

Smart Gaming Table

Divide and Conquer
Senior Design 1



Group 30

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Project Description:

Dungeons and Dragons (D&D) is an open-ended tabletop role-playing game where each player controls at least one character and cooperate with other players in their party to complete a series of adventures known as a campaign. Traditionally, the physical representation of game settings consists of a gridded board and figures representing the landscape and characters, respectively. Paper character sheets are used to keep track of character abilities, and dice are used to determine the outcomes of events in the game. During gameplay, keeping track of the locations of characters and monsters on the board with respect to each other is vital to various mechanics such as combat, using magic, and interacting with the environment. However, problems arise such as remembering character locations between game sessions or when a piece falls over. Further, counting grid squares to determine distances each turn often causes delays in gameplay and can be a matter of contention when paths do not lie along grid lines.

Another issue that arises with Dungeons and Dragons is the large amount of information that needs to be tracked. This includes things like character attributes, skills, equipment, and the amount and type of dice needed to be rolled for an interaction. These values evolve over the course of the game which normally requires a large amount of erasing and rewriting. Given that an average game involves four players and a game master, this information is tedious to track and slows down gameplay.

Our project seeks to solve these issues by using a “smart” game board that can recognize multiple character locations, represented by physical figures on the game board, track that information, and display the relevant information both on the board and in a phone application. Ideally when a character is moved on the board the application software will recognize this and ask for a confirmation. The application will save and remember character locations even after being closed which will greatly reduce the time it takes to reset a board between meetings.

Additionally, the application will track character information such as attributes and combat statistics. This will create a paperless game that removes the need for constant erasing and rewriting. Combining this with the location information will also greatly reduce the time it takes to perform combat interactions, as the board can automatically display the range of an ability or spell once it is selected by the user. Potentially, dice rolls will also be simulated in the software, removing the problems of needing a large surface to roll dice on and losing dice.

Project Constraints:

As we design a smart table for Dungeons and Dragons, we must consider what the most desirable characteristics of such a table would be, given a typical game. As a game usually includes several players and is run by a single game master (GM), support for a large number of simultaneous users is necessary. During an encounter or while exploring a specific location, a map consisting of a top-top view of the environment, divided into squares which represent a 5' square in the environment with a 1" square on the map. This map should be sufficiently large to show a reasonable portion of the environment and contain all of the relevant characters. Setting up the map, placing characters, and looking up character details should be quick processes to avoid delays in gameplay. As each player's character is represented using a miniature figurine of the character with a 1" diameter base, the figure must be accurately located on the map to determine which objects, enemies, and allies are within range of the character's

abilities (such as magic spells and weapons), as well as which locations (i.e. grid squares) the character can move to on their turn. A player should be able to easily tell where objects are on the map and distinguish features of the environment such as doors, levers, and walls in order to make decisions about which actions to take on their turn. Finally, the table must be affordable for a dedicated Dungeons and Dragons group and so that the benefits it confers are worth the price. These desirable features are organized in Table 1 as they are the general characteristics which the table must have.

Table 1: Marketing Requirements

Desired Features	Reasoning
Supports Normal Game Groups	D&D is balanced to be played by 4 players with a game master. A larger or smaller group is possible, but the table should be able to support groups of typical size.
Easy to Use	If the table is significantly more complicated than traditional paper/dry erase maps and figurines, there is little to be gained by using it. Setting up a map and placing characters should be comparably quick, and interfaces should allow easy access to desired character and ability information.
Supports Full Length Games	A typical game session is 3-6 hours, though it may last longer. A map is usually not required for the entire session, so the table may not be necessary for the whole session but being available for the entire duration is ideal.
Map Details Are Easily Distinguished	Map features such as landscape, locations of digital tokens, and areas of effect for character abilities should be easily distinguishable for effective gameplay
Character Locations and Touch Inputs Are Accurate	Locations of characters and choice of target when triggering an ability such as a spell should be accurate to the constraints of the game, which is played on a grid.
Low Cost	The table should be low enough cost that the benefits it brings to gameplay justify the expense, and maintenance (e.g. replacing projector bulbs) is not excessive.

