CRT 360: Advanced Prototyping

GamePad - Game Setup

Part I: Getting Started

1. Graphic Resources

Open Teensyduino and create a new sketch and save it as [FirstName]_GamePad. Create an appropriate header comment with information about your game. For example:

```
// HackBerry Attack!
// Zane Cochran || 01 Jan 2021
// CRT 360 Advanced Prototyping || GamePad
```

Export all pixel sprites from Piskel by going to Export -> Others -> Download C File. Make sure your scale is set to 1.0x to ensure proper sizing.

Then use the Piskel2LCD application to convert each Piskel file into an Arduino-friendly .h files. Each C file from Piskel will result in two Arduino files - an XXX_MASK.h and an XXX_PIX.h file. The MASK file contains all the transparency information for the images whereas the PIX file contains all the color information. The Arduino will use both of these files to draw the graphics you created.

Move these files into the folder created by Arduino when you saved your new sketch.

2. Frame Rate Sampling

Begin a Serial connection (9600 baud rate) in the setup( ) function.

Create a new tab called *frame.h* and include the Metro library. Create a new timer using the following format (replace *timerName* with a descriptive name for your timer and *timerDuration* for the number of milliseconds to delay):

```
#include <Metro.h>                          // This adds the Metro library to your sketch
Metro timerName = Metro(timerDuration);     // A prototype for a Metro timer
```

Create a function called checkFrame that will print how many times the Arduino has gone around the loop every 1 second. You can use the .check( ) function in Metro like this:

```
if(timerName.check( ) == true){
        // do something
}
```

Or even simpler - since the .check( ) function returns a true or false value, it is not necessary to include the == true part of the if statement:

```
if(timerName.check( )){
        // do something
}
```

void checkFrame( ) Copy/Paste your function in the space below

```
#include <Metro.h>        // This adds the Metro library to your sketch
Metro frameTimer = Metro(1000); // A prototype for a Metro timer
int x;

void checkFrameRate(){
  x++;
 if(frameTimer.check( )){
   Serial.println(x);
 }
}
```

Include the frame.h file in the header of your program's main tab and call the checkFrame function in the loop( ). Record an example of the types of frame rates you observe below:

Observed Frame Rate
13,635,610

3. Screen Setup:

Connect your Teensy to your LCD screen using the following configuration:

Teensy / ILI9341 LCD Screen Pinouts			
ILI9341 Pin	**Teensy 4.0 Pin**	**ILI9341 Pin**	**Teensy 4.0 Pin**
VCC	VIN	GND	GND
CS	10	RESET	8
D/C	9	SDI (MOSI)	11
SCK	13	LED	VIN (w/ 100Ω Resistor)
SDO (MISO)	12	Source: https://www.pjrc.com/store/display_ili9341_touch.html	

Create a screen.h tab and include the SPI and ILI9341 libraries, screen pin definitions, and create the screen object in the header of the tab:

```
#include "SPI.h"
#include "ILI9341_t3n.h"

#define TFT_DC  9
#define TFT_CS  10
#define TFT_RST 8

ILI9341_t3n tft = ILI9341_t3n(TFT_CS, TFT_DC, TFT_RST);
```

Also define the screen width and height and initialize the screen buffer in the header as well:

```
#define screenW  320
#define screenH  240
DMAMEM uint16_t screenBuffer[screenW * screenH];              // Screen Buffer
```

Create the function void initScreen( ) to begin communicating with the screen. Connect to the LCD and rotate the screen using the .setRotation( ) command. Initialize and activate the frameBuffer and fill the screen with black:

```
tft.begin();                          // Connect to LCD Screen
tft.setRotation(1);                   // Rotate Screen 90 Degrees

tft.setFrameBuffer(screenBuffer);     // Initialize Frame Buffer
tft.useFrameBuffer(1);                // Use Frame Buffer

tft.fillScreen(ILI9341_BLACK);        // Clear Screen
```

Create another function called screenTest( ). This function should change the entire screen from black to white over and over again every 2 seconds. Use the Metro library, a boolean, and the resources from the Adafruit GFX Documentation to help you.

