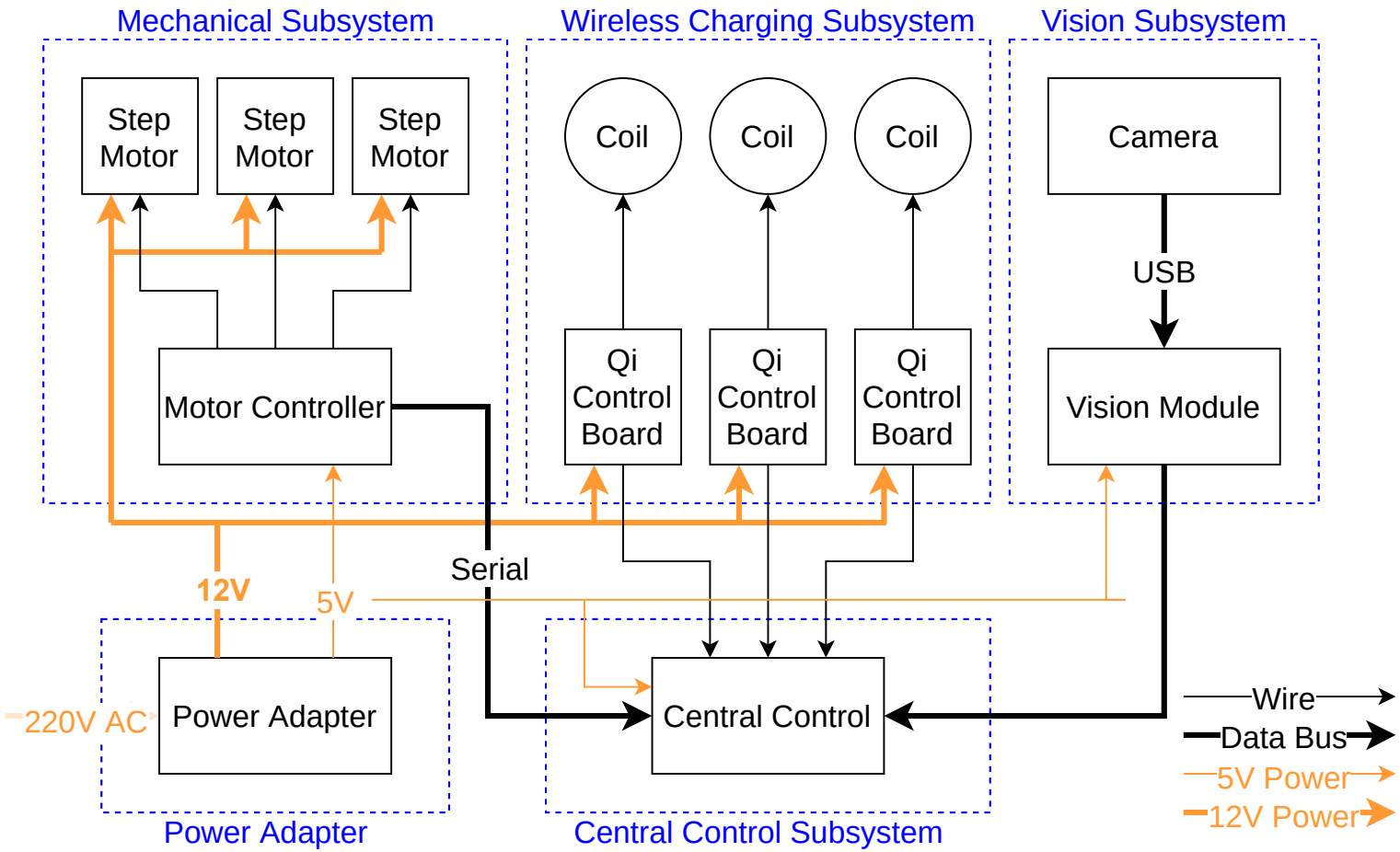
- Using mechanism like 3D printer
- Recognize devices with computer vision
- Qi wireless charging standard

