Hand-Motion Controlled Doodle Jump

TEAM 07
B08901061陳永縉 B08901062張家翔 B08901102李允恩

Table of contents

01

Introduction

Features

1. Full Motion-Controlled Game
2. Application of Image and Voice Processing
3. FPGA-based Real-time Interactive Game

02
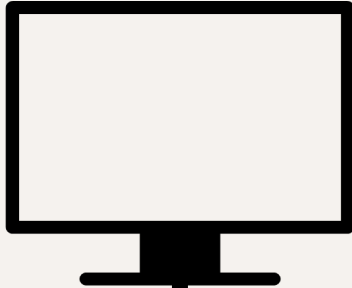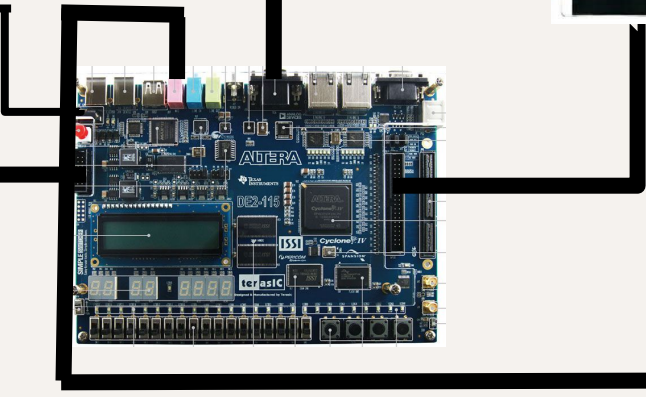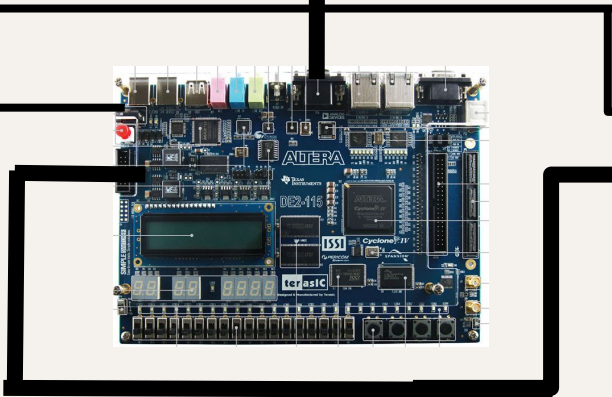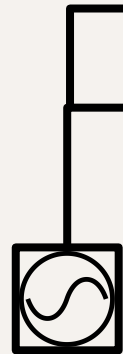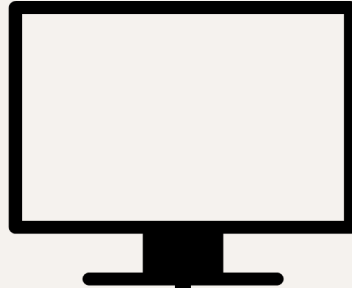## Structures