Include the screen.h file on the program's main tab and call the initScreen( ) function in the main program's setup( ). Call the screenTest( ) function in the loop( ) and test. After testing, remove the screenTest( ) from the loop.

void screenTest( ) Copy/Paste your function and any helper variables.

```
#include "SPI.h"
#include "ILI9341_t3n.h"
#include <Metro.h>

#define TFT_DC  9
#define TFT_CS  10
#define TFT_RST 8
ILI9341_t3n tft = ILI9341_t3n(TFT_CS, TFT_DC, TFT_RST);
Metro screenTime = Metro (2000);

boolean flip;
```

```
#define screenW  320
#define screenH  240
DMAMEM uint16_t screenBuffer[screenW * screenH];                // Screen Buffer


void initScreen(){
   tft.begin();                      // Connect to LCD Screen
 tft.setRotation(1);                 // Rotate Screen 90 Degrees

 tft.setFrameBuffer(screenBuffer);   // Initialize Frame Buffer
 tft.useFrameBuffer(1);              // Use Frame Buffer

 tft.fillScreen(ILI9341_BLACK);      // Clear Screen
}
void screenTest (){
 if(screenTime.check()){
  flip=!flip;
 }
 if(flip==true){
  tft.fillScreen(ILI9341_BLACK);
 }else{
   tft.fillScreen(ILI9341_WHITE);
 }
}
```

4. Drawing Level Tiles

Create a new tab called *tile.h* and include all the pixel sprite .h files you added in Step 2 into its header. For example:

```
#include "tiles_MASK.h"
#include "tiles_PIX.h"
```

Define some parameters for the level sprite tiles. For example:

```
#define tileW 16        // 16 Tiles Across
#define tileH 12        // 12 Tiles Down
#define tileSize 20     // Tile Width (in pixels)
#define numLevels 6     // Number of Levels
```

Create a 2-dimensional array called levels to store each level's tile layout. Each value in the array will correspond to a specific bitmap tile you created in Piskel. You can reference the tiles using their hex values you recorded in the previous assignment. If you have some parts of the level that will not have a tile, indicate this by using the hex value 0xFF. Use your level maps and game resources from the concept development assignment to help you. For example:

```
int levels[numLevels][tileW * tileH]{
  // Level 0 - Front
```

```
{
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, 0x01,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x1C, 0x1D, 0x00, 0x00, 0x1E, 0x1F, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0F, 0x04, 0x04, 0x04, 0x04, 0x05, 0x05, 0x04, 0x04, 0x04, 0x04, 0x0C,
},
// Level 1 - Design Studio
{
  0xFF, 0xFF, 0xFF, 0xFF, 0x0F, 0x04, 0x04, 0x04, 0x04, 0x05, 0x05, 0x04, 0x04, 0x04, 0x04, 0x0C,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x17, 0x14, 0x03, 0x03, 0x17, 0x14, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x16, 0x15, 0x03, 0x03, 0x16, 0x15, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x07,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x07,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x17, 0x14, 0x03, 0x03, 0x17, 0x14, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x16, 0x15, 0x03, 0x03, 0x16, 0x15, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0A, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x03, 0x21, 0x06,
  0xFF, 0xFF, 0xFF, 0xFF, 0x0E, 0x08, 0x08, 0x08, 0x08, 0x09, 0x09, 0x08, 0x08, 0x08, 0x08, 0x0D,
},
// Etc..
};
```

Write a function called void drawLevel(int thisLevel) that takes an input of which level should be drawn and store each tile at the appropriate location in the screen buffer using the tft.drawRGBBitmap( ) function.