Proposed Device:

To meet the marketing requirements above, we propose to implement a design with the following features:

The proposed smart table will host the game from a user's laptop and communicate with players' phones using Wi-Fi, similar to JackBox games. From their phones, players and game masters (GMs) will use a menu system to create characters, view and modify their stats, and trigger events on the table's surface corresponding to character movements and abilities. Further, a character's statistics will be saved on the corresponding player's phone, to reuse the character on different maps that may be loaded onto the board for different scenarios. All character and digital token locations on the board will

be saved to the GM's phone or computer when the table is shut down, allowing the group to recreate the game board quickly for subsequent game sessions. The GM will have access to additional options such as map selection and enemy creation that should not be accessible to players. The current map along with additional relevant graphical information will be projected onto the table's surface from the interior of the table. The structure of this phone application/computer program/table system is given in Figure 1.

In order to track characters, figures on the table's touch surface will be located by using Rear Diffused Illumination (Rear DI). In Rear DI, in addition to the image being displayed, infrared light illuminates the table's surface from below and diffused for even coverage of the surface. The translucent material of the surface allows some light to be transmitted through the surface while some is reflected downwards. When an object is placed on or hovers closely above the table's surface, the transmitted infrared light is reflected downwards by the object and creates a region of higher intensity infrared light, which can be detected by a camera under the surface. The generated heat map is used to determine object and touch locations. This method was selected based on location accuracy requirements, cost efficiency, and the need for object detection in addition to detection of fingers and specially designed styluses. Touch input will also be used to select locations for ability usage (e.g. the center of a spells areas of effect) and movement of digital tokens representing enemies or allied non-player characters.

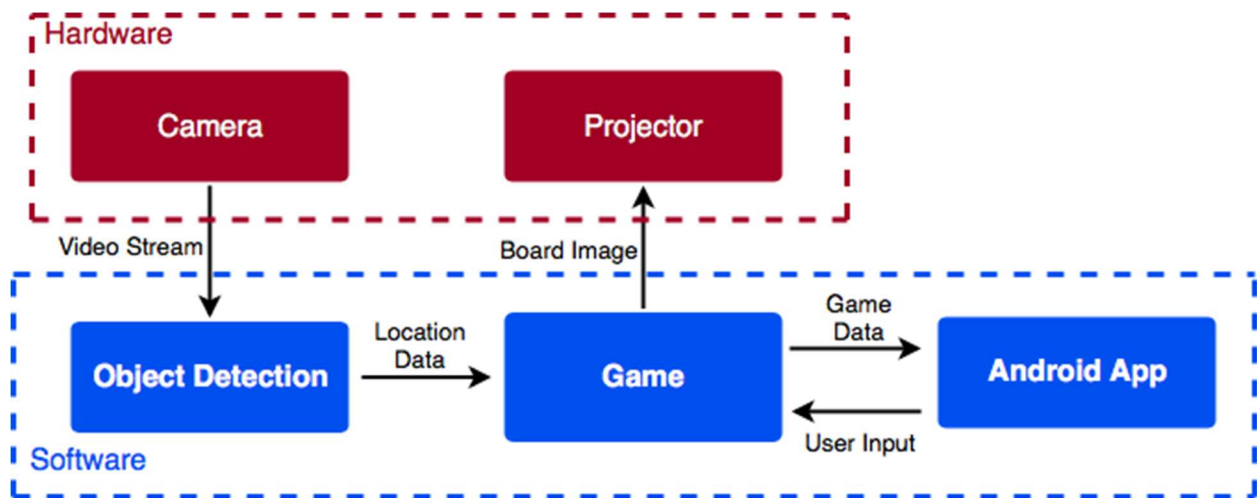


Figure 1: Software Block Diagram

The table will rely on a standard electrical outlet for power in order to remain turned on for lengthy game sessions. An automatic cooling system will trigger when the inside of the table, which will contain most of the electrical components, exceeds safe operating temperatures. This system will include of at least one fan and an associated temperature sensor. To ensure visibility, manual controls will be available to set the baseline brightness of the table's image. Additionally, a light sensor will automatically adjust the brightness of the table when possible as the table's environment brightens or dims.

