HoloMon

A holographic entertainment system

Group A

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Presentation Overview

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1. Team Intro

Team Intro

Diego Rodrigues

(CpE)

Taniya Shaffer

(CpE)

Nathaniel Kissoon

(CpE)

Elizabeth Mikulas

(EE)

2. Motivations, Goals & Objectives

Motivations

- **Due to experiences with the Pandemic/Quarantine:**
  - Social anxiety
    - Struggle in the transition from quarantine to back to school/work/hobbies

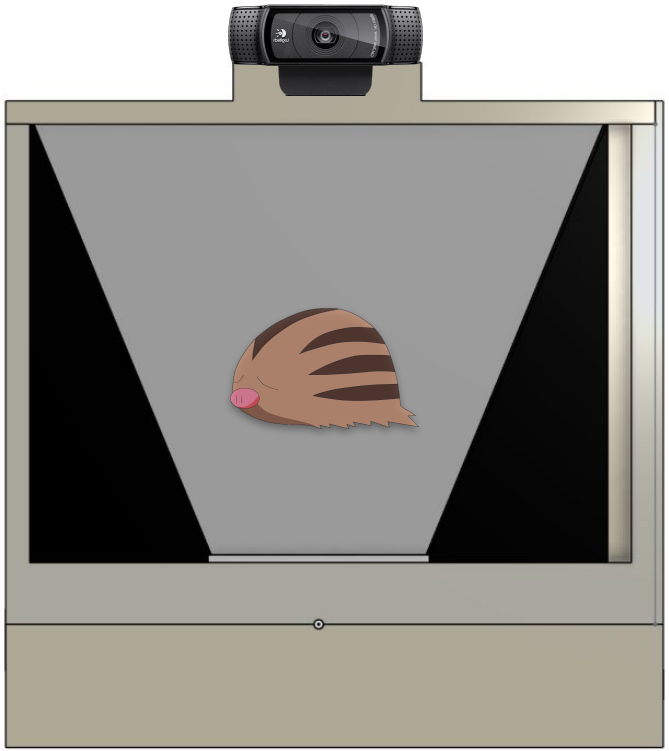
- **Goal:**
  - Create a form of entertainment that will motivate people to interact with each other
  - Make the HoloMon interactive with its user
  - To engage this device in a audience of all ages
    - What better way than to introduce a classic childhood icon played by millions?

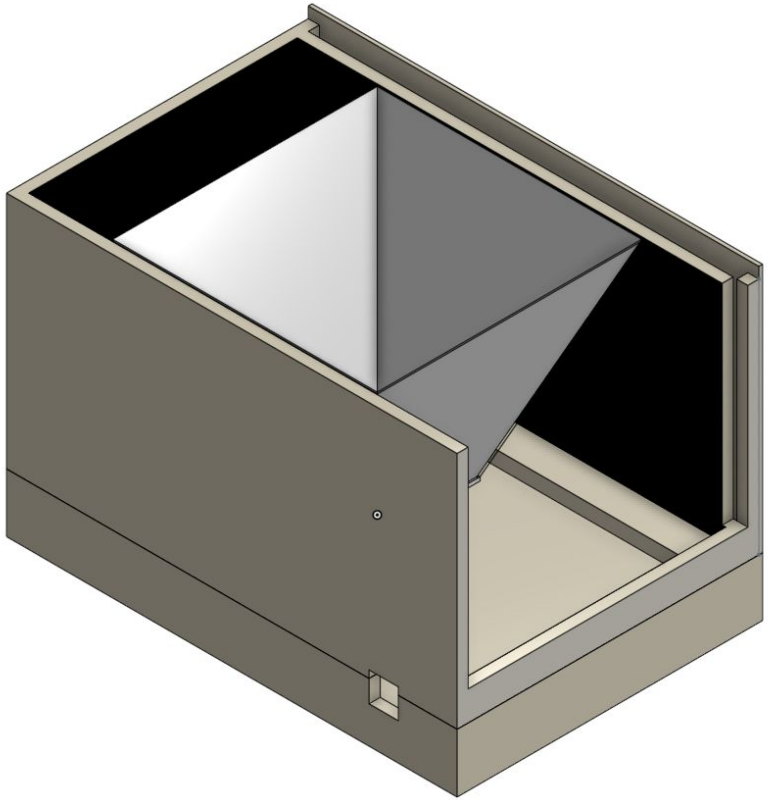
3. Engineering Specifications

#	Requirements	Units
1.1	The system requires a stationary holographic display unit for HoloMon.	32”x21”x24”
1.2	The system requires the ability to change the displayed HoloMon through a mobile app and bluetooth with a set maximum delay.	4 characters, <5 sec
1.3	The system requires that a user can interact with HoloMon using a camera and a gesture-based recognition machine learning model.	3 gestures, ≥40% accuracy
1.4	The system requires that the device can sustain power for a set duration of time without the need to recharge.	>1 hour
1.5	The system requires a cloud server (AWS) to host the server and mobile app components.	10 GB
1.6	The system requires HoloMon to have a set maximum delay to respond to gestures.	<1 sec
1.7	The system requires the mobile app user assets connection to the holographic display should have a set maximum delay.	<10 sec
1.8	The system requires that the budget not exceed a set maximum amount.	<$400

