AutoPuzzlr

Taking the fun out of puzzles

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Application Area

Puzzles are fun and relaxing, but time consuming .

More people could benefit from puzzles if they took less time.

We are creating a tech based solution to help people get more enjoyment out of puzzles.

Those who may want to improve their fine motor skills will be able to work on puzzles without having to struggle through finding the pieces themselves.

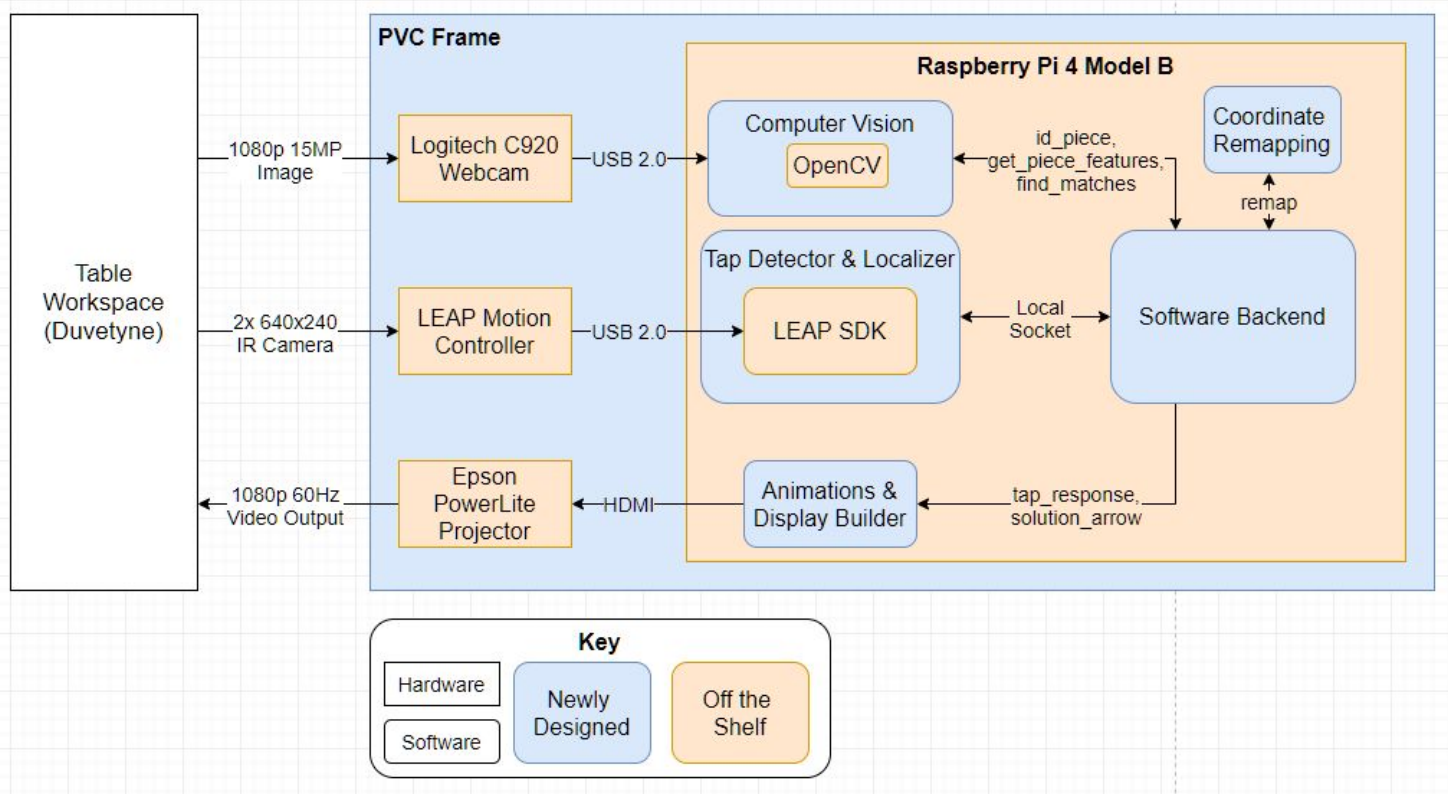
Plus it will count the pieces and let the user know if they’re missing any.

