MODULAR SCREEN PROPOSAL

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Abstract

To bridge the gap between flexible and often complex systems that exist in spaces that prioritize visual demonstration and identification for many to see, most traditional methods are oftentimes static, and bulky in their implementation. We have set out to create an interchangeable and more dynamic solution to this problem; the Modular Screen System. This system will be composed of at least 4 square shaped screens, with the capability of being placed into a total of 7 configurations via magnets on the side of each tile. In their configurations they will communicate with one another to display a set of images that when combined show a larger more comprehensible one. Users will be able to control what the image is and how the tiles will be arranged via a mobile application, allowing for easy access to a more robust presentation/display system.

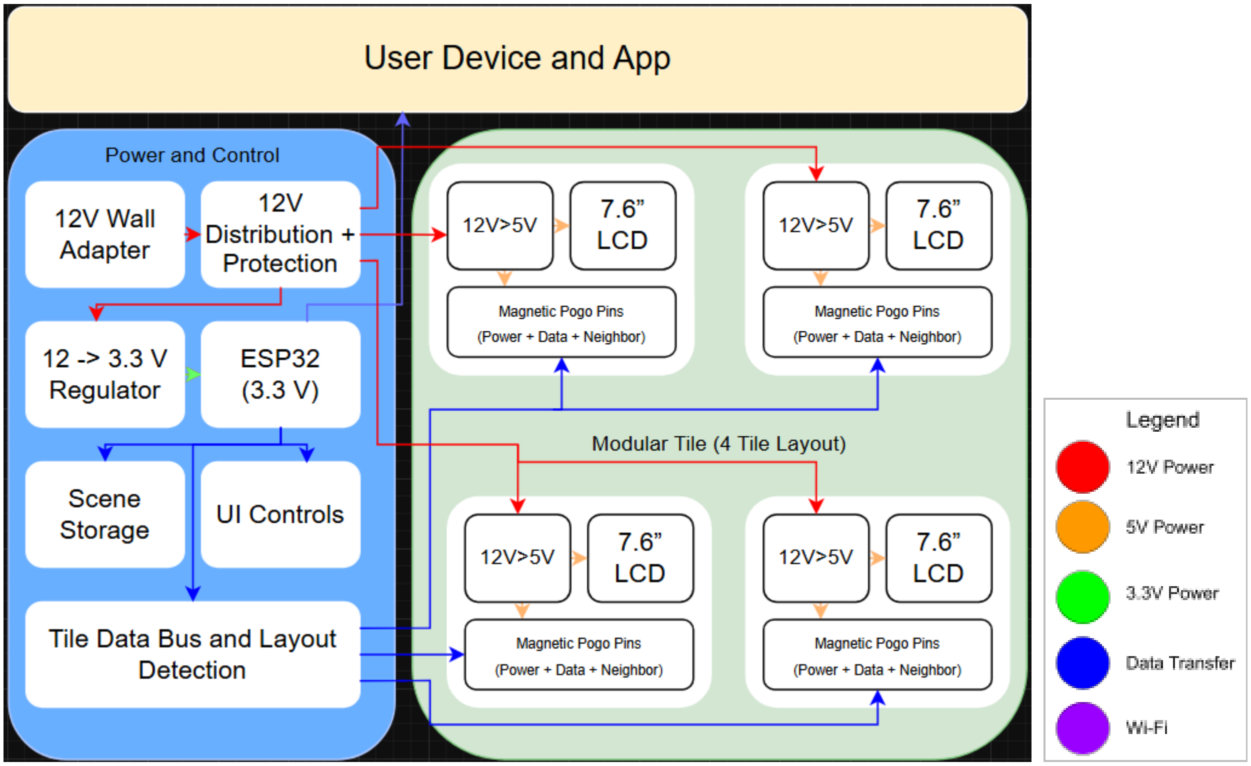
Contents

1. Introduction

This report will address the issue of there not being a great way to customize or enhance the horizontal presentation of media onto a flat surface. Our proposed solution will allow users to freely configure how they might want to do both of those things, and does so in a way that makes the overall experience very simple. As of right now, the proposed “Modular Screen System” will mostly focus on Wireless/Wired Communication, Image processing, Embedded Systems and Mobile Application Design. The rest of this document will discuss the system as a whole (as well as its respective subsystem), the prices of what we might potentially purchase, and the overall impact that we hope to have given what we create.