4. HoloMon Model

HoloMon CAD Model

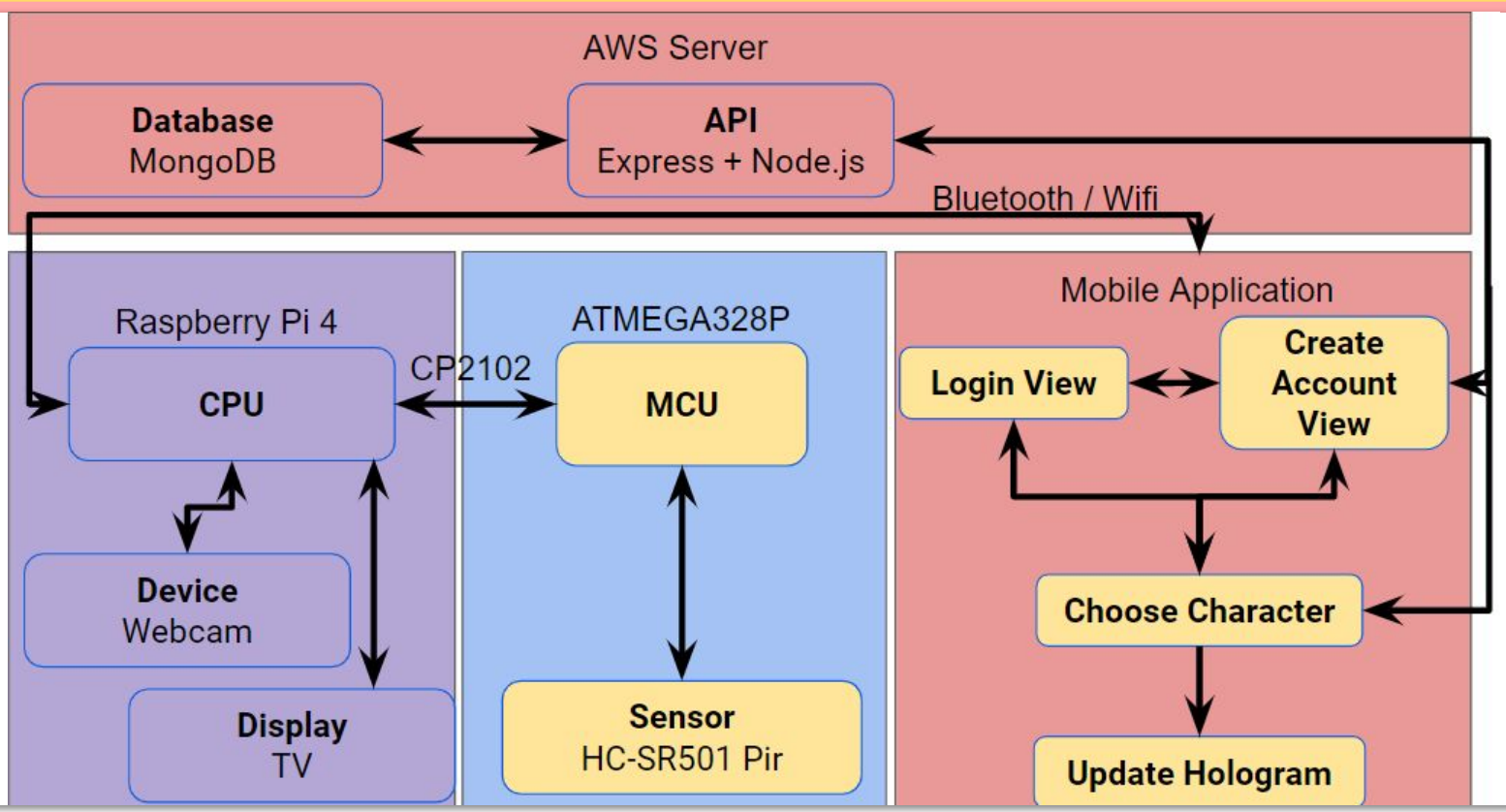




5. Project Block Diagram

Project Block Diagram

Diego | Nathan | Elizabeth | Taniya

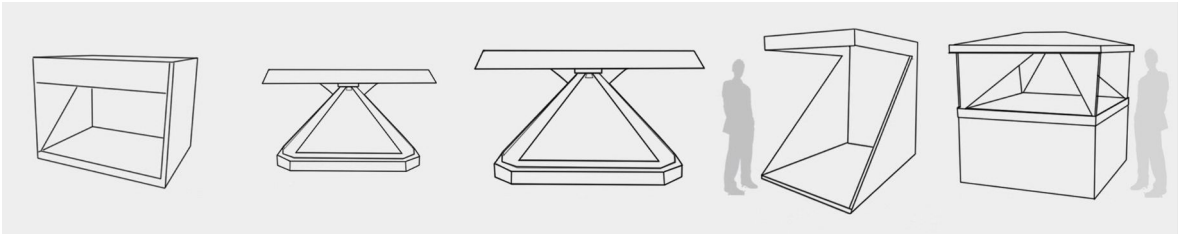


6. Existing Products

Existing Products

- Olomagic - Olomagic is a company creating holographic displays that generate 3D images in mid air
  - Not interactive
  - Mainly used for product advertisement

- SolidLight™ by Light Field Lab
  - Not interactive
  - Expensive



Current Olomagic products

7. Main Components Selection

HoloMon : Main Components

- ➔ Mobile Application
- ➔ Holographic Display
- ➔ Electronics
- ➔ Gesture-Based Recognition