Solution Approach

1. User taps piece
    a. Why? Because we have the Leap Motion and Camera information we can use to create an interactive surface.
2. Camera + Leap Motion data is used to determine where the tap is
    a. Why? By determining where the user has tapped, we can then “solve for” the piece they tapped.
3. Segment out the piece
    a. Why? So that we can extract the features from that piece specifically.
4. Extract piece and puzzle features
    a. Why? Once we have these features we can then match them up to figure out where the piece should go.
5. Match piece features to puzzle features
    a. Why? Once these features are matched then we are able to tell the user where this piece should go.
6. Project information
    a. Why? So that the user will know where on the puzzle the piece should go.

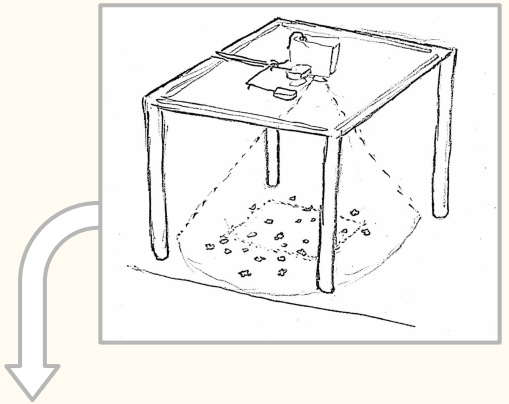
In action

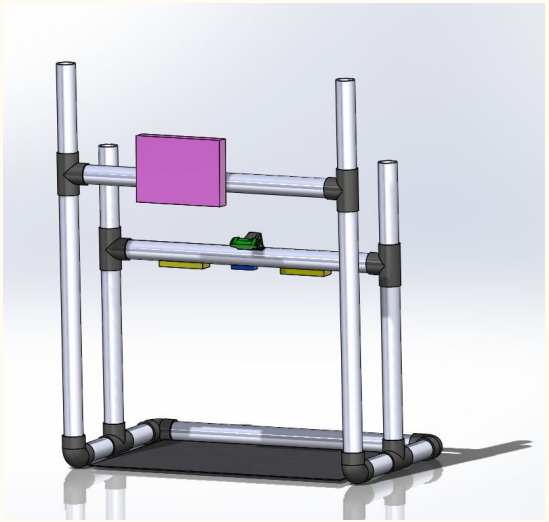
Block Diagram

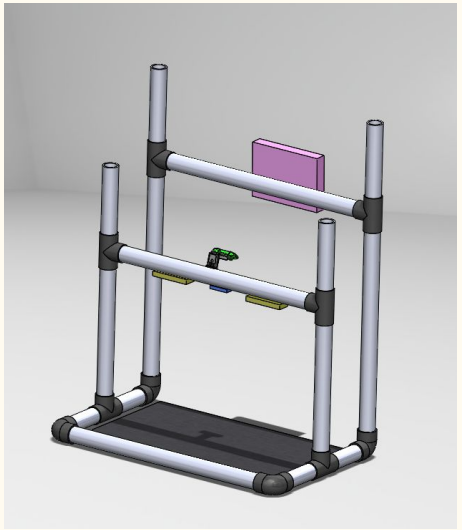


Frame Specification

- 2” diameter PVC Pipe
  - sturdy, cheap, easy to drill
  - sliding parts
  - easily assembled, portable
- Adjustable heights
  - alter projector, webcam, and leap motion distance
  - clamp horizontal bars
- Duvetyne fabric
  - Absorb light