Test the drawLevel( ) function by calling it in the main loop sampling each of the levels you designed. You will need to call the tft.updateScreen( ) function to send the screen buffer to the LCD screen. Also, open the Serial monitor and make a note of the frame rate. Remove these functions from the main loop when you are done testing.

void thisLevel( ) Copy/Paste your function in the space below

```
void drawLevel(int thisLevel){
 for(int y=0; y<tileH;y++){
  for(int x=0;x<tileW;x++){
    int index = x +(y* tileW);
    int whichTile = levels[thisLevel][index];

    int finalX = x * tileSize;
    int finalY=  y * tileSize;
    tft.drawRGBBitmap(finalX,finalY, tiles_PIX[whichTile],tileSize, tileSize);

  }
 tft.updateScreen();
 }
}
```

Part II: Get Moving

1. Setting up Controls

On your breadboard, hook up 4 push buttons that use the Teeny's internal pullup resistors (no external 10k resistors needed) on pins 0 - 3. Also, attach the X-axis of an analog stick to pin 14 and the Y-axis to pin 15.

Create a controls.h tab and include the Bouce2 library. Create a variable called buttonBounce and set it to 10 to represent a 10ms debounce time for reading the button. Create an array of 4 buttons to keep track of the debounce state of each of them like so:

```
#include <Bounce2.h>
int buttonBounce = 10;
Bounce * buttons = new Bounce[4];
```

Also create an array called buttonPins[4] and initialize it with the pin assignments of each of your buttons. Create another array called buttonBuffer[4] and initialize it with zeros. The buttonBuffer will serve as a place to save the current state of each button. Similarly, create an array called joystickPins[2] and initialize it with the joystick pin assignments and create a joystickBuffer[2] as well.

Create a function called initControls( ) and use a for loop to attach and set the interval for each button. Those functions will look like this:

```
buttons[i].attach(buttonPins[i], INPUT_PULLUP);
buttons[i].interval(buttonBounce);
```

Add this initControls( ) function to the main setup of your program.

void initControls( ) Copy/Paste your function in the space below

Create a function called getControls( ) that will get that current status of each button and update the buttonBuffer with its state (0 - Not Pressed, 1 - Pressed). Use a loop to avoid writing code for each individual button. You can check the status of each button using the .fell ( ) and .rose( ) functions. For example:

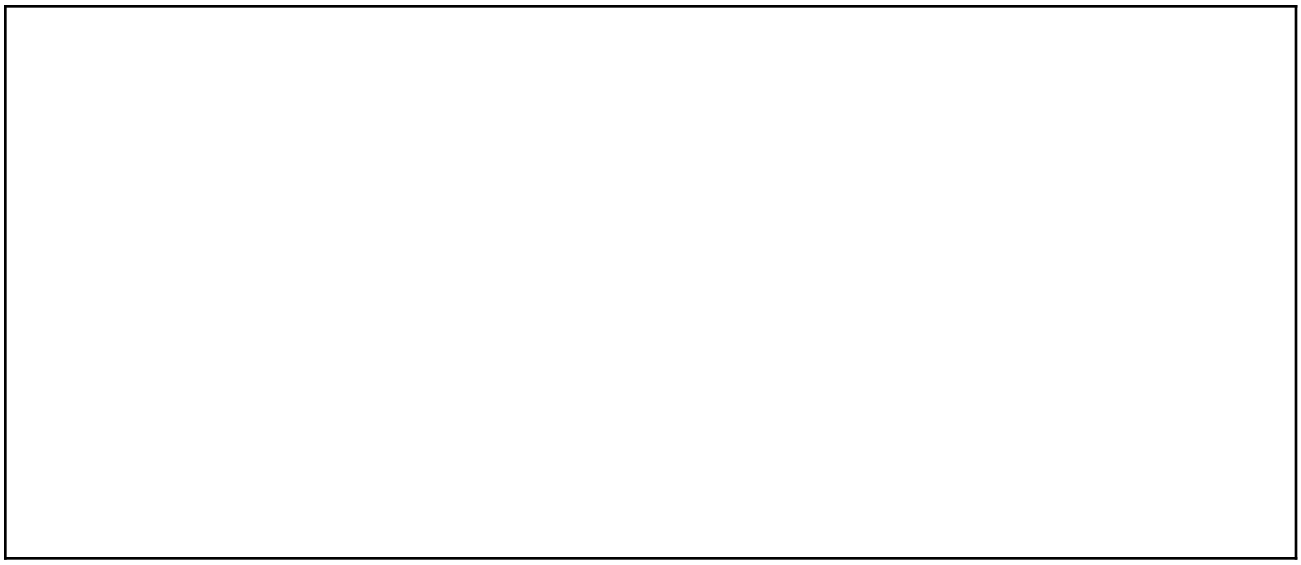
```
if(myButton.fell( ) ){ } // button is not pressed anymore
if(myButton.rose( ) ){ } // button was just pressed
```