Cloud Server

Using AWS as the Cloud Provider

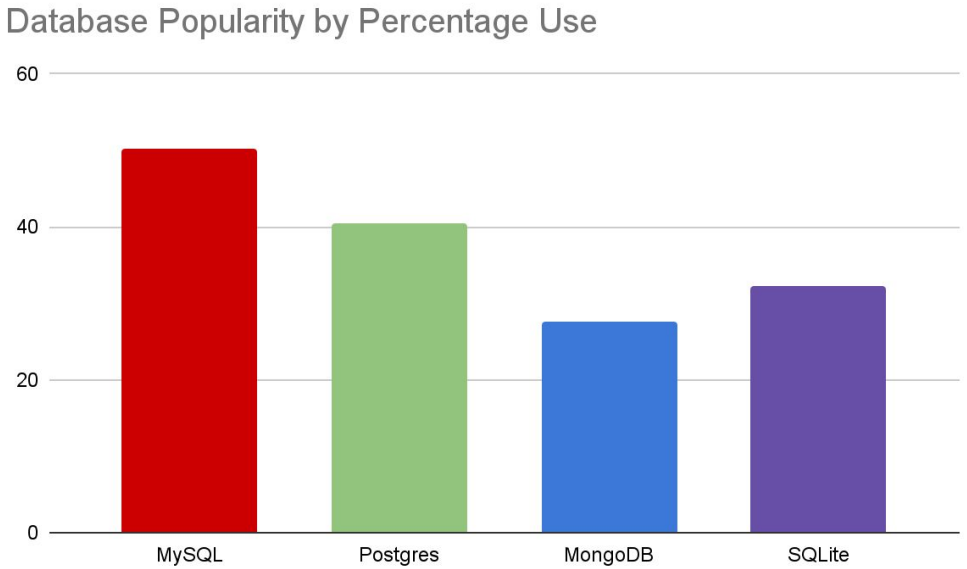
- Half of market share
  - More resources
  - Larger community
- Better familiarity
  - Previously used by team members
  - Instance already set up
- Better free tier
  - No point system
  - Less nuances

AWS	Azure	Google Cloud
10GB Storage	500GB Storage	10GB Storage
10,000 Git requests monthly	5G Outbound data	50GB outbound data
750hr/month (EC2)	400 requests to storage/month	2m HTTP invocations
1GB RAM	1M requests/month	1TB of queries

Database

MongoDB for Data Management

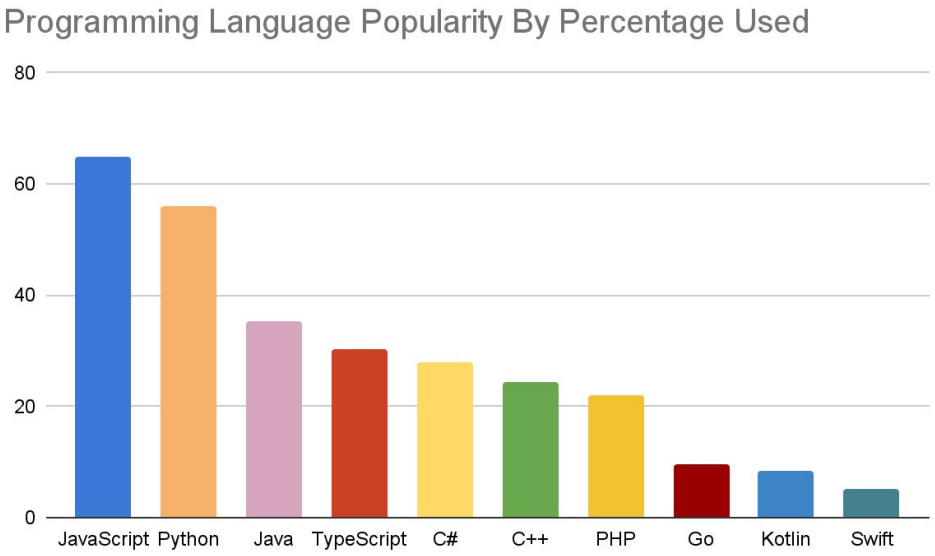
- Non-relational
  - More flexible
    - Unordered data
    - Easier for prototyping
    - Dynamic Schema
  - Scalable
- Large community
- Easy to use



API Framework

Node.js and Express for the Backend

- JavaScript Community
  - Great documentation
  - Easy to use
  - Most of team knows JS
- Works well with MongoDB
  - Mongoose
    - Well documented in JS
- Type safe
  - TypeScript
    - Easy to debug



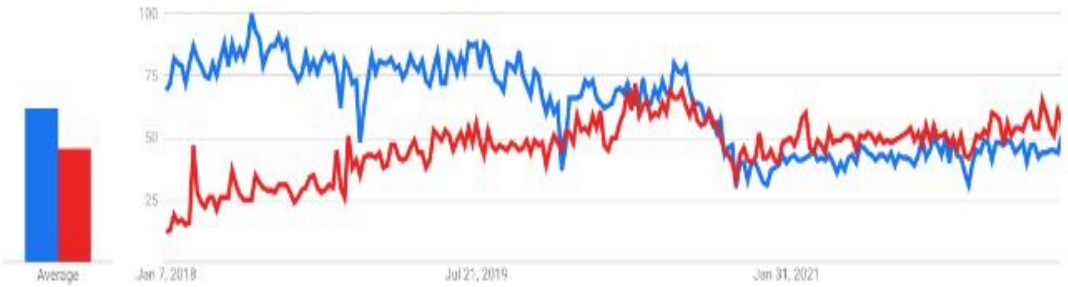
API Endpoints

- **API/Login**
  - Sends {UserName, Password}
  - Returns {JWT, status code}
- **API/Register**
  - Sends {Username, FirstName, LastName, DOB, Password}
  - Returns {status code}
- **API/GetUser**
  - Sends {JWT}
  - Returns: {All of user data - Password}
- **API/PostPokemon**
  - Sends {JWT, pokemon enum}
  - Returns {status code}
- **API/GetPokemon**
  - Sends {JWT}
  - Returns {status code, pokemon asset}