System Specification

Projector	Size (depth, width, height)	Throw Ratio	Resolution	Lumens	Price
Epson Powerlite 1776W	210 x 292 x 44 mm	1.25	1280 x 800	3000	$0 (from dept.)
Insignia Slim-line Pico	5.7" x 3.1" x 0.9"	X	854 x 480	50	$160 ($70 used)
Viewsonic M1 mini	104 x 110 x 27 mm	0.83	854 x 480	50	$70
PIQO mini projector	2.25" x 2.25" x 2.25"	X	1920 x 1080	200	$27
Apeman M7 Mini	4.0" x 3.9" x 3.9"	1.2	854 x 480	4000	$70
AAXA P4X Pico	141 x 71 x 31 mm	2.18	854 x 480	175	$200 ($70 used)
BenQ MX631ST	287 x 232 x 114	1.08	1024 x 768	3200	($445 used)
NEC NP-M353WS	14.5" x 11.5" x 5.3"	0.45	1280 x 800	3500	$936

Our system has **2 inputs:**

1. Logitech C920 webcam
   a. high resolution and image quality,
   b. interfaces directly with the Computer Vision software
2. LEAP Motion controller
   a. capable hand tracking
   b. Interfaces with the Tap Detector & Localizer software via its SDK

and **1 output:**

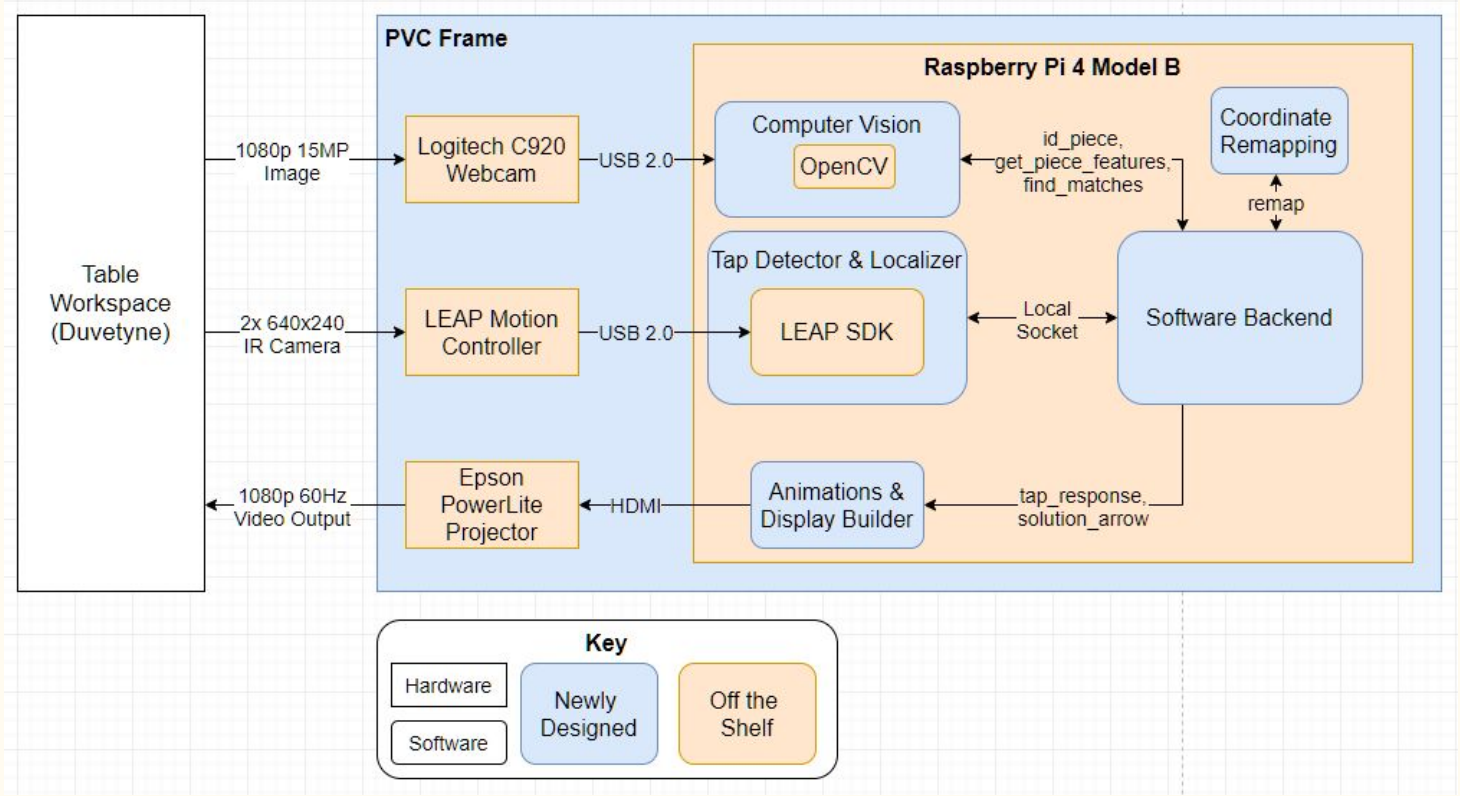
1. Epson PowerLite projector
   a. High brightness and projection detail
   b. Interfaces with the Animations & Display Builder software

