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Game Design in Computer Engineering Capstone Projects

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Game Design in Computer Engineering Capstone Projects

Abstract

The purpose of a capstone design project course is to provide graduating senior students the opportunity to demonstrate understanding of the concepts they have learned during their studies. As with many computer science and engineering programs, students of the computer engineering program at Utah Valley University (UVU) conclude their degree programs with a semester capstone design experience. The intent is for students to utilize competencies developed in the first three years of the curriculum in the solution of an embedded design problem.

Recently many of our computer engineering students have shown interest in game design and choosing to design games for their capstone project. This paper presents the details of sample game projects that the computer engineering students have done in this capstone course.

Introduction - Computer Engineering Senior Design Project Course at UVU

Our senior design course is structured as a collection of independent student projects. This course is offered every semester. Usually, the students in the Computer Engineering program take this course during their last semester. Students either can come up with an embedded project independently or work on a project that is given to them by their advisors. Students write a proposal to define problems and identify solution approaches for their project and the hardware and software that is needed for their project. After several iterations, the advisor approves their project.

The faculty adviser will meet with each student individually on a weekly basis at a regularly scheduled, mutually agreeable time. At each meeting, issues associated with the project will be discussed and a status report will be provided to the advisor. Students will keep a daily journal/work log detailing the work that was done, how much time was spent that day, and any technical details that might be needed for later reference. Faculty advisor keeps notes of each meeting as well as action items to be accomplished for the next meeting. Reviewing the log sheet from the previous meeting is a great way for the faculty to prepare for the upcoming one and provides further evidence to the student of the meeting's importance.

At the end of the semester, they turn in a final written report and a final presentation which is evaluated by several faculty members from the department.

Introduction

In order to engage today's students who are always on mobile devices, new models and approaches to teaching and learning are needed from the educators. There are two types of games: fun games and serious games. One approach which has been successful is using serious games. Serious games are different from fun games in that they have a serious purpose that is combined with the entertainment aspect [1]. Game based learning is increasingly being used in educational settings and is widely predicted to become mainstream in the next few years [2-4]. The use of computer games for educational purposes is an important aspect that can improve the learning process. In a study conducted by Mateos, they have successfully implemented the ShopC serious game and tested it with students. The adaptation of the game followed the motivation, learning, and gaming design principles. Their evaluation validates the design of computer-based game regarding the three dimensions (motivation, learning, and gaming) and suggest a positive effect in the learning process [5]. In another practical study by Chllaghan into the use of serious games for teaching, they developed the Circuit Warz game and the approach taken potentially offers a new engaging and highly interactive way to teach engineering related material [4]. Most students are highly accustomed to and very skillful in playing computer games. A remarkable feature of serious games is their power to motivate. Research has indicated that computer games can achieve high learning results in areas where interdisciplinary knowledge is necessary and where skills such as problem solving, critical thinking, group communication, and decision making are of high importance [6].

Games have been gaining tremendous interest as tools for teaching and learning in recent years. The merits of game-based learning (GBL) include supporting effective learning [7], enhancing higher order thinking [8], increasing problem-solving skills, and promoting engagement [9].

There are many arguments in favor of the use of games in education. Games are considered to be a very important learning tool. Playing develops capabilities and aptitude that contribute to the formation of personality. The game is a way of learning as a consequence of the increase of motivation. Different games have demonstrated to motivate students. The use of games for educational purposes is an important aspect that can improve learning process.

Laser Tag Game

Laser tag game is a competitive shooting sport where players use infrared-emitting guns to shoot players who are wearing infrared-sensitive signaling devices. Each player is equipped with a gun and a vest. Since its inception in 1979, laser tag has evolved into both outdoor and indoor game. In early 1980s, United States Army employed a system which was using infrared beams to combat train their solders. This system which was called MILES functioned like laser tag where beams are fired into receivers that scored hits [10]. Laser tag systems vary widely in their technical capabilities and applications.