Front-End

React Native in the Frontend

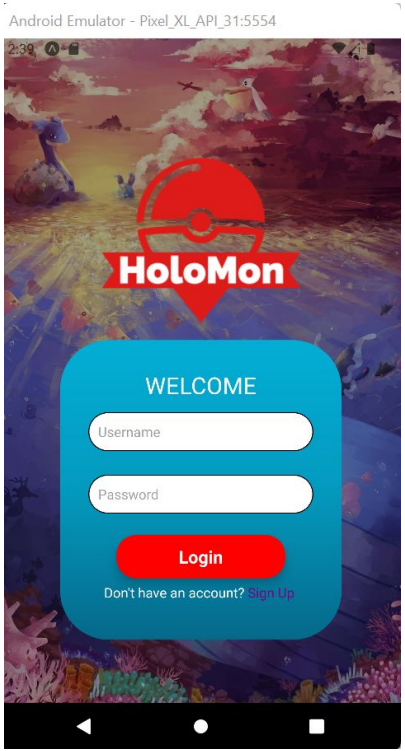
- One code base
- JavaScript
  - Same language as backend
  - Very similar to React.js
  - Large community
    - Variety of 3rd party packages
- Great documentation
- Performant
- Expo Go

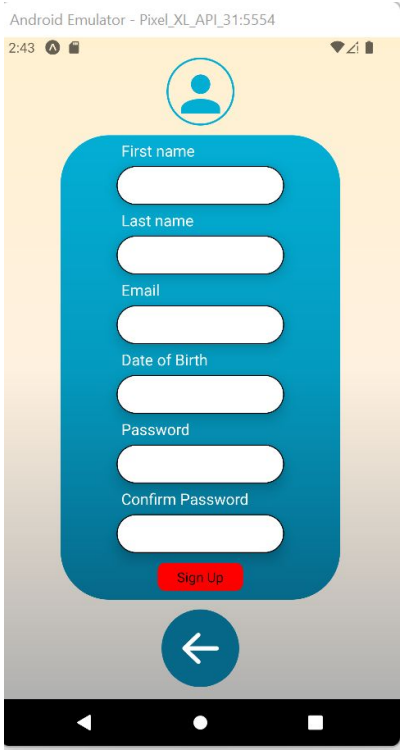


United States Flutter (red) and React Native (blue) popularity trend (2018–2022).

Source: Google Trends

Front-End UI Diagram

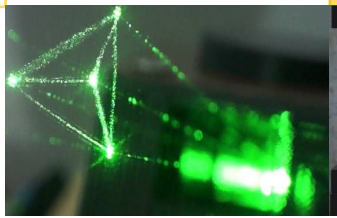
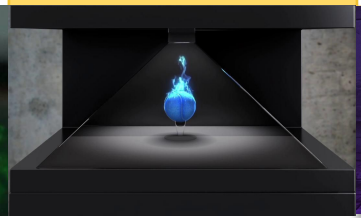




HoloMon : Main Components

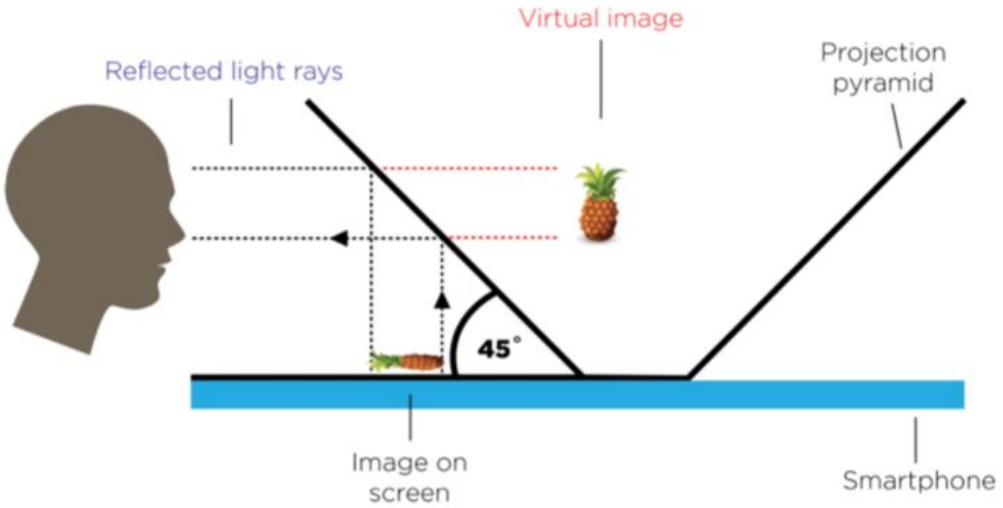
- ➔ Mobile Application
- ➔ Holographic Display
- ➔ Electronics
- ➔ Gesture-Based Recognition

Parts Comparison : Hologram

	Laser Hologram	Pepper's Ghost Illusion	LED-Hologram	Volumetric 3D Display
Parallax	Yes	No	No	Yes
Autostereoscopic	Yes	Yes	Yes	Yes
360 Viewing Range	Yes	No, has some blocked edges	Yes	Yes
Cost	~$1000s	~$20	~$100	~$700-$1000s
				

Pepper’s Ghost Illusion

- Image is reflected on a transparent screen at a 45-degree angle
- No parallax
- Autostereoscopic
- Popular in amusement parks and concerts
- Difficulty scaling



Pepper’s Ghost Illusion Demonstration

Parts Comparison : Display Material

Material	Light Transmittance
polycarbonate (PC)	~88%
(polymethylmethacrylate) PMMA	~93%
Polyethylene terephthalate (PET)	~88%
Polyvinyl chloride (PVC)	~82%