Software Specification

Our software is composed of **3 libraries and a back-end** functioning like microservices, running on a **Raspberry Pi 4 Model B**.

1. Computer Vision software
    a. Identifies pieces and matches them to their place in the solved puzzle
    b. Interfaces with the webcam and the back-end
    c. Utilizes OpenCV
2. Tap Detector & Localizer
    a. Recognizes hands and taps and reports their locations
    b. Interfaces with the LEAP Motion controller and the back-end via local sockets
    c. Utilizes the LEAP SDK
3. Animations & Display Builder
    a. Creates animations on an image and outputs as a “display”
    b. Interfaces with the projector and the back-end
4. Back-end
    a. Runs the core of the software, including the solving loop, the initialization, and the coordinate remapping system

Implementation Plan



Metrics and Validation

Component Testing:

- Code timing tests using *time.perf_counter* to measure latency of CV & animations according to requirements
- Tap detection latency using a custom timing script
  - Measure time between a key-press and receiving a tap notification
  - Tester presses a key and taps on a puzzle piece concurrently

Puzzle Solving Testing (using various 100 and 250-piece puzzles):

- Solve 20 pieces using AutoPuzzlr and record accuracy and precision using ruler against the projected solution to ensure requirements are met

Tasks and Division of Labor

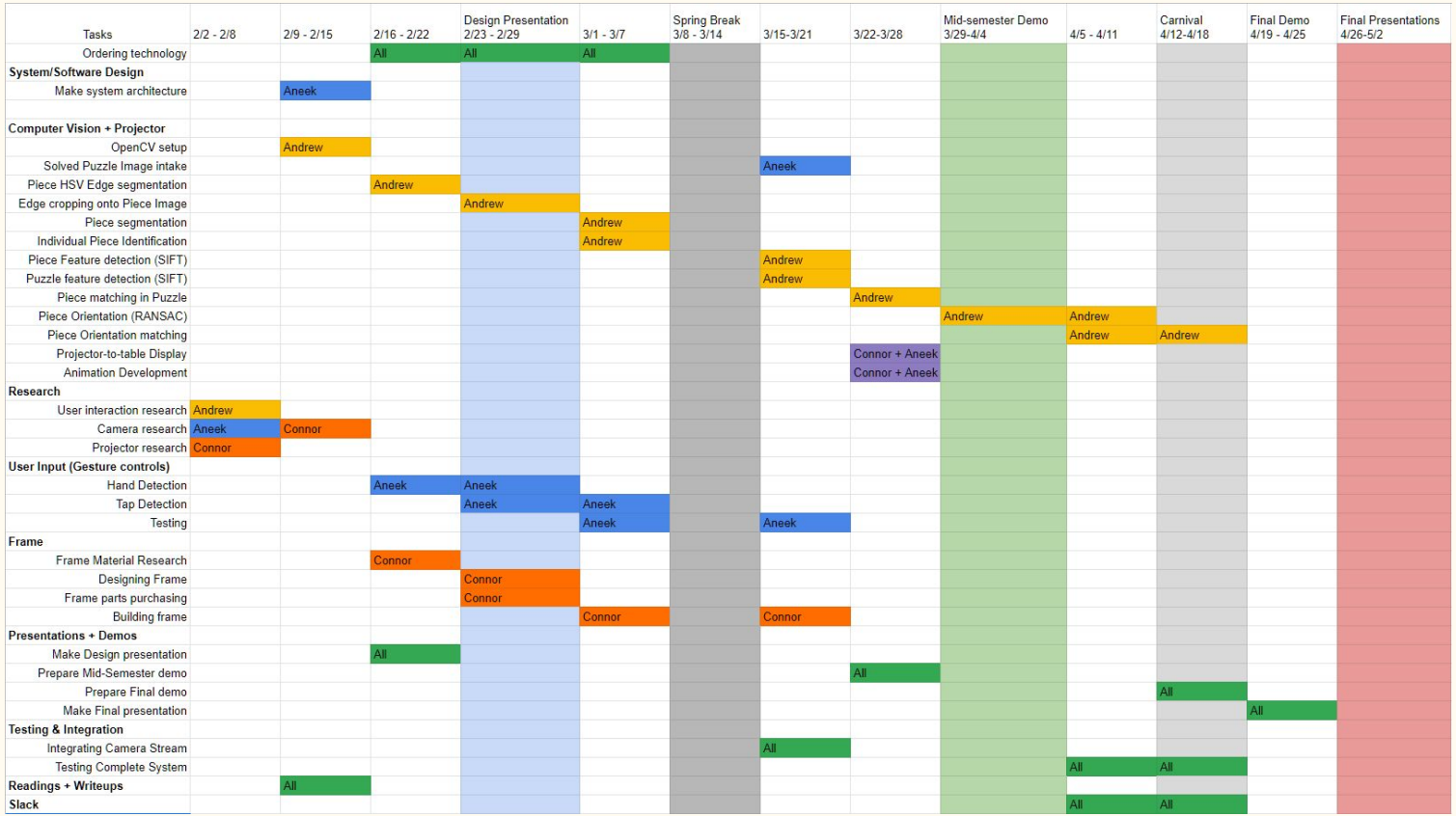
While we will all be working collectively on some tasks:

Andrew will take the lead on the Computer Vision portions

Aneek will take the lead on the Leap Motion Gesture tracking and integration

Connor will head the Projector interfacing and the design and construction of the frame.

Project Management & Schedule



