DUCK HUNT '22

Design Document

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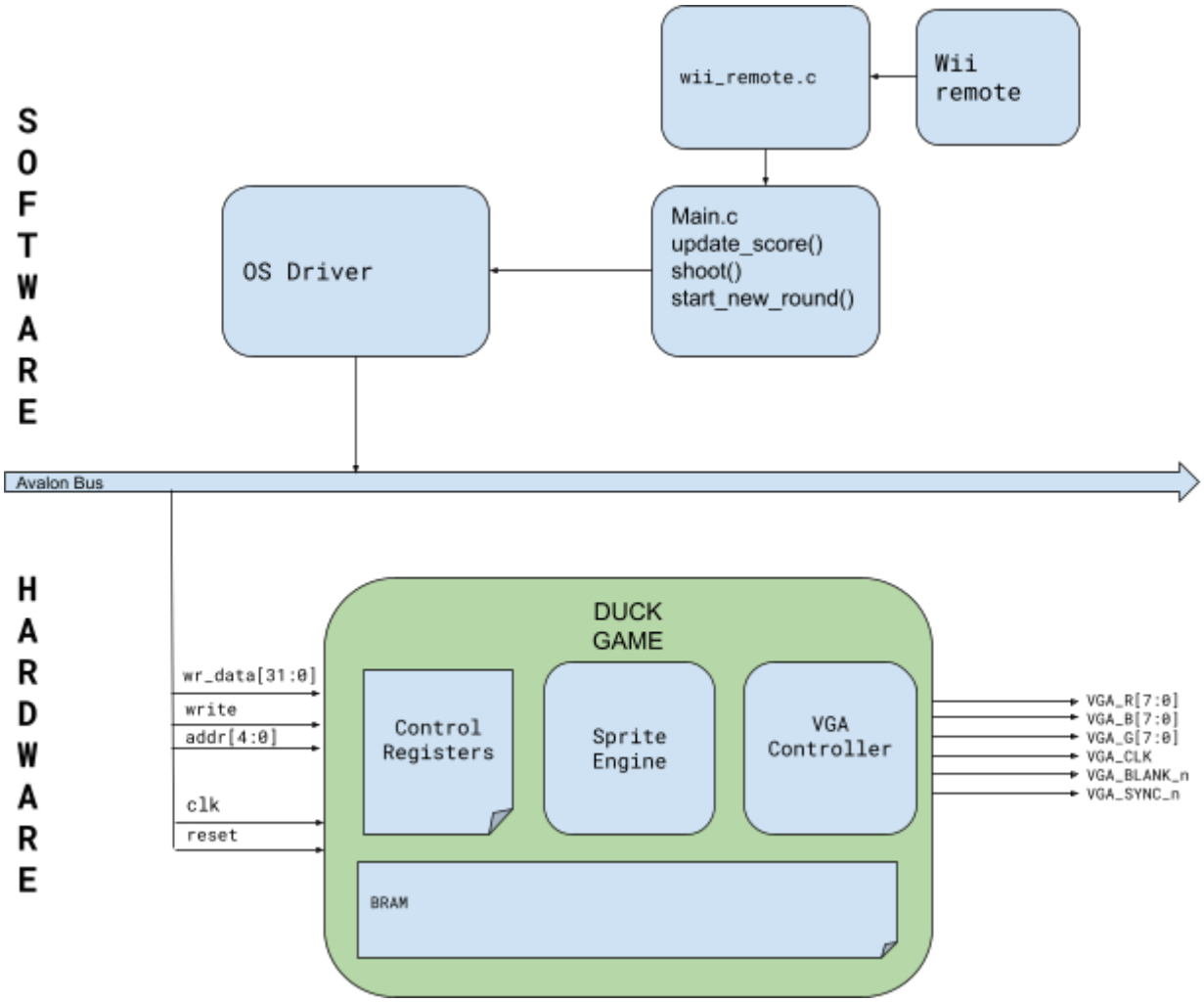
We are recreating the classic NES game “Duck Hunt.” The premise of the game is that ducks are introduced from the bottom of the screen and fly in a randomized pattern. The player has three shots to hit the ducks. After shooting all three bullets, the state resets and new ducks are introduced. We will use a Wii remote to control the position of a crosshair on the screen displayed by the VGA. If a player successfully positions the crosshair over a duck and clicks the trigger, they have successfully shot the duck. The player score will be computed from the number of ducks shot in a single game instance, and we will incorporate varying game difficulties.

We will be using tile and sprite graphics to display our visuals. The game logic and input will be handled by software. We will prioritize making a functional Wii remote controller for our game, which will communicate to the FPGA via Bluetooth. The software will communicate coordinates and game state to the hardware for display on a screen.