The concept of incorporating infrared guns and sensors into a game of tag was conceived by George Carter III, who opened the first laser tag arena in 1984 [11]. The game has increased in popularity since then, with the opening of a multitude of laser tag arena locations and production of numerous children's toys. The first competitive international laser tag tournament took place in 2003 in San Diego with teams from across the world [12]. As of 2017, an estimated 1,150 businesses operate laser tag arenas around the U.S. with over $412 million in revenue [13].

Recently many of our computer engineering students have shown interest in game design and choosing to design games for their capstone project. Following presents the details of sample game projects that the computer engineering students have done in their capstone course.

Sample Project 1: Embedded Systems Infrared Laser Tag Game

The goal of this project was to create a laser tag system. The laser tag system was implemented by using multiple microcontroller units that handled the firing of the gun, the receipt of infrared data, and the depletion of the player's health pool. Two laser tag kits were created, which consisted of a wearable vest with an embedded microcontroller unit and infrared receiver, and a gun featuring a switch and infrared LED. Pressing the switch made the LED flash on an off at 36 kHz, which registered as a hit when picked up by the opposing player's infrared receiver. The status of each player's health was indicated by the color of the microcontroller's built-in LED. The receipt of the 36 kHz signal by the infrared receiver triggered a falling edge interrupt on the MCU, which tracked the number of hits left for the player and changed the color of the LED.

This laser tag system used two Texas Instruments Tiva C Series TM4C123G Launch Pad evaluation boards (Figure 1) running an ARM Cortex-M processor, two Vishay VSLY5940 940 nm wavelength infrared emitting diodes, and two Vishay TSOP53136 infrared receiver modules that sense infrared signals flashing at 36 kHz. The LED and receiver were powered by the board. The flashing of the LED was controlled by a square wave generated on the board and outputted through one of the board's GPIO pins. Due to the low current provided by the board's GPIO pins, the LED was controlled by a CMOS buffer gate comprised of PNP and NPN BJTs to allow the full +5.5V from VBUS to power and illuminate the LED.

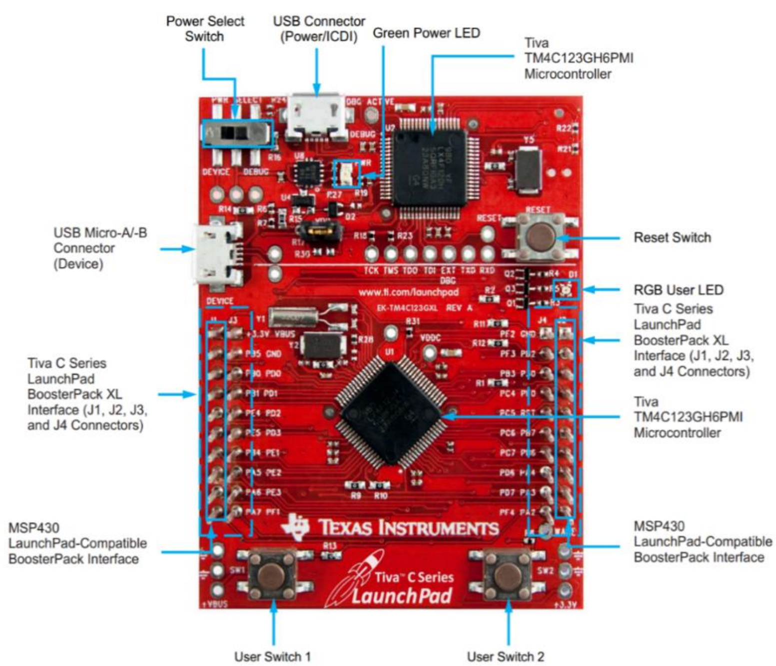

Figure 1. Texas Instruments TM4C123G Evaluation Board [14]

The evaluation board was responsible for the creation of a square wave at 36 kHz and the sensing of an incoming signal from the IR receiver. Additionally, the board used interrupts to track the number of hit points left for the user as well as change the color of the board's on-board RBG LED. A green light indicated full health, a yellow light indicated two thirds health, a red light indicated that the user has one hit left, and a flashing red light indicates the user is dead. The red light will continue to flash until the user was able to respawn (i.e. return to the game).