2. Design

2.1 Block Diagram



2.2 Subsystems

Power

The power system will supply and distribute power to all the modular tiles the user has connected as well as powering the electric components in the control tile. Because many display tiles may be connected simultaneously based on the user's needs one must send power to each tile effectively. Meaning one must prevent voltage drops or surges which could reset display, burn out the system, or cause safety issues. A reliable power system will ensure stable operation with any board configurations. For our power we will be using a 12V adaptor which will be connected to the wall for constant power. This power will move through the microcontroller (ESP32) which is described below and will control all the modular tiles as well as the PCB which will have some form of voltage regulation.

Control

The control system will act as the processing unit of the board. It will detect the tile layout, assign images, send image data, and sync updating the displayed images. At the moment this will be an ESP32 and will be powered with 3.3 volts. The micro controller will be connected to the application wirelessly through a Wifi connection.

Modular Tiles

The modular tile system will form the main display surface. It will allow for flexible board configurations. Tiles will have to display assigned image portions correctly and maintain alignment through magnetic pogo pins. These pogo pins should also allow the tiles to recognize their neighbors connecting back to the control tile which will then understand the configuration. Through the power and control tile we will send 5 V across the screens which will be regulated and controlled internally. The screen is a 7.6 inch LCD which creates clear images for every direction. Each tile will be housed by a 3d printed box in order to maintain a consistent spacing between each.

2.3 Subsystem Requirements

Power

1. The system must allow for wall power by a 12VDC adapter and be able to operate continuously with no time limit.
2. The system must supply power to 4 to 9 tiles and the control tile simultaneously.
3. The power system must regulate voltage and send 5V to each tile and 3.3 V to the MCU.
4. The PCD must include overcurrent protection and short circuit protection to prevent any damage. to components and users.
5. The system must include a power on indicator which visibly confirms the board is powered on.

Control

1. The control system must be centered around the ESP32 MCU running at 3.3 V and will need to remain stable over the time it is being used.
2. The ESP32 must automatically detect the connected tile layout and understand a valid board configuration within 5 seconds after powering on or after the tiles are rearranged.
3. The ESP32 must assign each tile to a position and map each tile to its correct portion of the full image.
4. The control system must update all tiles in sync so the image does not appear staggered across tiles.
5. The ESP32 must provide 2.4 GHz Wi-Fi connectivity to interface with the application for uploads and scene control.

Application

1. The application must allow the user to upload custom images (png or jpg) and deploy it to the tile layout.
2. The application must communicate wirelessly to the ESP32 over the wifi connection and confirm when an image has been deployed successfully.
3. The application must support a scene library view so users can reselect previously uploaded images without reuploading (if it is possible these should be categorized in the application).
4. If the application is turned off or shut down the system should still work as intended.
5. The application will be implemented as a desktop or mobile interface.

Modular Tiles

1. The system must support 4-9 tiles, each containing a 7.6 inch LCD.
2. Each tile must receive 5v of power from the power system and operate reliably without any form of brightness chane or resetting.
3. Tiles must align using magnetic pogo pin connectors to allow for a seamless easy to build display.
4. The tile connector must carry both power and data, and must allow for neighbor detection so the control system can understand tile adjacency.
5. After layout detection, each tile must display the correct image portion corresponding to their assigned sections without swapped or rotated regions.
6. Tile housing must be 3D printed and designed to protect displays.

2.4 Subsystem Testing

Power

We will validate the power subsystem by performing load and startup stress tests using a wall-powered 12V adapter. First, we will connect an increasing number of tiles (1 → 9) and measure the power within each component 12V to the input, 5V per tile, and 3.3V to the ESP32 with an oscilloscope to ensure the voltages remain within the expected range under load. Second, we will test worst case startup conditions by powering on the system with multiple tiles already connected to simulate real use. During these tests, we will monitor for brownouts, resets, display flicker, or overheating, and we will verify that the protections we put in place behave correctly.