Image source: mobilefun.com

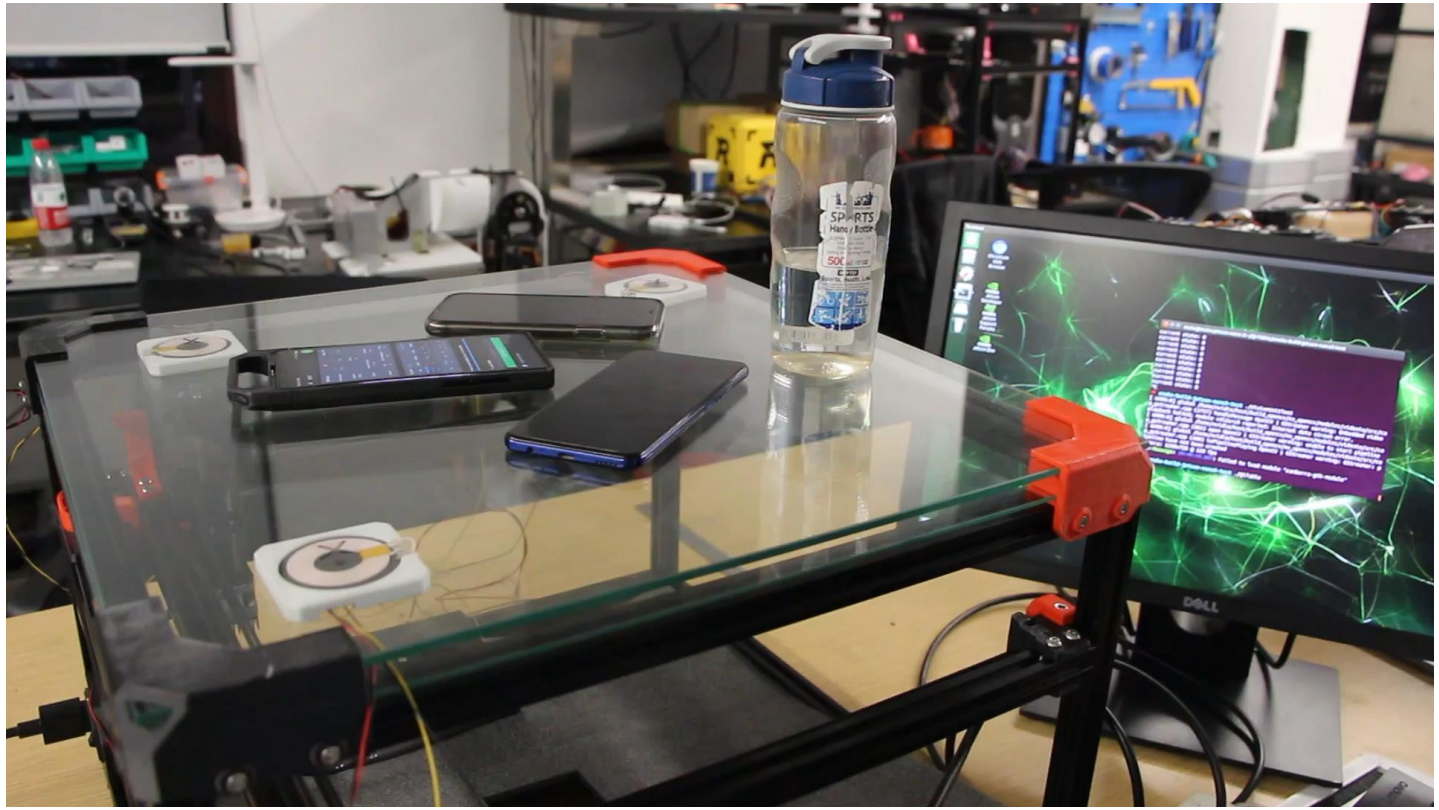
High-Level Objectives

- Charge 3 devices concurrently
- Maximal 15W each
- Accommodate phone cases up to 2mm
- Response within 15s after device placements
- Recognize and memorize Qi-incompatible devices
- Withstand 20kg at the center of table surface