The final hardware consisted of two laser tag vests and guns that allow two players to play the game. The system level view of the laser tag system is shown in Figure 2. On the vest, the female connectors of the evaluation board were connected to male header connectors soldered to a Paxcoo protoboard. Wires were used to connect the GPIO pins connected to the protoboard in order to implement an external IR receiver and LED gun. The gun consisted of a small protoboard Velcroed to a toy gun. The gun was comprised of a switch button, the CMOS buffer gate and the infrared LED.

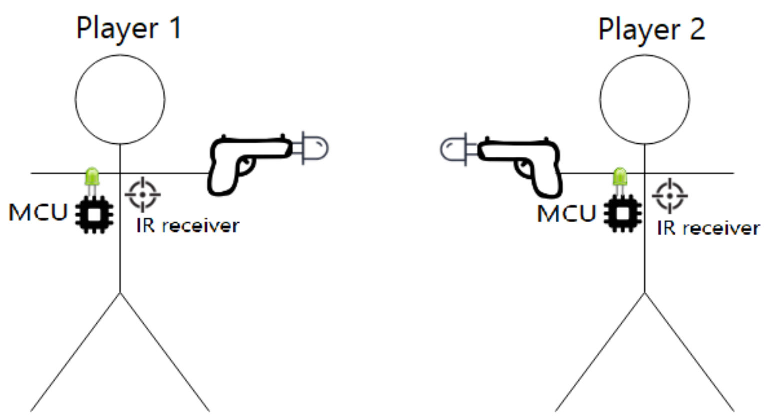

Figure 2: System level view of the infrared laser tag system

This project was programmed in C using the Keil µVision 4.0 IDE. The code was compiled in µVision using GNU Compiler Collection (GCC). The build was sent to the board using the board's built-in micro USB cable.

Sending the Signal

Main on the board initializes ports F, B, and C; the SysTick timer; and port C edge-triggered interrupts. After initialization, main sets the health bar color to green and uses the PortF_Output function to output the code for the color green to DATA in the port F data register, which in turn changes the onboard LED to green. Next, main enters a while loop to create a square wave. A local toggle variable switches between 0 and 1 as the while loop repeats. When toggle = 1, 0x0F is written to the port B data register. When the toggle = 0, a 0x00 is written to the data register.

After toggling the value of the data register, the SysTick timer waits 13.89 μs, which is the one half of the period of a 36 kHz wave.

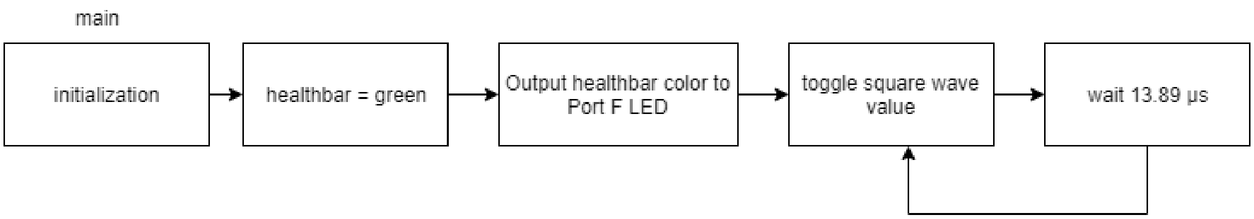

Figure 3: UML diagram of main running on the microcontroller.

Receiving the signal

The data pin of the IR receiver is connected to port C4 on the evaluation board. When a signal is sensed by the receiver, the data pin goes low. This falling edge triggers a port C interrupt which is handled by the following interrupt service routine. When an interrupt is triggered, the health pool will be decremented by one and the color of the LED will be changed to the next color. The ISR will then wait two seconds using the SysTick timer to avoid the problem of registering the hit multiple times. This will in effect give the player two seconds of invulnerability. If the player has health left, the ISR will terminate. If the health bar is red, the player will be dead, and the red LED will flash on and off for five seconds at 500 ms intervals until the player is able to respawn and rejoin the game.

