```c
/*
 * helloworld.c: simple test application
 * Currently used to test lab 3 for Space Invaders.
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 */

#include <stdio.h>
#include <stdint.h>
#include "platform.h"
#include "xparameters.h"
#include "xaxivdma.h"
#include "xio.h"
#include "time.h"
#include "unistd.h"
#include "tank.h"
#include "interface.h"
#include "aliens.h"
#include "bunkers.h"
#include "mother_ship.h"
#include "util.h"

#include "xgpio.h"
#include "mb_interface.h"
#include "xintc_l.h"

#define DEBUG

#define SCREEN_RES_X 640    // Our screen resolution is 640 * 480
#define SCREEN_RES_Y 480    // Our screen resolution is 640 * 480
#define BLACK 0x00000000    // Hex value for black
#define BLUE  0x2222FF

#define ONE_SECOND  100     // 100 ticks in a second
#define HALF_SECOND 50      // 50 ticks in half a second
#define QUARTER_SECOND 25   // 25 ticks in a quarter second
#define EIGHTH_SECOND 12    // 12 ticks in an eigth second
#define TENTH_SECOND 10     // 10 ticks in a tenth second
#define TWENTIETH_SECOND 5  // 5 ticks in a twentieth second
#define SUPER_FAST 2        // super fast

#define MOTHER_SHIP_SPEED TENTH_SECOND      // Mother ship moves slowly
#define MOTHER_SHIP_SPAWN_CONSTANT 1000     // Mother ship spawns infrequently
#define ALIEN_SHOT_SPAWN_CONSTANT 100       // Aliens shoot frequently
#define ALIEN_MOVE_SPEED HALF_SECOND        // aliens move very slowly

#define BUTTON_UP       0x10    // Constants for button masks
#define BUTTON_DOWN     0x4
#define BUTTON_LEFT     0x8
#define BUTTON_RIGHT    0x2
#define BUTTON_CENTER   0x1

void print(char *str);          // print exists!

#define FRAME_BUFFER_0_ADDR 0xC1000000  // Starting location in DDR

//-----------------------------
void timer_interrupt_handler();
void pb_interrupt_handler();
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void interttupt_handler_dispatcher();
//-----------------------------


XGpio gpLED;  // This is a handle for the LED GPIO block.
XGpio gpPB;   // This is a handle for the push-button GPIO block.
uint32_t* framePointer0 = (uint32_t*) FRAME_BUFFER_0_ADDR;
int32_t currentButtonState;     // Current button being pressed
int32_t mother_ship_points;


void timer_interrupt_handler(){
    static uint32_t timerCount;                 // Timer for timing
    static uint32_t mother_ship_move_counter;   // Timer for mother ship
    tank_update_bullet(framePointer0);          // update all bullets
    aliens_update_bullets(framePointer0);       // update all bullets

    timerCount++;                               // Increment all counters
    mother_ship_move_counter++;
    mother_ship_points++;

    int32_t r = rand();
    if(r%ALIEN_SHOT_SPAWN_CONSTANT == 0){
        alien_missle(framePointer0);    // Make the aliens fire
    }
    if(r%MOTHER_SHIP_SPAWN_CONSTANT == 0){
        mother_ship_spawn();            // mother ship spawns!
    }
    if(mother_ship_move_counter >= MOTHER_SHIP_SPEED){  // MS moves
        mother_ship_move_counter = 0;
        mother_ship_move();
    }
    if(mother_ship_points > TENTH_SECOND){
        mother_ship_points = 0;         // Mother ship points will display
        mother_ship_points_blink();
    }
    if(timerCount >= 5 ){
        timerCount = 0;
        aliens_move(framePointer0); // move the aliens
    }

    // Now to check the buttons.
    if(currentButtonState & BUTTON_LEFT){
        tank_move_left(framePointer0);      // Moving the tank left
    }
    if(currentButtonState & BUTTON_RIGHT){
        tank_move_right(framePointer0);     // Moving the tank right
    }
    if(currentButtonState & BUTTON_CENTER){
        tank_fire(framePointer0);           // Fire the tank!
    }
    if(currentButtonState & BUTTON_UP){     // Not functional yet
    }
}
void pb_interrupt_handler(){
    XGpio_InterruptGlobalDisable(&gpPB);    // Can't be interrupted by buttons
    xil_printf("Button Interrupt\n\r");
    currentButtonState = XGpio_DiscreteRead(&gpPB, 1);
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    // Time to clear the interrupt and reenable GPIO interrupts
    XGpio_InterruptClear(&gpPB, 0xFFFFFFFF);
    XGpio_InterruptGlobalEnable(&gpPB);
}

// Main interrupt handler, queries interrupt controller to see what peripheral
// fired the interrupt and then dispatches the corresponding interrupt handler.