Four Main Subsystems + Power Supply

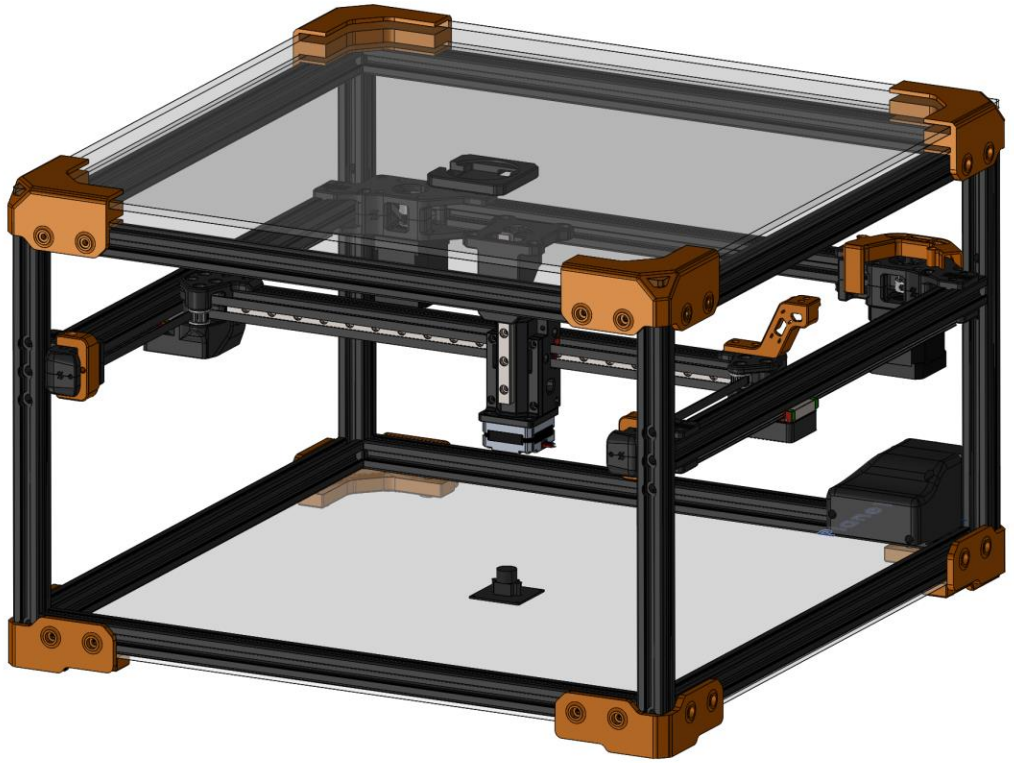


Our System Works Well!



Physical Design of Three Layers

- **Top:** two glass sheet of 5mm and 3mm, above and below charging coils
- **Middle:** 3D motion system with a magnetic grabber.
- **Bottom:** all the electronics and the camera at the center