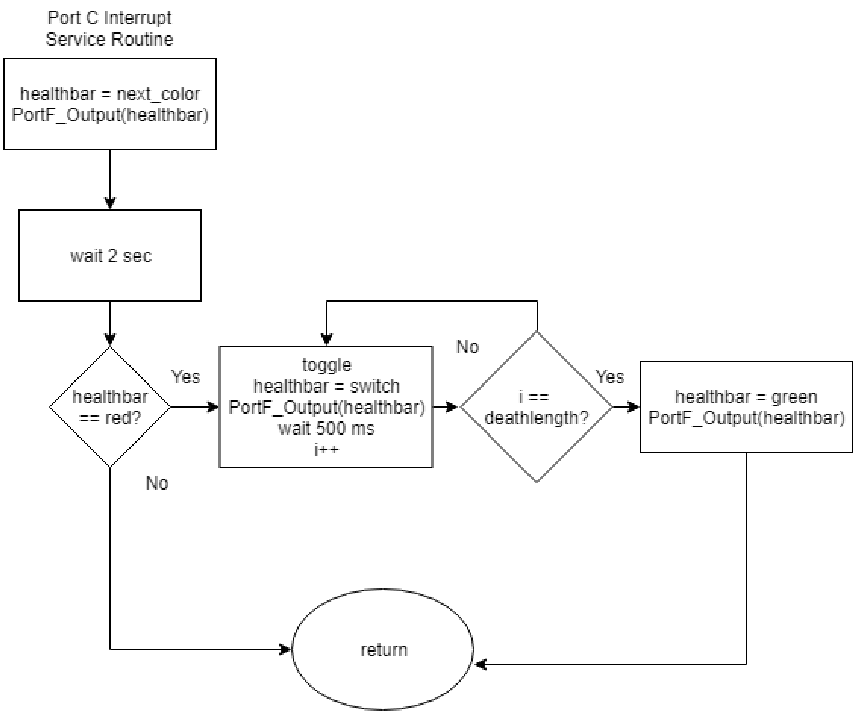

Figure 4: Port C interrupt handler UML diagram.

The final hardware is shown in Figure 5. The range for the game was about 10 meters. This range proved to be close to initial expectations and the game was able to be played at a distance suitable for a fun experience. This project was a success and student commented “I made an embedded systems laser tag system for my senior design project. I was able to apply what I learned in my engineering courses to achieve my design goals. I was able to combine such subjects as digital design, embedded systems, electronic systems, digital signals processing, and physics. I also honed practical skills like soldering, putting together breadboards and programming in C. My professor helped me maintain a disciplined schedule to make sure I started early on prototypes so my final design would meet my goals”.

This project was funded by NSF S-STEM Scholarship program at UVU. The student was one of the scholars in the NSF S-STEM LEAP program at UVU.

