

FPGA Cat Invaders Proposal

Adam Jablonski (asj2172)
Yilei Meng (ym2974)
Fernandos Magee Jr. (fm2756)
Yuxiang Xia (yx2821)
Zhili Yan(zy2593)

Spring 2024

This project is to bring back to life the iconic 70/80's game Space Invaders with the aliens replaced by cats and the hero replaced with a poodle (Figure 1). This classic game implemented on an FPGA will require a combination of hardware and software working together.

The basic premise of the game is that the aliens exist as a matrix at the top of the screen and the hero is at the bottom behind some barriers. As time moves forward the aliens shift right until they reach the edge of the screen, then shift down a row, and shift left until they hit the other edge of the screen. During their motion they shoot lasers towards the hero and the hero tries to eliminate the aliens by shooting lasers back. The game ends if the aliens reach the bottom of the screen, or if the aliens manage to hit the hero three times (initially the hero has three lives). The game starts off slow with a small subset of the aliens types and gets faster/harder and adds more alien types as the levels progress¹.

Figure 1: Example images of poodle [4] and cat [3] sprites (we will create our own)



At a high level the hardware will be responsible for creating a static background to be displayed throughout the game, several sprites, and playing the background sounds. Next the software will be responsible for the overall game play and communication to the keyboard. Finally the software and hardware will communicate over the avalon bus to ensure coordination between the two.

¹ Interestingly, according to wikipedia [1] the aliens moving faster when less were on the screen was technically a bug, but rather than compensate for the speedup the creator kept it in as a feature. Our team will include the speed increase to stay true to the original game.

Space Invaders Algorithm: The software will be responsible for implementing the space invaders algorithm. This means generating the location of the sprites and triggering the sounds.

Display: The output display will be using a VGA Display with standard VGA resolution 640x480 and a framerate of 60 frames per second.

Sounds: The sound clips will be stored on the hardware and using an audio codec they will be played through standard speakers at the will of the software.

User interface: The left and right arrow keys and spacebar will be read in using libusb and move the hero onscreen and shoot out the projectile.

Hardware Software Interface: The software will communicate with the hardware through the Avalon bus. It will be writing to register aspects such as sprite position and when to play sounds.

Major Tasks:

- Study the Space Invader algorithm in detail. Understand the ins and outs of how the game works.
- Explore the limitations of the board. This will determine the resolution of our sprites; decide how the assets (music and sprites) will be laid out in the allotted memory size.
- Write testbenches to ensure the sprites will look the way they are intended and the audio sounds correct.
- Save the assets on the hardware for the software to be able to refer to them during gameplay. Write hardware to draw sprites onto the display at a given position.
- Implement display output through the frame buffer and sound output with the audio codec.
- Write software algorithms for the game. Integrate the keyboard with the software and have key presses move the sprites.
- Bring it all together and work through any integration bugs.

References:

[1] Space invaders overview, https://en.wikipedia.org/wiki/Space_Invaders

[2] Example of space invaders game, https://freeinvaders.org/?_ga=2.126103371.754523267.1708803339-1764679121.1708803339

[3] Example Cat Images, <https://www.pinterest.com/pin/pixel-art-cute-cat-16x16pix--589619776224110518/>

[4] Example Poodle Images, <https://www.youtube.com/watch?app=desktop&v=giMDf-l4QSo>