AnalogRead the status of the analog sticks, but this time, find the centerpoint of each axis on the analog sticks and set the buffer to -1 if the axis dips below a certain threshold, 1 if the axis is above that threshold, and 0 if it is within that threshold of the center point. You will need to experiment to determine this threshold. Your stick should conform to the following logic:

Analog Stick - Left/Up Stick Array [-1, -1]	Analog Stick - Neutral/Up Stick Array [0, -1]	Analog Stick - Right/Up Stick Array [1, -1]
Analog Stick - Left/Neutral Stick Array [-1, 0]	Analog Stick - Neutral Stick Array [0, 0]	Analog Stick - Right/Neutral Stick Array [1, 0]
Analog Stick - Left/Down Stick Array [-1, 1]	Analog Stick - Neutral/Down Stick Array [0, 1]	Analog Stick -Right/Down Stick Array [1, 1]

Serial print the status of the analog sticks and push buttons to a single line and test all your code and hardware. Put these Serial print statements in a Metro timer that updates every 25ms to avoid overwhelming the Serial monitor. Call the getControls( ) function in the main loop and debug and adjust as necessary. Once you have dialed in the controls, comment out the Serial.print statements.

void getControls( ) Copy/Paste your function in the space below



2. Drawing a Hero

Create a new tab named hero.h and include it in the main program header. On the hero.h tab include the graphics for your hero bitmaps. Create two floating point variables (heroX and heroY) and initialize them to the middle of the screen. Also create a floating point variable heroSpeed and initialize it to 1.0 to keep track of how fast the hero should move. This can be adjusted as necessary.

Create a function called drawHero( ). This function should update the location of the hero based on input received from the buttonBuffer and joystickBuffer created on the controls.h tab. It should then use the following logic to draw the hero:

1. Update the location of the hero (heroX, heroY) from the button and joystick buffers. Remember to multiply the values in the buffers by the heroSpeed (adjust speed as necessary) and constrain the movement to the screen.
2. Draw the current level using the drawLevel function
3. Set a clipping rectangle using the .setClipRect( ) function. Be sure to include a margin around the edges to prevent artifacts
4. Draw the hero using .drawRGBBitmap( ) function. You should use the version of this function that takes both a _PIX and _MASK array for transparency. Do not worry about animating the hero yet -- just use the first sprite in the hero_MASK and hero_PIX arrays.
5. Update the screen using the tft.updateScreen( ) function.

Run and test the getControls( ) and drawHero( ) functions to make sure that you are able to move your hero sprite around the screen.

Next, create a global variable called heroDir to keep track of the direction the hero should be facing as well as a global variable called heroFrame to keep track of which frame in the hero running animation should be shown. Also create a new Metro timer called heroFrameTimer and set its value to 250 ms.

In the drawHero( ) function, update heroDir based on the direction of the input. Every time the

timer goes off, advance to the next frame of the hero animation (and go back to the beginning as necessary). Use this to draw the hero running in the correct direction. Also check to see if the action/attack button has been used and show that frame of the animation.

void drawHero( ) Copy/Paste your function in the space below