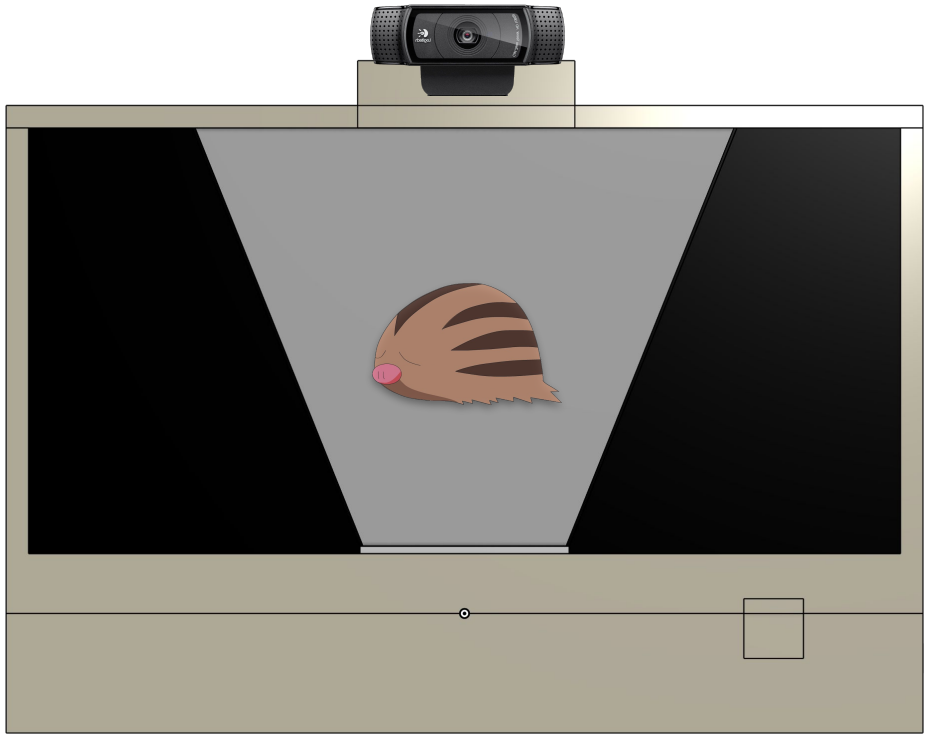
- Plexiglass or PMMA
- Higher transparency will result in better hologram quality

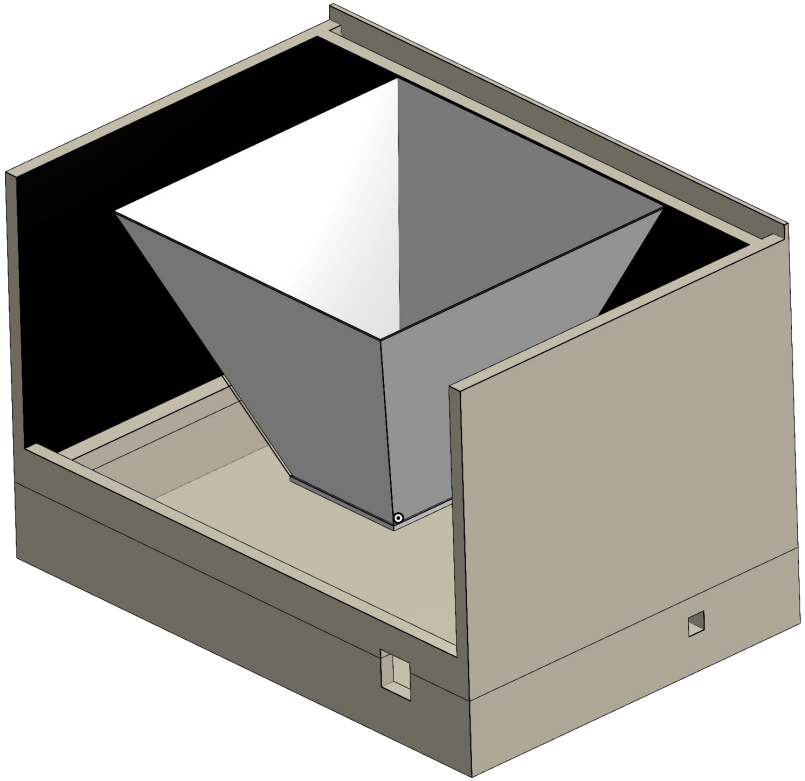
Parts Comparison: Housing Unit

- Hologram sensitive to vibrations
- Main criteria for selection
  - Standard width = 0.75″
  - Sheet size = 3/4″ x 2’ x 4’

Material	Cost	Weight
Hardwood Plywood	$38.14	207.89 lbs
Pressure-Treated Plywood	$27.29	348.5 lbs
Medium Density Fiberboard	$27.98	43.5 lbs

HoloMon Model





HoloMon : Main Components

- ➔ Mobile Application
- ➔ Holographic Display
- ➔ Electronics
- ➔ Gesture-Based Recognition

List of Electronics Used in HoloMon

- Raspberry Pi
- PCB Board - ATMEGA328P Chip
- Motion Sensor
- USB-TTL Converter
- Power Supply
- Webcam
- TV Monitor