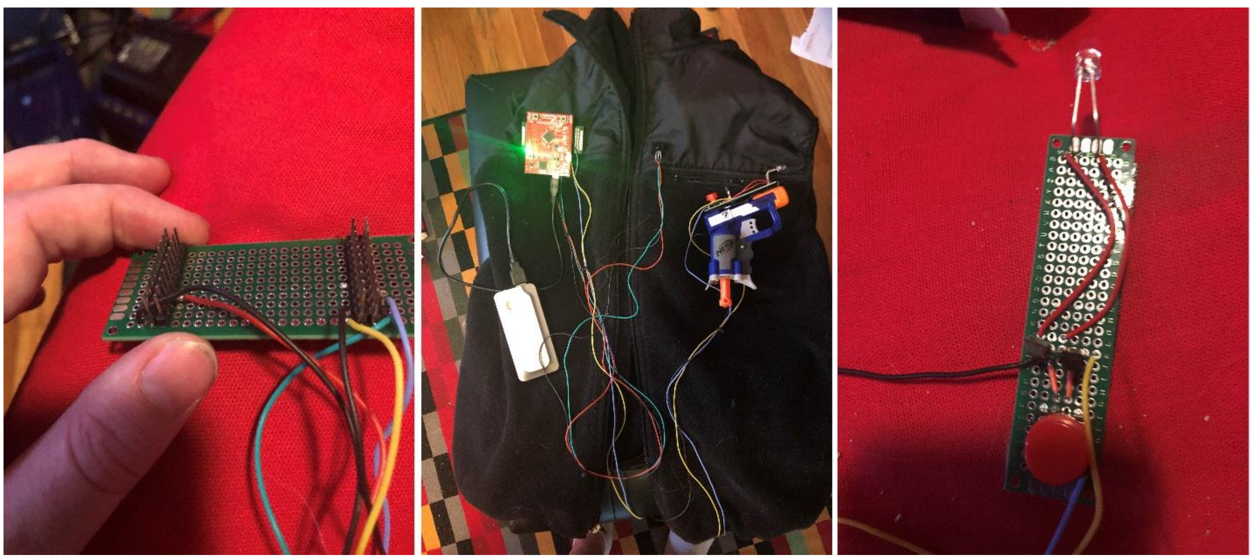

Figure 5: Left: protoboard soldered to header connectors and wires. Interfaces with evaluation board. Middle: final hardware vest, including board, gun, battery and IR receiver. Right: small protoboard connected to gun, including switch, buffer gate and infrared LED.

Sample Project 2: Infinite Laser Tag

In this project, a team of two computer engineering students worked together to design a laser tag game. This game was implemented as a wireless sensor network. Their game had three nodes: two player nodes and a master node which managed the game. A Raspberry Pi 4 was used for the master node. The player node included a blaster gun and a vest. The guns used infrared LEDs to shoot at the other players. The guns and vests were designed by the students and printed using a 3D printer. Figure 6 shows the vest and gun which were used in this project. The guns transmitted information about the shooter using Pulse Width Modulation (PWM) controlled by a microcontroller on the vest. On each gun, there was a rumble motor and a speaker which provided physical feedback to the user who shot them. The vest used infrared transistors to receive signals from other players, indicating with LEDs that the player was hit, and used the microcontroller to decode the information sent by those other players' blasters, and share that information with the master node via the Zigbee network [15].

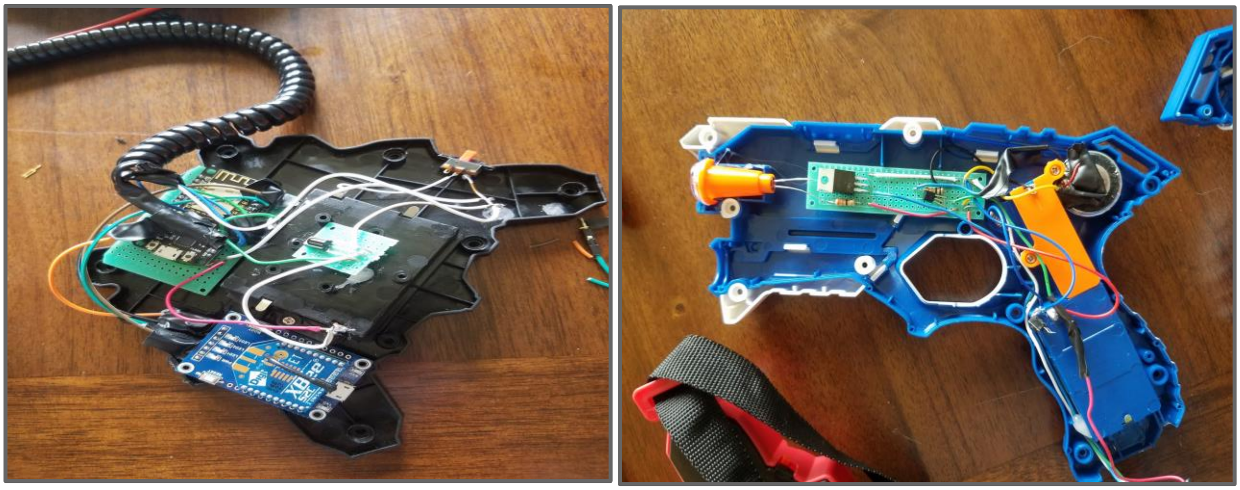

Figure 6: Vest and Gun [15]

The master node primarily kept score and managed other information important to the game. When a player is hit, information about who was shot and by who is sent to the Master node which tracks the game and announces the winner. Since this is a wireless sensor network it can have limitless number of nodes allowed on the network. The system also is portable to different locations. The system diagram for this project is shown in Figure 7 [15].