To improve the quality of gameplay, there will be several additional features to the table. Indicator lights on the table will be used to denote player turn and/or ability effects. These lights will be able to emit various colors, with each player character corresponding to a unique color. A player's color will also be used to mark their character's location for the purposes of recreating a map layout at the start of a session. Further, speakers inside the table will allow the game master to play ambient music or special

effects, controlled by the app on their phone. Finally, a programmable timer will be included for timed skill challenges and limiting decision-making time in combat.

The incorporation of the many proposed features of the table is detailed in Figure 2.

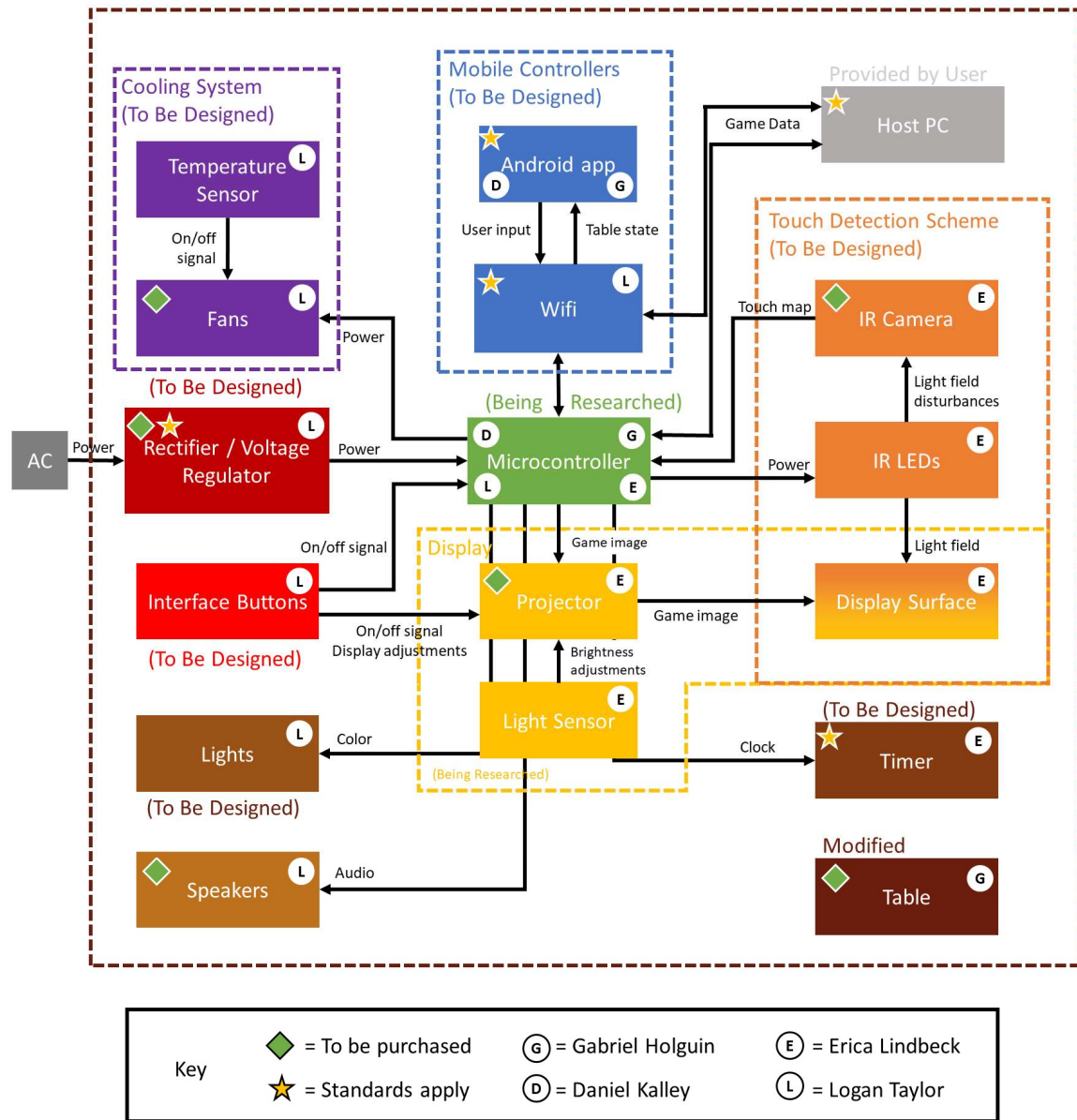


Figure 2: Hardware Block Diagram

Engineering requirement specifications of the table which will ensure the table meets marketing requirements are given in Table 2. These requirements are chosen in compliance with relevant standards, given in Table 3, and requirements based on our chosen implementation using Rear DI and a