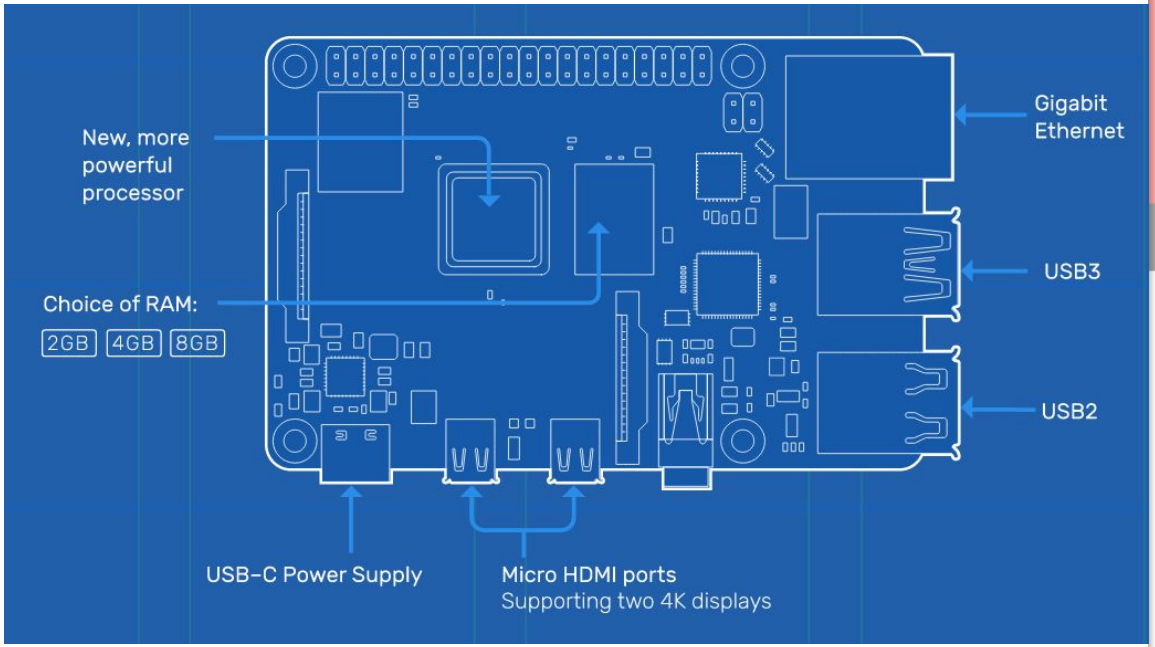
Parts Comparison : Single-Board CPUs

Criteria	Raspberry Pi 4B	Orange Pi Zero	Nvidia Jetson NANO
GPU	Broadcom VideoCore VI	Multi-core, Mali T720	Maxwell 128-core GPU
CPU	Quad-core 1.5GHz ARM Cortex - A72	H6 64-bit 1.8 GHz Cortex - A53	Quad-core 1.43GHz ARM Cortex - A57
Recommended Current (at Idle)	575 mA	90 mA	2 A
Memory	8 GB	512 MB	4 GB
Pins	40	26	260
Price	$188.76	$62.99	$399.00

- Also reviewed different versions of Raspberry Pi

Raspberry Pi 4 Model B

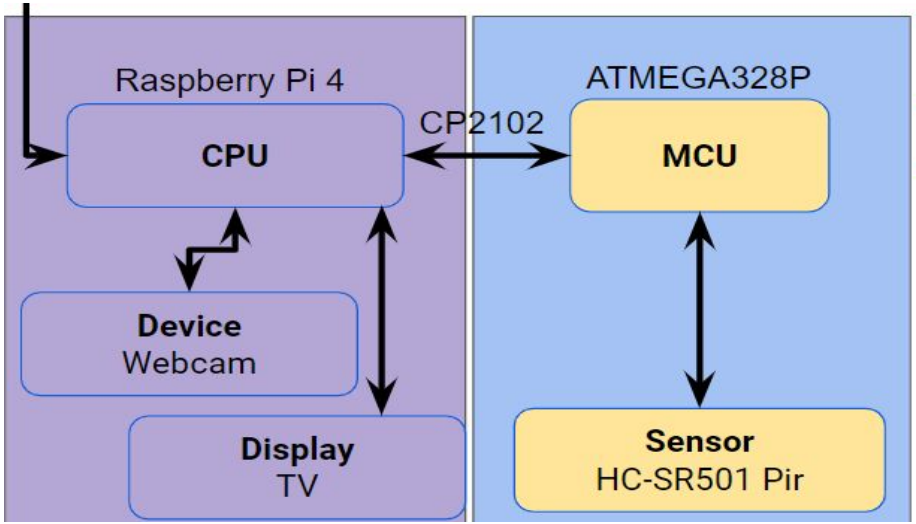
- Connection to Logitech HD Pro Webcam C920
- Will host ML model
- Requesting/sending HTTP protocol from/to AWS server
- Connection to PCB through CP2102 Adapter
    - Pi will program the ATMEGA328