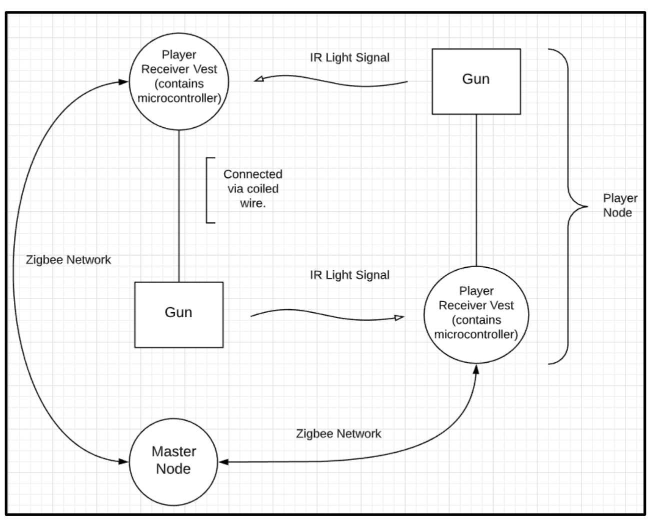

Figure 7: System diagram [15]

This project was a success and a fully designed laser tag system connected wirelessly in a mesh network was created.

Sample Project 3 – The ATLAS Tank

In this project, a team of two computer engineering students designed a laser tag game. In this game, students designed a Laser Tag tank which is an autonomous robot. This tank plays laser tag game autonomously. Along with the tank, a laser tag gun and vest were designed for a person to play with the tank. The tank is controlled by a Raspberry Pi B+ and a mini ATtiny85. The tank uses a camera and the OpenCV library to help navigate while playing in an arena or open area. With the help of the OpenCV (Open Source Computer Vision), when the camera detects a corner or a wall it will move to avoid it. If it sees the opponent's bright light on the vest, it will readjust a micro servo to that angle and fire a pulse from a red laser pointer. When the player pulls the trigger, it will activate the laser and send a, player identifiable, signal through the red laser pointer. The tank boots up after a few seconds after power is introduced to it and will run until its battery dies. The vest and gun are the same way. Figure 8 depicts the Tank and Tank circuitry [16].