OVERVIEW


SOFTWARE
wii_remote.c
Wii remote
OS Driver
Main.c
update_score()
shoot()
start_new_round()
Avalon Bus
HARDWARE
DUCK GAME
wr_data[31:0]
write
addr[4:0]
clk
reset
Control Registers
Sprite Engine
VGA Controller
BRAM
VGA_R[7:0]
VGA_B[7:0]
VGA_G[7:0]
VGA_CLK
VGA_BLANK_n
VGA_SYNC_n

HW/SW Interface

Register Table			
Offset	Bits	Name	Description
0x000	[1:0]	GameState	Controls background for displaying start screen (0), game (1), and game over (2).
0x020	[31:0]	Score	Current Score
0x040	[31:0]	Bullets	Number of Remaining Bullets
0x060	[31:0]	Round	Current Round
0x080	[19:10] [9:0]	Crosshair X Crosshair Y	X and Y location of crosshair
0x0A0	[24:20] [19:10] [9:0]	D1 Sprite D1 X D1 Y	Control parameters for duck 1
0x0D0	[24:20] [19:10] [9:0]	D2 Sprite D2 X D2 Y	Control parameters for duck 2

Algorithms

The core game logic and game state will be updated through control algorithms on the software side. The main states we keep track of during gameplay are:

- Game state (score, round, bullets remaining, ducks hit)
- Duck states (position, velocity vector, sprite option)
- Crosshair position

Game state - The main game loop will be responsible for tracking the gameplay in one instance. On game over, the loop will reset all states for a new playthrough. The game state we track during gameplay are the scores (increasing by multiples of 500 as ducks are shot), bullets remaining (from 3), round (increasing after each set of ducks), and total ducks hit (used for display). The score displays are communicated over to hardware for display.

Duck states - Each duck state encapsulates the information that should be communicated to the hardware during each frame (position, sprite option) as well as some meta information about the velocity of the duck. This provides sufficient information to determine duck position at the next frame. E.g. If the duck has been shot, decrease Y position and display “dead” sprite.

Crosshair position - This information is polled from the Wii remote controller during each pass and checked for collision with ducks that are not dead or inactive. We note that there is required setup before the main game loop to sync the Wii controller for accurate positions.

We have produced the following pseudocode which captures the general interfaces, components, and main function logic of our program:

```
enum duck_state  { flap_up, flap_down, dead, inactive };

typedef struct {
       unsigned int x,y;
       unsigned int vx, vy;
       unsigned int value;
       duck_state state;
} duck_config_t;

typedef struct {
      unsigned int x,y;
};

typedef struct {
       unsigned int bullets, score, round;
} game_config_t;

// Calculates hit-square associated with the x,y position of the duck. returns 1 if
wii controller x, y coordinates are in the hit-square.
int shoot(duck_coord_t * coord);

// called during game initialization. set number of bullets to three, score to zero
and round to 1.
int set_up_config(game_config_t * config);

// called when a player shoots or when a round is over.
int update_game_config(game_config_t * config);

// uses ioctl calls to tell our driver to update the coordinate of the duck.
int write_duck_coord(duck_config_t * config);

// uses ioctl calls to tell our driver to update the state of the duck.
int write_duck_state(duck_config_t* config);

int poll_wii_controller();


int main() {
// sync Wii remote locations

  while(1){
        play_game();
    }
}

int play_game(){
// setup logic, send stuff to hardware
```

```
duck_config_t duck;
game_config_t game;
set_up_config(&game);
while (1) {
	// poll for x,y values and trigger press
	poll_wii();
	if( is_game_over() )
	{
		return;
	}
	if( trigger_pressed ){
		if( shoot_duck() ){
				update_duck_state(); // change duck state to dead;
				game.score += duck.value;
			}
		game.num_bullets -= 1;
	}
	// Note: ducks below location Y on screen are hidden behind bush sprites
	// compute location of ducks
	move_duck(&duck);

	update_game_config(&game);  // ioctl calls to update hardware
	write_duck_coord(&duck);

	}
	return 0;
}
```

Resource Budget

Category	Image	Size (pixels)	Variants	Total Bits
Duck		40 x 34	3	3 * 40 * 34 * 4 = 16,320 bits
Bullet		16 x 16	1	1 * 16 * 16 * 4 = 1024 bits
Background		16 x 16	8	8* 16 * 16 * 4 = 8192 bits
Score (numbers)		16 x 16	10	10 * 16 * 16 * 4 = 10240 bits
Ducks Counter		16 x 16	1	1 * 16 * 16 * 4 = 1024 bits
Color Pallet				10 * 24 = 240 bits

Total Memory: 37040bits = 4.63 kB