Control

We will test the control subsystem by verifying the ESP32's ability to detect layout, assign the correct image location to the correct tile, and deploy content reliably. We will repeatedly rearrange the tile configuration and measure the time required for the ESP32 to recognize a configuration change and produce a stable mapped layout. We will also perform synchronization testing by deploying scenes repeatedly and confirming that tiles update together without staggering. Finally, we will test Wifi reliability by deploying images from different distances and with interference to ensure the system remains responsive and does not drop connections during deployment.

Application

We will test the application subsystem by validating the full user workflow connect, upload, deploy, and switch scenes. First, we will verify that the application can successfully upload images and that the ESP32 confirms it has received the data. Second, we will test deployment latency by timing how long it takes from deployment to the full board displaying the new content. We will also test failure cases (invalid file type, interrupted Wi-Fi connection, mid-deploy cancellation) to ensure the system falls back to preloaded scenes without crashing.

Modular Tiles

We will test the modular tile subsystem using two tests to confirm correct mapping, reliability, and reconfiguration behavior.

Test 1 - Full Image Scene Test:

We will deploy a test image across all connected tiles. This verifies that each tile displays the correct image segment, that edges align at tile boundaries, and that no tile is flipped, swapped, or offset. We will repeat this test across multiple physical layouts (2×2, 1x4, 4x1, and irregular shapes) and after multiple assembly/disassembly cycles to ensure connector stability and consistent rendering.

Test 2 - Coordinate Test:

We will deploy a diagnostic mode where each tile displays a number determined by the layout map computed by the control tile. For example, for a 2×2 square starting from the control tile, tiles should display 1, 2, 3, 4 in a consistent ordering. If a tile is removed, numbering should automatically update (removing tile 3 results in 1, 2, 4). If tiles are rearranged, the system should re-run layout detection and the numbering should update so that the new physical positions still display the correct consistent sequence 1, 2, 3, 4 according to the chosen ordering rule. This test directly verifies neighbor detection, coordinate assignment, and automatic remapping

2.5 Tolerance Analysis

Our modular display system must supply enough power to all connected tiles under both normal operation and worst case scenarios. The system is powered from the wall using a 12V DC adapter. To reduce voltage drop and connector current, we will distribute 12V across the board and use a local regulator in each tile to generate 5V for the 7.6" LCD and its driver. The control tile will also regulate 12V down to 3.3V for the ESP32.

Worst case occurs when 9 tiles run at high brightness plus control overhead:

$$P = 9 * 8W = 72\,W$$

$$P_{total} = 72\,W + 10\,W = 82W$$

With our current adapter that means

$$I_{12V} = \frac{P_{total}}{V} = \frac{82}{12} = 6.83A$$

To provide support for connector losses and startup spikes, we will select a supply above the requirement. A 12V, 10A (120W) wall adapter which provides a margin of:

$$I_{supply} = 10A$$

$$Margin = \frac{10A}{6.83A} = 1.46$$

This margin should help to prevent a reduction in voltage during tile power on and reconfiguration

Each tile will regulate a 12V input to 5V for the LCD system. Under worst case 8W the per tile current will be:

$$I_{12V,tile} = \frac{12\,W}{8\,V} = 0.67A$$

If we instead input 5V without local control we have a per tile current of:

$$I_{5v,tile} = \frac{8\,W}{5\,V} = 1.6\,A$$

Therefore we know that distributing 12V is better as instead of pushing 1.6A through every connector we push 0.67A reducing voltage to 5V within each tile.

If we attempted to distribute 5V across all tiles at worst case load:

$$P_{tiles} = 72\,W \Rightarrow I_{5V,tiles} = \frac{72\,W}{5\,V} = 14.4\,A$$

This is a high current for modular pogo-pin connections and would increase risk of voltage drop, heating, and unstable operation. Therefore, distributing 12V and regulating locally in each tile is better. Using 12V distributed and 5V regulated locally per tile a 12V 10A wall adapter provides sufficient power for a full tile configuration while maintaining safety margin for startup events. The final values will be validated experimentally, and protections will be included to prevent damage.