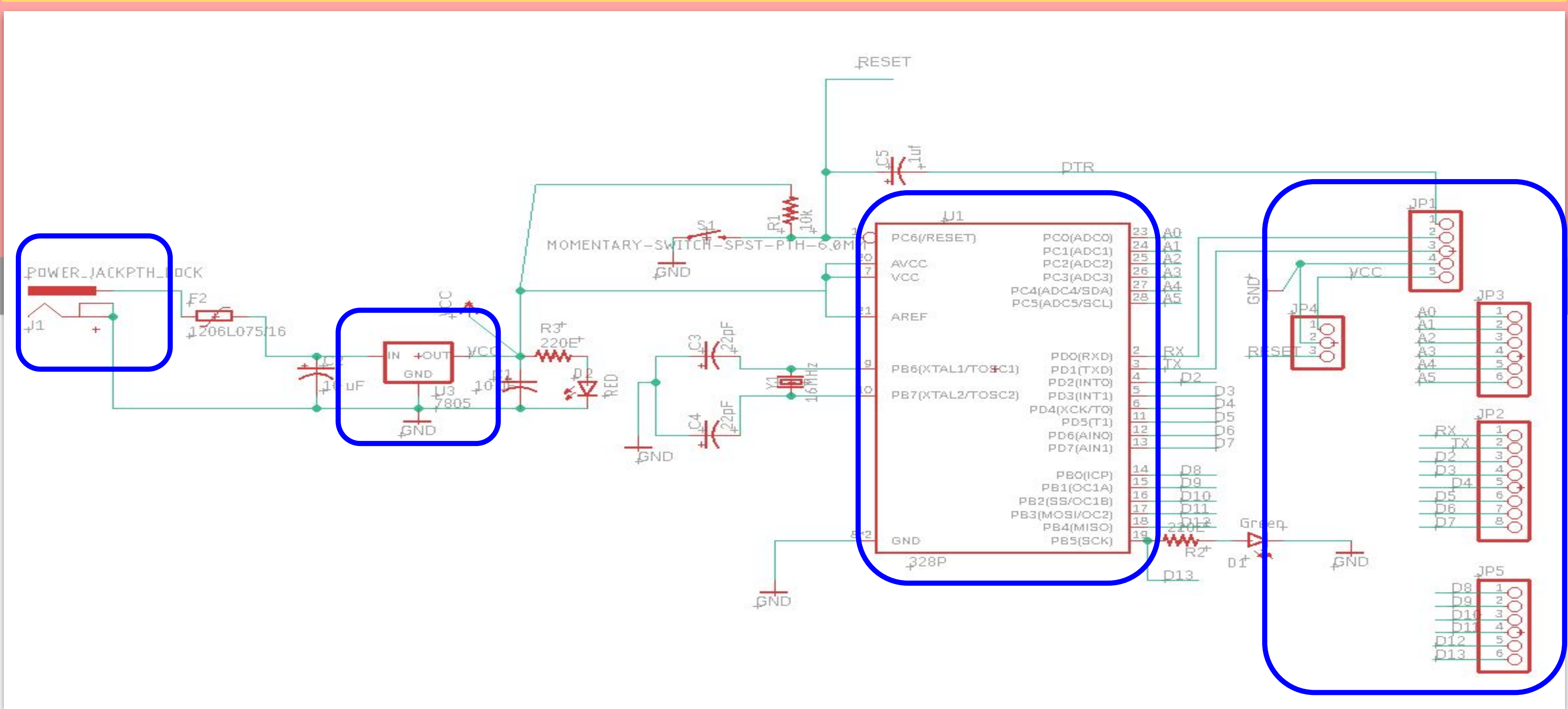
7. PCB Schematic

PCB Board

- Battery Saving Operations
- Chip: ATMEGA328P
- 66 by 69 mm
- Sensor connected to the PCB
- PCB communicates to the Raspberry Pi through CP2102
  - Turns off Webcam - no motion
  - Turns on Webcam - motion



PCB Layout


RESET
DTR
C5
1uf
S1
MOMENTARY-SWITCH-SPST-PTH-6.0MM
R1
10k
GND
POWER_JACKPTH_LOCK
J1
F2
1206L075/16
C1
10uF
IN
OUT
GND
U3
7805
VCC
R3
220E
D2
RED
C3
22pF
C4
22pF
Y1
16MHz
U1
PC6(/RESET)
AVCC
VCC
AREF
PB6(XTAL1/TOSC1)
PB7(XTAL2/TOSC2)
GND
328P
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
A0
A1
A2
A3
A4
A5
RX
TX
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
R2
220E
Green
D1
JP1
JP2
JP3
JP4
JP5
VCC
GND
RESET

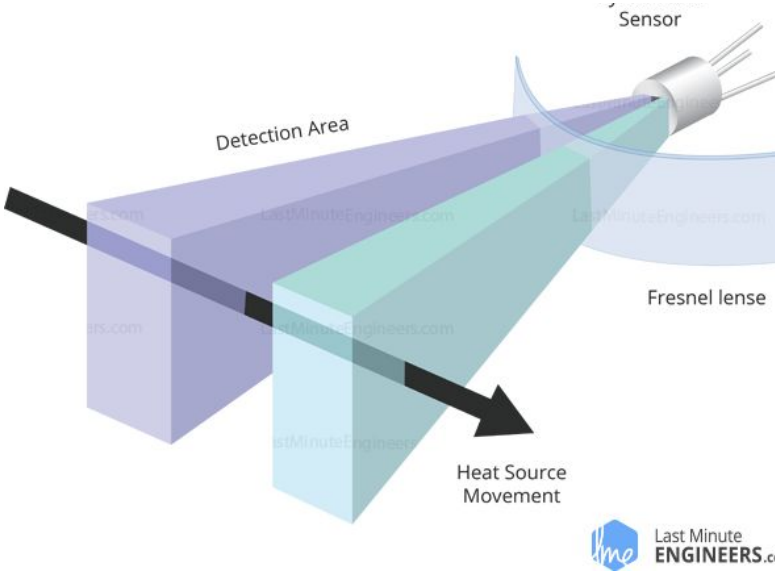
Parts Comparison : Motion Sensors

- Selected HC-SR501 motion sensor
- Adjustable sensitivity and delay times
- Uses heat

Criteria	HC-SR501	HC-SR505	HC-S04
Operating voltage	5 - 20V DC	4.5 - 20V DC	5 - 20V DC
Quiescent Current	<50uA	<60uA	<2mA
Adjustable sensitivity	Yes (3-7 meters)	No (3 meters)	No (4 meters)
Board Dimensions	32mm x 24mm	40mm x 10mm	45mm x 20mm
Adjustable Delay time	Yes	No	No

HC-SR501 PIR Motion Sensor

- This motion sensor will be attached to the PCB(ATMEGA328P)
- The Raspberry Pi will be receiving information from Arduino
- Coding: C++
- Sensor will be connected to ports:
    - D2, 5V, and GND



CP2102 USB-TTL Converter

- Highly-integrated USB-to-UART Bridge Controller
  - Used to program the ATMEGA328p
- Plug into the Raspberry Pi port
- From Pi program the PCB board
- Connected by jumpers on PCB