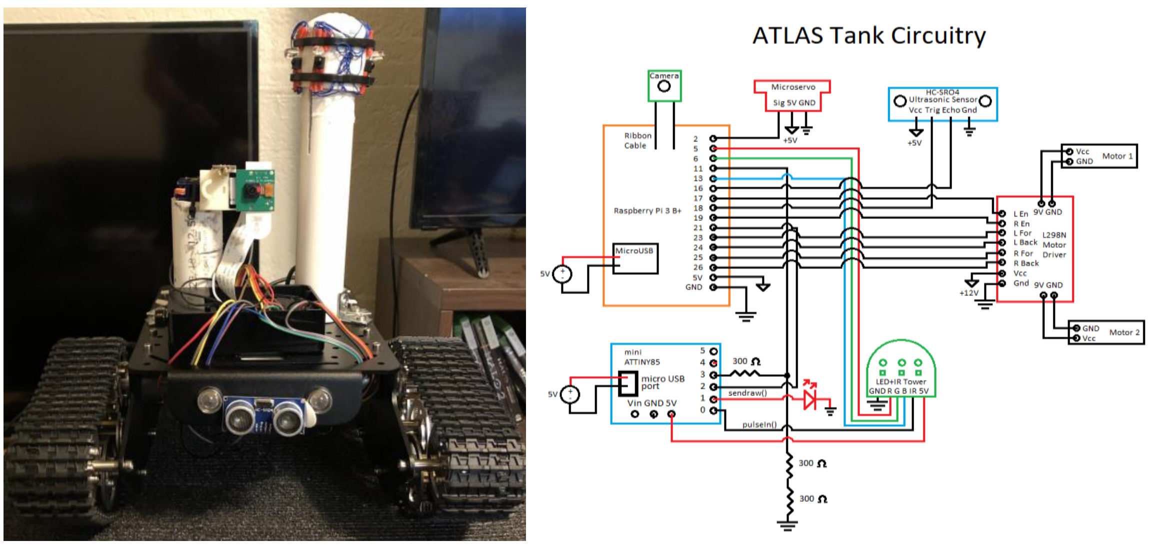

Figure 8: Tank Chassis and Circuitry [16]

Figure 9 shows the Vest and Gun circuitry and design.

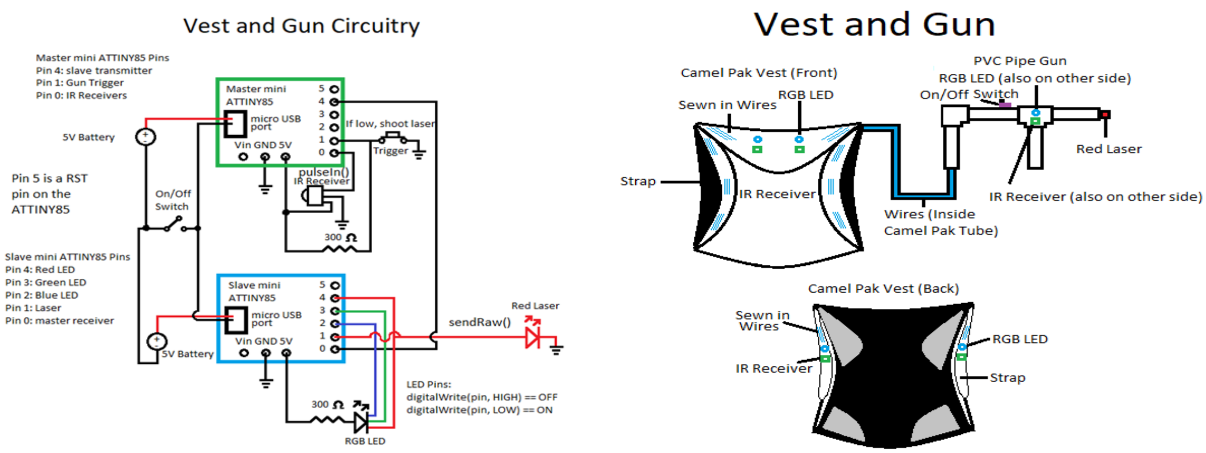

Figure 9: Laser Tag Vest and Gun [16]

This project was successful, and the student commented that “there was a lot of learning that had to be done in order to complete this project. I started out not knowing anything about Arduino or Android app development and now I feel pretty confident in using them.”

Summary and Conclusion

Nowadays, majority of students have grown up with digital technology such as computers, the internet, video games, and mobile phones. These students are fundamentally different from previous generations in the way they learn. Currently, students prefer learning experiences that are digital, connected, experiential, immediate, and social. It appears that students prefer learning by doing rather than learning by listening and often they choose to study in groups. Most students are highly accustomed to and very skillful in playing games. A remarkable feature of games is their power to motivate. Research has indicated that computer games can achieve high learning results in areas where interdisciplinary knowledge is necessary and where skills such as problem solving, critical thinking, group communication, and decision making are of high importance.

This paper discussed recent senior design projects in the area of game design where three teams worked on designing a laser tag game. Our senior design course is structured as a collection of independent student projects. Students find this course both challenging and rewarding as they are required to design, build and troubleshoot a fully functional embedded project. These projects give the students the chance to use their technical expertise and knowledge gained during years of study. Students work very hard to have a working project by the end of the semester. These projects provide students many opportunities to engage in self-directed learning. They develop the ability to debug, seek and find information they need, and the ability to understand and reverse-engineer poorly written documentation. The students’ feedback and their final project presentation indicate that they have pride in their project accomplishments and have gained confidence in their engineering abilities.

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