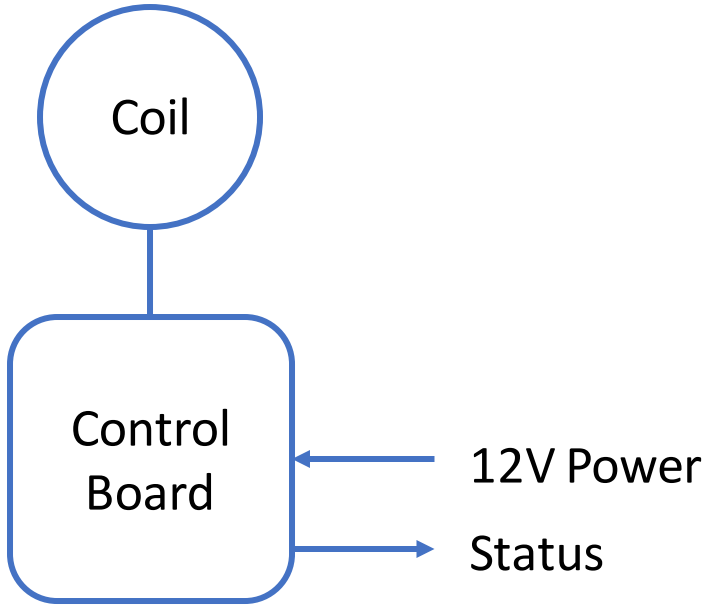
Mechanical Subsystem

- Core-XY motion system:
  - Partially adapted from Voron Design[1].
  - Advanced 3D printer structure with low moving weight.
  - 0.012mm accuracy, $600\text{mm}/s$ speed, $5{,}000\text{mm}/s^2$ acceleration
- PETG for structural parts: rigidity and impact resistance.
- PBT for coil bases: self-lubricating and low friction coefficient.
- BigTreeTech SKR V1.3 with x86 chipset as the control board.

[1] https://vorondesign.com/

Wireless Charging Subsystem

- Commercial Qi module: coil + control board
- Output charging status
- Three modules
- In 3D-printed containers



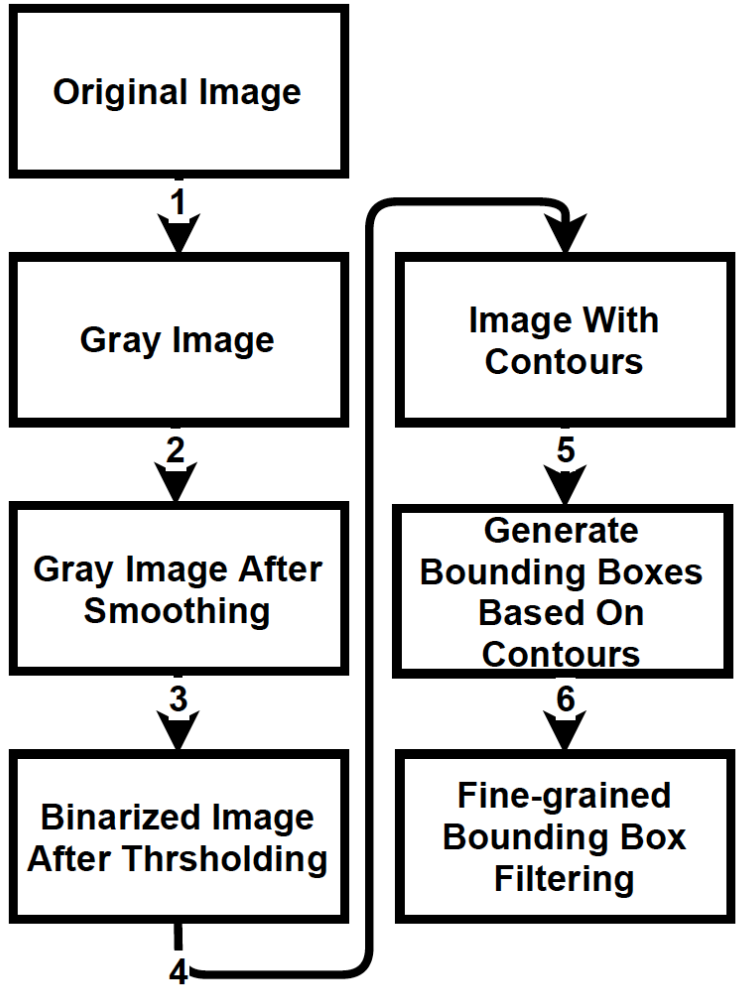
Qi Modules Meet Our Needs

- 10mm maximal charging distance by specs
- We use 5mm glass in actual implementation
- Accuracy requirements for vision detection and control unit