3. Costs

3.1 Parts

Table X Parts Costs

Part	Manufacturer	Retail Cost ($)	Bulk Purchase Cost ($)	Actual Cost ($)
7.6 Inch 800x800 Square TFT Display	AISON	$29.00	$116.00	X
Magnetic pogo pin connector	JHYOSSTHI	9.99	79.92	X
PCB board	FREE			
12V 2A AC Power Supply Adapter Cord	Tugermoola	8.99	8.99	X
3d printing filament		12	12	
Esp32-c3 mini development board	Shenzhen Jingmaoyuan Electronics	2	8	
Total			**224.91**	

3.2 Labor

Researching compatible components and protocols

We will begin by first mapping our project requirements to components that we can realistically build or purchase (display to TFT screen, simple modularity to Pogo pins, etc.) then from that we will have a list of hypothetical physical components that we will need.

Establishing a coherent set of systems that work together to solve the issue of rigid displays

Once we have somewhat of a mapping of design attributes to physical components we will then need to consult the datasheets and manuals of each component to make sure that there is a coherence between each of the pieces (Video protocols, Voltage requirements, etc.).

Designing functional hardware (PCBs capable of our high level goals) and complementing software

After we confirm component compatibility and have a general understanding of how pieces will come together we will then need to design and prototype our PCB so that we can bring the aforementioned tests together.

Testing of each of the individual subsystems within our project

Once we establish a reasonable prototype of our board and application, we will need to test our subsystems individually to make sure that they are worthy of being tested together in the future (App should be able to work over a short distance, tiles should be able to easily connect, Control Tile should be able to process tile configurations and receive image data, etc.)

Testing how each subsystem works with each other subsystem

When individual testing is done we will need to test our subsystems together with one another as there will most likely be problems that will come with combining them. We will need to test each of the systems that interact (App to Control Tile, Control tile to App, Control tile to other tiles), testing these together should help us flatten out the kinks of our project as a whole

4. Conclusion

4.1 Accomplishments

The goal of this project is to develop a modular display system for presentations, tabletop games, and other interactive applications that benefit from flexible screen configurations. The system allows users to control screen size, image selection, and the ability to connect or disconnect screens as needed. Each screen module communicates with the others and can be placed in any orientation. The displays automatically detect their position relative to a central tile, enabling seamless image alignment. Additionally, users can wirelessly control the tiles through an application on their personal devices.

4.2 Uncertainties

At this stage, several uncertainties remain. First, we are unsure whether pogo pins are reliable enough to transfer both power and data efficiently. We are also uncertain whether the screens can be fully controlled wirelessly and whether image processing across multiple displays can be handled smoothly. To address these concerns, we will conduct further research on pogo pins to better understand their electrical and data transfer limitations. If wireless control proves unreliable, we will implement a direct wired connection option for image input. This alternative may also improve performance when displaying large or high-resolution images.

4.3 Ethical considerations

One potential concern is user safety. If someone touches the power connectors while the system is connected, it could create a safety hazard. To reduce this risk, we plan to use low-voltage power and incorporate protective shielding around the connectors so they cannot be accessed while connected. Another concern is unauthorized access to the system through wireless communication. To prevent this, we will implement password protection or secure authentication methods to ensure that only authorized users can control the display panels.

4.4 Future work

For future development, we plan to improve synchronization between display modules and explore more cost-effective data transfer solutions to reduce the approximately $80 cost of connectors. We plan to add eventual touch screen functionality and support animation rather than still images, to complement that we plan to have audio integration to have full video capabilities.

5. References

[1] *Motorola Semiconductor Data Manual,* Motorola Semiconductor Products, Inc., Phoenix, AZ, 2007.

[2] *Company Overview*, Shenzhen Aison Technology Co., Guangdong, China, 2014

[3] *LED Matrix Sports Scoreboard*, Adafruit Industries, 2025