// This routine acks the interrupt at the controller level but the peripheral
// interrupt must be ack'd by the dispatched interrupt handler.
// Question: Why is timer_interrupt_handler() called after ack'ing controller
// but pb_interrupt_handler() is called before ack'ing the interrupt controller?
void interrupt_handler_dispatcher(void* ptr) {
    int intc_status = XIntc_GetIntrStatus(XPAR_INTC_0_BASEADDR);
    // Check the FIT interrupt first.
    if (intc_status & XPAR_FIT_TIMER_0_INTERRUPT_MASK){
        XIntc_AckIntr(XPAR_INTC_0_BASEADDR, XPAR_FIT_TIMER_0_INTERRUPT_MASK);
        timer_interrupt_handler();  // It was a timer interrupt! call that fn
    }
    // Check the push buttons.
    if (intc_status & XPAR_PUSH_BUTTONS_5BITS_IP2INTC_IRPT_MASK){
        pb_interrupt_handler();     // It was a button interrupt!
        XIntc_AckIntr(XPAR_INTC_0_BASEADDR, // Acknowledge the interrupt
                XPAR_PUSH_BUTTONS_5BITS_IP2INTC_IRPT_MASK);
    }
}

void init_interrupts(void){
    int32_t success;
    print("\n\rHello . Let's have a fun \e[31m\e[1mtime \e[21m\e[0m\n\r");
    success = XGpio_Initialize(&gpPB, XPAR_PUSH_BUTTONS_5BITS_DEVICE_ID);
    // Set the push button peripheral to be inputs.
    XGpio_SetDataDirection(&gpPB, 1, 0x0000001F);
    // Enable the global GPIO interrupt for push buttons.
    XGpio_InterruptGlobalEnable(&gpPB);
    // Enable all interrupts in the push button peripheral.
    XGpio_InterruptEnable(&gpPB, 0xFFFFFFFF);
    // Register the interrupt handler
    microblaze_register_handler(interrupt_handler_dispatcher, NULL);
    // And enable interrupts
    XIntc_EnableIntr(XPAR_INTC_0_BASEADDR,
            (XPAR_FIT_TIMER_0_INTERRUPT_MASK |
                    XPAR_PUSH_BUTTONS_5BITS_IP2INTC_IRPT_MASK));
    // Master the enable
    XIntc_MasterEnable(XPAR_INTC_0_BASEADDR);
    // And enable again
    microblaze_enable_interrupts();
}

int main() {
    init_platform();                    // Necessary for all programs.
    init_interrupts();
    int Status;                         // Keep track of success/failure of system
function calls.
    XAxiVdma videoDMAController;
    // There are 3 steps to initializing the vdma driver and IP.
    // Step 1: lookup the memory structure that is used to access the vdma driver.
    XAxiVdma_Config * VideoDMAConfig = XAxiVdma_LookupConfig(XPAR_AXI_VDMA_0_DEVICE_ID);
    // Step 2: Initialize the memory structure and the hardware.
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    if(XST_FAILURE == XAxiVdma_CfgInitialize(&videoDMAController,
VideoDMAConfig, XPAR_AXI_VDMA_0_BASEADDR)) {
        xil_printf("VideoDMA Did not initialize.\r\n");
    }
    // Step 3: (optional) set the frame store number.
    if(XST_FAILURE ==  XAxiVdma_SetFrmStore(&videoDMAController, 2, XAXIVDMA_READ)) {
        xil_printf("Set Frame Store Failed.");
    }
    // Initialization is complete at this point.

    // Setup the frame counter. We want two read frames. We don't need any write frames
but the
    // function generates an error if you set the write frame count to 0. We set it to 2
    // but ignore it because we don't need a write channel at all.
    XAxiVdma_FrameCounter myFrameConfig;
    myFrameConfig.ReadFrameCount = 2;
    myFrameConfig.ReadDelayTimerCount = 10;
    myFrameConfig.WriteFrameCount =2;
    myFrameConfig.WriteDelayTimerCount = 10;
    Status = XAxiVdma_SetFrameCounter(&videoDMAController, &myFrameConfig);
    if (Status != XST_SUCCESS) {
        xil_printf("Set frame counter failed %d\r\n", Status);
        if(Status == XST_VDMA_MISMATCH_ERROR)
            xil_printf("DMA Mismatch Error\r\n");
    }
    // Now we tell the driver about the geometry of our frame buffer and a few other
things.