Surface Glass Thickness	Phone Case about 2mm	Result
3mm	No	OK
3mm	Yes	OK
6mm	No	OK
6mm	Yes	Require strict alignment

Vision: Original Design

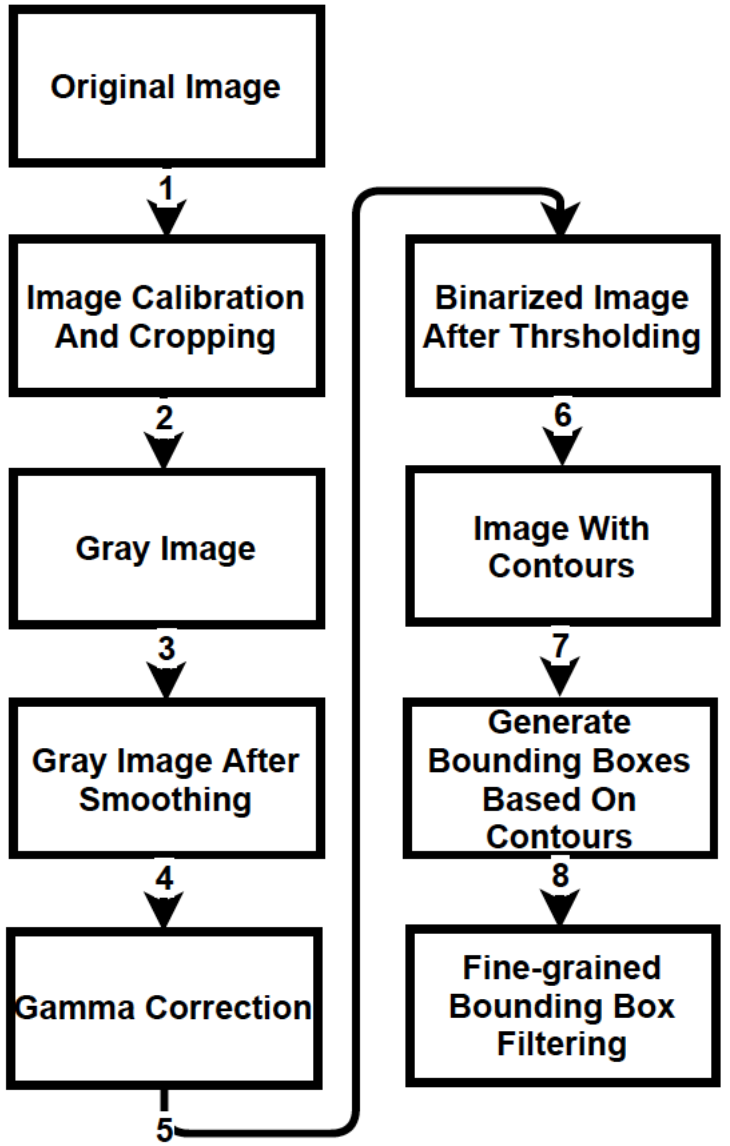
- Camera + Jetson Nano
- Camera right below the table
- Traditional object detection algorithms
- Inter-process communication with central control unit



Original Image Processing Pipeline

Vision: Changes

- New interface with the central control
- More information passed to the central control
- Image calibration and cropping
- Gamma correction