phone application. We will likely encounter more standards as we finalize our design and begin its implementation, but for now we believe our design will either satisfy standards or be modifiable to meet them.

Table 2: Engineering Constraints

Aspect	Constraint	Reasoning
Touch Surface Dimensions	2'-3' per side	Sufficient play area without causing significant detection issues
Table Height	1.5'- 3.5'	Players are expected to sit around the table during gameplay
Maneuverability	Can be safely moved by 2 people	The table will have to be moved for demonstrations and in home without special equipment
Device Lifetime	≥ 3 years	Desirable lifetime given expected cost of development/replacement
Simultaneous Touches Detected	≥ 6	Support 4 player tokens + 2 touch points for user input
Simultaneous Mobile Controllers	≥ 5	Support at least 4 players and a game master
Mobile Controller Range	$\geq 10'$	Avoid disconnecting walking around a room
Mobile Controller Input Delay	≤ 1 s	Acceptable delay considering inherent wireless communication delays over a stable connection
Touch Input Delay	≤ 0.2 s	Acceptable delay for touch input detection to interact with the table in near-real time
Operating Temperature Inside Table	$\leq 32^{\circ}\text{C}$	Safe operating temperature for most electronic devices/components
Time to Cool from Startup (assuming ambient temperature is within operating range, internal temperature at most 10°C higher than allowable)	15 minutes	Acceptable delay assuming ambient room temperature is within operating range, long enough for fans to significantly cool the interior of the table
Average Projector Bulb Change Time	≤ 6 minutes	Ease of replacement is necessary as projector bulb is an expected point of failure in the long term
Continuous Operation Time	≥ 6 hours	Enough for most game sessions
Display Resolution	$\geq 1080 \times 1080$	Possible with affordable projectors and provides reasonable image quality at expected display dimensions
Object Size for Detection	$\geq 0.5''$ diameter	Must detect fingers and $1''$ diameter figure bases
Object Location Accuracy	$\leq 0.5''$ from true location	Must be able to accurately place track objects/touches to $1''$ grid squares
Object Removal/Placement Detection	$\geq 95\%$	Must reliably detect when a figure is moved for character tracking
Locations Tracked and Saved on Exit	≥ 20	Able to store location data for the next game session for 4 player characters and a reasonable number of virtual allies/enemies
Average Time to Set Up New Map	≤ 2 minutes	Acceptable set up time based on average time needed using a traditional map and figures

Table 3: Applicable Standards

Standard	Application
IPC-2221B	Generic Standard on Printed Board Design
NASA-STD-8739.3	Soldered Electrical Connections
IEEE 802.11-2016	IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks. (Wi-Fi Standard)
IEEE 3007.3-2012	IEEE Recommended Practice for Electrical Safety in Industrial and Commercial Power Systems
CUI Power Supply Safety Standards	Standard for power supplies
Android Design Guidelines	Regulates Android applications
Google Java Style Guide	Non-mandatory standard for program formatting
IEEE 29119	Software testing

The relationships between a selected subset of engineering requirement specifications and the marketing requirements are detailed in the House of Quality in Figure 3.