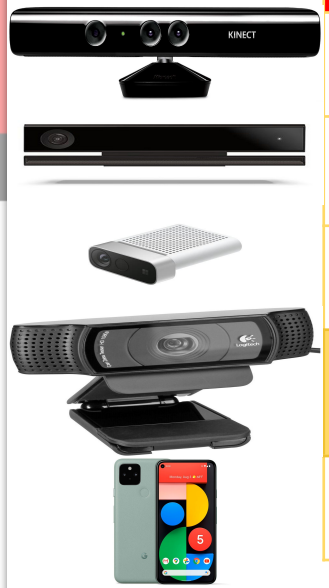
Parts Comparison : Power Supply: Pi

Criteria	LABISTS	Cankit	Li-ion HAT
Input Voltage	100 - 240 V AC	100 V AC	168 V AC
Output Voltage	5.1 V	5 V	1.2 V
Input Current	2.5 A	2.5 A	2.4 A
Connection Type	Micro-USB	Micro-USB	On-board connection
Price	**$11.98**	**$9.95**	**$23.99**

Power Supply for System: 3 Solutions

1. Powering the Pi and PCB by a 9V battery.
    i. This would most likely create a very short battery life
2. Powering the PCB by the Pi (Labsists-Wall Outlet) through CP2102.
    i. The CP2102 has a voltage regulator
    ii. Voltage from the Pi and supply it to the PCB
3. Powering each component individually
    i. The 9V battery - PCB
    ii. Pi plugged into the wall
    iii. This option is preferable so that all components will have enough voltage to operate and not have any shortages or overloads

Parts Comparison : Webcam



Camera	Resolution	Frame Rate	Price
Kinect v1	640 x 480	30 fps	$70
Kinect v2	1920 x 1080	30 fps	$70
Azure Kinect	3840 x 2160	30 fps	$400
Logitech HD Pro Webcam C920	1920 x 1080	30 fps	$0 (acquired)
Camera Phone	3840 x 2160	60 fps	$700+

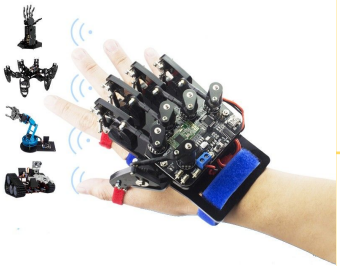
Parts Comparison : Display Unit

Criteria	TV	PC Monitor	Tablet	Smartphone
Cost	$100+	$100+	$300+	$500+
Resolution	1920 x 1080	1920 x 1080	1920 x 1080	1080 x 2340
Connection	HDMI	HDMI	USB-A	USB-C
Relative Size	Extra Large	Large	Medium	Small

HoloMon : Main Components

- ➔ Mobile Application
- ➔ Holographic Display
- ➔ Electronics
- ➔ Gesture-Based Recognition

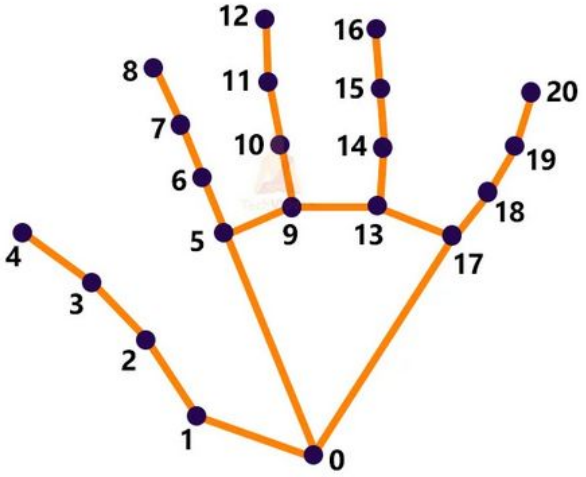
Parts Comparison : Gesture-Based Recognition



Criteria	Wearable-Based	Camera-Based
Cost	$70+	$20+
Convenience	Uncomfortable for user to wear, tethered by wires	Natural for user to use since it does not require them to wear anything
Accessibility	Not very accessible due to the fact that there is no “mainstream” product that can be rented or bought	Very accessible since webcams and cameras are prolific for commercial/private use

Gesture-based Recognition

- ML model trained on Tensorflow NN
- Using MediaPipe to establish hand key points
- Capturing data via Logitech HD Pro Webcam C920



0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

8. Budget

Budget

- Total budget = $400
- Current estimated cost over total budget = $ 133 / $400

- A weighty constraint on technology used in HoloMon
- Most expensive items = plexiglass, fiberboard
- Very resourceful as most items were acquired beforehand

9. Limitations

Limitations

- **Initially wanted our device to be small and compact**
  - Device will not be mobile
  - Device will be heavy
- **Device might be utilized in a darker environment due to projection**
  - May make it challenging for webcam to catch gestures
    - Light source may need to be incorporated by the webcam
- **Hologram will most likely need to be seen only from the front**
- **Might have to use static hand gestures (thumbs up) over dynamic**

10. Project Progress

Project Progress

- **PCB arrived**
  - All components for PCB were soldered on and all external components such as CP2102 has been acquired
  - PCB connections are correct and LED's indicate everything is functioning
  - Next, the chip will be programmed to ensure the PCB is working perfectly
- **Display Unit (Plexiglass) got laser cut**
  - Grabbed dimensions from the overall CAD model and sent to TI Innovation Lab
  - Next, taping the trapezoidal prism and testing placement on TV for hologram
- **Backend**
  - Database is fully configured
  - AWS instance is protected and configured
  - Communication between the endpoints, clients, and database are functional
  - Basic endpoints are implemented and tested
- **Frontend**
  - User Interface is mostly finished
  - Next, need to connect to backend

HoloMon

Group A

Taniya Shaffer

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