Final Image Processing Pipeline

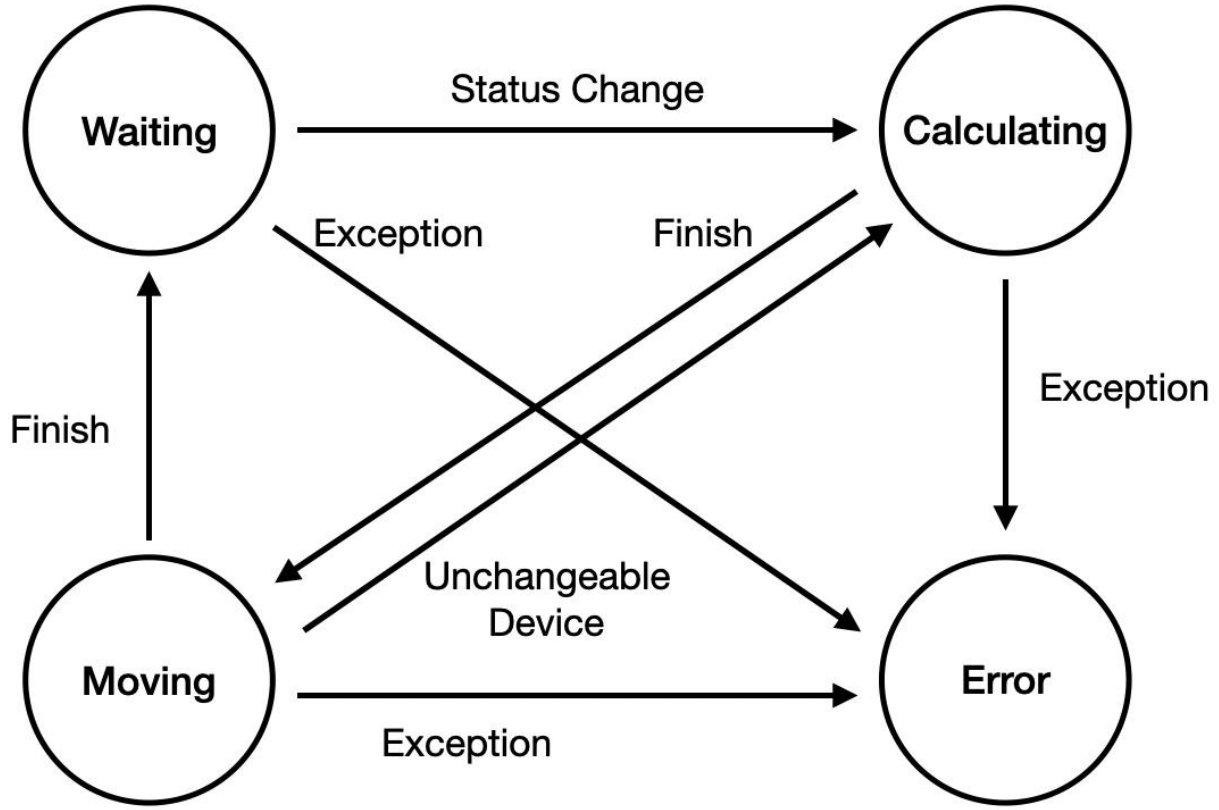
Testing of The Vision Subsystem

- Unit tests over the vision subsystem
  - Static image recognition
  - Real-time detection

The Central Control and the Vision Subsystem is on the same Hardware

- Linux OS on a multi-core CPU is available
- Easier communication
- Less hardware cost

Control Algorithm Uses a State Machine



Three Control Algorithm Highlights

- Resolve the conflict between vision and wireless charging statuses
- Explore around to overcome low-accuracy vision detection
- Schedule 3 kinds of moves differently to avoid collisions

We care about Ethics

- Potential damage caused by wireless charging
- Privacy concern of the camera

The Cost is Low

- ¥2000 in total
- Jetson Nano and Camera take a large fraction

Component	Quantity	Cost
NVIDIA Jetson Nano	1	769
Camera	1	445
Qi Module	3	84
Power Adapter	1	97.2
Mechanical Components		628.24
Total		2023.44

Vision Detection can be an Uncertainty

- Works well in the lab environment
- Gets threaten by complicated light conditions in real world

- Tune parameters for specific environments?

Future Work

- Alternative approach to detect devices?
- Detection for phones with white phone cases?

Thanks!
Q&A