		Simultaneous touches	Simultaneous controllers	Image Resolution	Screen Size	Continuous Operating Time	Touch Input Delay	Average Time to Set Up New Map
		+	+	+	+	+	-	-
Supported group size	+	↑↑	↑↑		↑			
Ease of use	+				↑		↑	↑↑
Supported game duration	+					↑↑		
Detail distinguishability	+			↑↑	↓			↑
Touch input accuracy	+				↓		↑	↑
Cost	-			↓	↓		↓	
		≥ 6	> 5	≥ 1080x1080	2'-3' per side	≥ 6 hours	≤ 0.2 s	≤ 2 minutes

Figure 3: House of Quality for Selected Engineering Constraints

Cost Analysis and Budget:

Researching other projects of similar scope, we estimate the budget of this project to be around \$650. Just under \$500 of this is for materials, as shown in Table 4, and the rest is for unforeseen development costs. Some tools and components such as screwdrivers, small resistors, and soldering equipment were not included as we can feasibly acquire those for free or from UCF. As this project does not have any sponsors, the group members will be responsible for providing the funds for this project. We will try to split the cost equally among our members unless otherwise agreed upon later in development. As for the mount for our multi touch screen we were thinking of constructing a table out of wood, but as none of us have experience making wood tables, we decided to buy a table and cut a center hole to serve as a mount for our screen. The cost of the multitouch display is may exceed the amount stated in as the touch surface must be cut without damaging the sheet, which requires a special tool. This process will most likely be handled by the company we are trying to buy the sheet from.

Table 4: Cost Analysis and Budget

Item	Quantity	Price Per Unit	Total Cost
Table	1	\$150.00	\$150.00
Wheel For Table	4	\$2.50	\$10.00
Vankyo Leisure 3 Mini Projector	1	\$89.99	\$89.99
Silicone for Screen	1	\$2.00	\$2.00
Acrylic Sheet 36" x 36" x 0.093"	1	\$39.96	\$39.96
PlayStation Eye IR Camera	1	\$8.99	\$8.99
IR Illuminator	1	\$14.99	\$14.99
Wi-Fi Module Board	1	\$4.99	\$4.99
PCB Board	1	\$100.00	\$100.00
Microcontroller	1	\$10.00	\$10.00
Push-buttons	5	\$0.50	\$2.50
Android App Registration Fee	1	\$25.00	\$25.00
Temperature sensor	2	\$2.50	\$5.00
80mm cooling fan	1	\$6.95	\$6.95
LEDs	20	\$0.02	\$0.40
Light sensor	1	\$2.50	\$2.50
Speakers	4	\$3.50	\$14.00
Estimated total Cost			\$487.27

Project Milestones:

Project milestones are determined by course requirements and our chosen design features. These milestones are detailed below in Table 5.

Table 5: Project Milestones

Project Milestones					
Number	Task	Start	End	Status	Responsible
Senior Design 1					
Project Report					
1	Initial Project Identification Divide and Conquer	9/13/2019	9/20/2019	Completed	Group
2	Divide and Conquer V2	9/20/2019	10/4/2019	Completed	Group
3	Table of Contents	9/20/2019	10/18/2019	In Progress	Group
4	60 Page Draft	9/20/2019	11/1/2019	In Progress	Group
5	100 page Draft	9/20/2019	11/15/2019	In Progress	Group
6	Final Document	9/20/2019	12/2/2019	In Progress	Group
Research and Design					
7	PCB	9/20/2019	11/15/2019	Researching	Group
8	Touch Detection Scheme	9/20/2019	11/15/2019	Researching	Erica
9	Image Projection	9/20/2019	11/15/2019	Researching	Erica
10	Display Surface	9/20/2019	11/15/2019	Researching	Erica
11	Timer	9/20/2019	11/15/2019	Researching	Erica
12	Indicator Lights	9/20/2019	11/15/2019	Researching	Logan
13	Power System	9/20/2019	11/15/2019	Researching	Logan
14	Speakers	9/20/2019	11/15/2019	Researching	Logan
15	Cooling System	9/20/2019	11/15/2019	Researching	Logan
16	Wi-Fi	9/20/2019	11/15/2019	Researching	Logan
17	Android App	9/20/2019	11/15/2019	Researching	Daniel/Gabe
18	Table	9/20/2019	11/15/2019	Researching	Gabe
19	Order Parts	11/15/2019	11/22/2019	Researching	Group
Senior Design 2					
20	Build Prototype	TBA	TBA		Group
21	Testing & Redesign	TBA	TBA		Group
22	Finalize Prototype	TBA	TBA		Group
23	Peer Presentation	TBA	TBA		Group
24	Final Report	TBA	TBA		Group
25	Final Presentation	TBA	TBA		Group