Tasks	2/2 - 2/8	2/9 - 2/15	2/16 - 2/22	Design Presentation 2/23 - 2/29	3/1 - 3/7	Spring Break 3/8 - 3/14	3/15-3/21	3/22-3/28	Mid-semester Demo 3/29-4/4	4/5 - 4/11	Carnival 4/12-4/18	Final Demo 4/19 - 4/25	Final Presentations 4/26-5/2
Ordering technology			All	All	All								
System/Software Design													
Make system architecture		Aneek											
Computer Vision + Projector													
OpenCV setup		Andrew											
Solved Puzzle Image intake							Aneek						
Piece HSV Edge segmentation			Andrew										
Edge cropping onto Piece Image				Andrew									
Piece segmentation					Andrew								
Individual Piece Identification					Andrew								
Piece Feature detection (SIFT)							Andrew						
Puzzle feature detection (SIFT)							Andrew						
Piece matching in Puzzle								Andrew					
Piece Orientation (RANSAC)									Andrew	Andrew			
Piece Orientation matching										Andrew	Andrew		
Projector-to-table Display								Connor + Aneek					
Animation Development								Connor + Aneek					
Research													
User interaction research	Andrew												
Camera research	Aneek	Connor											
Projector research	Connor												
User Input (Gesture controls)													
Hand Detection			Aneek	Aneek									
Tap Detection				Aneek	Aneek								
Testing					Aneek		Aneek						
Frame													
Frame Material Research			Connor										
Designing Frame				Connor									
Frame parts purchasing				Connor									
Building frame					Connor		Connor						
Presentations + Demos													
Make Design presentation			All										
Prepare Mid-Semester demo								All					
Prepare Final demo											All		
Make Final presentation												All	
Testing & Integration													
Integrating Camera Stream							All						
Testing Complete System										All	All		
Readings + Writeups		All											
Slack										All	All		