    // Our image is 480 x 640.
    XAxiVdma_DmaSetup myFrameBuffer;
    myFrameBuffer.VertSizeInput = 480;    // 480 vertical pixels.
    myFrameBuffer.HoriSizeInput = 640*4;  // 640 horizontal (32-bit pixels).
    myFrameBuffer.Stride = 640*4;         // Dont' worry about the rest of the values.
    myFrameBuffer.FrameDelay = 0;
    myFrameBuffer.EnableCircularBuf=1;
    myFrameBuffer.EnableSync = 0;
    myFrameBuffer.PointNum = 0;
    myFrameBuffer.EnableFrameCounter = 0;
    myFrameBuffer.FixedFrameStoreAddr = 0;
    if(XST_FAILURE == XAxiVdma_DmaConfig(&videoDMAController, XAXIVDMA_READ,
&myFrameBuffer)) {
        xil_printf("DMA Config Failed\r\n");
    }
    // We need to give the frame buffer pointers to the memory that it will use. This
memory
    // is where you will write your video data. The vdma IP/driver then streams it to the
HDMI
    // IP.
    myFrameBuffer.FrameStoreStartAddr[0] = FRAME_BUFFER_0_ADDR;
    myFrameBuffer.FrameStoreStartAddr[1] = FRAME_BUFFER_0_ADDR + 4*640*480;

    if(XST_FAILURE == XAxiVdma_DmaSetBufferAddr(&videoDMAController, XAXIVDMA_READ,
            myFrameBuffer.FrameStoreStartAddr)) {
        xil_printf("DMA Set Address Failed Failed\r\n");
    }
    // Print a sanity message if you get this far.
    xil_printf("Woohoo! I made it through initialization.\n\r");
    // Now, let's get ready to start displaying some stuff on the screen.
    // The variables framePointer and framePointer1 are just pointers to the base address
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    // of frame 0 and frame 1.
    uint32_t* framePointer0 = (uint32_t*) FRAME_BUFFER_0_ADDR;
    // Just paint some large red, green, blue, and white squares in different
    // positions of the image for each frame in the buffer (framePointer0 and
framePointer1).
    int row=0, col=0;
    for( row=0; row<SCREEN_RES_Y; row++) {
        for(col=0; col<SCREEN_RES_X; col++) {
            framePointer0[row*SCREEN_RES_X + col] = BLACK;
        }
    }

    bunkers_init(framePointer0);            // Init the bunkers
    tank_init();                            // initialize the tank
    tank_draw(framePointer0, false);        // draw the tank
    interface_init_board(framePointer0);    // draw the tanks at the top
    aliens_init(framePointer0);             // initialize aliens
    mother_ship_init(framePointer0);        // Init the mother ship

    // This tells the HDMI controller the resolution of your display (there must be a
better way to do this).
    XIo_Out32(XPAR_AXI_HDMI_0_BASEADDR, 640*480);

    // Start the DMA for the read channel only.
    if(XST_FAILURE == XAxiVdma_DmaStart(&videoDMAController, XAXIVDMA_READ)){
        xil_printf("DMA START FAILED\r\n");
    }
    int frameIndex = 0;
    // We have two frames, let's park on frame 0. Use frameIndex to index them.
    // Note that you have to start the DMA process before parking on a frame.

    if (XST_FAILURE == XAxiVdma_StartParking(&videoDMAController, frameIndex,
XAXIVDMA_READ)) {
        xil_printf("vdma parking failed\n\r");
    }
    char input;
    srand((unsigned)time( NULL ));

    xil_printf("Are we getting here?\n\r");
    while(1){       // This doesn't need to be here no more
        //aliens_move(framePointer0);   // move the aliens
        tank_update_bullet(framePointer0);  // update all bullets
        aliens_update_bullets(framePointer0);   // update all bullets
        //interface_increment_score(framePointer0,0);
        input = getchar();
        switch(input){
        case '4':
            tank_move_left(framePointer0);      // move the tank left
            break;
        case '6':
            tank_move_right(framePointer0);     // move the tank right
            break;
        case '8':
            mother_ship_spawn();
            break;
        case '2':
            interface_kill_tank();
            interface_increment_score(1);
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            //aliens_kill(framePointer0);   // Kill an alien
            break;
        case '5':
            tank_fire(framePointer0);       // Make the tank fire
            break;
        case '3':
            alien_missle(framePointer0);    // Make the aliens fire
            break;
        case'9':
            mother_ship_move();
            break;
        case '7':
            break;
        }
    }
    cleanup_platform();
    return 0;
}
```