Doodle Jump
Game Display

Hand Motion
Display

Hand Motion Detection
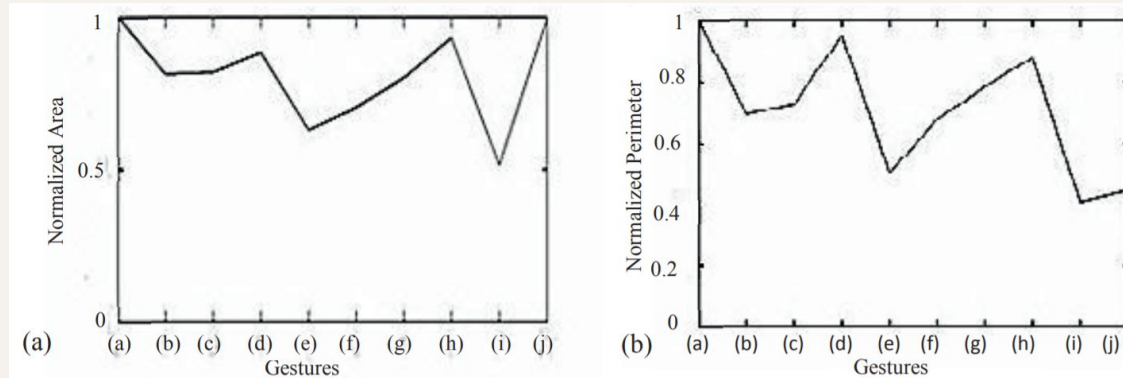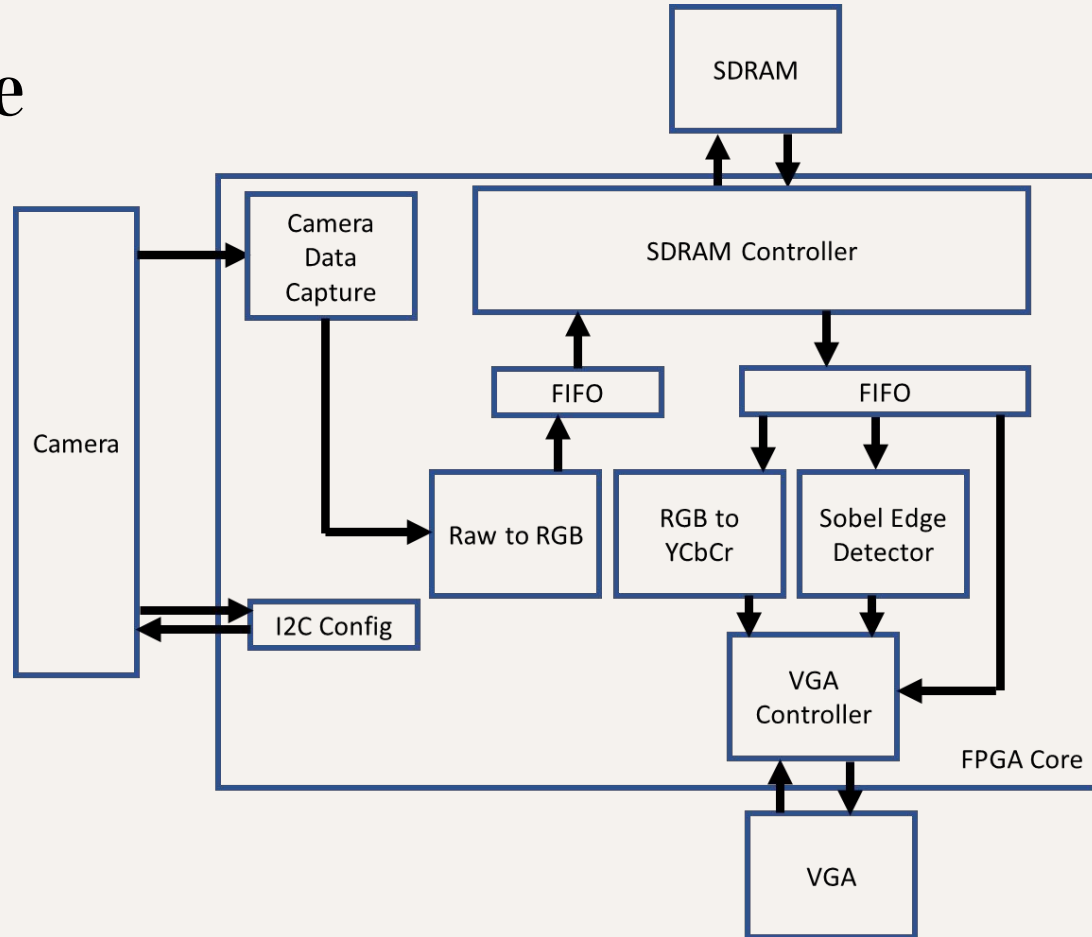
Related Works

FPGA based Real Time Human Hand Gesture Recognition System

$$Area\ of\ Hand = \sum_{x=0}^{W-1} \sum_{y=0}^{H-1} I(x,y)(segmented)$$

$$Perimeter\ of\ Hand = \sum_{x=0}^{W-1} \sum_{y=0}^{H-1} Edge(I(x,y))$$

Structure

SDRAM

SDRAM Controller

Camera Data Capture

Camera

I2C Config

Raw to RGB

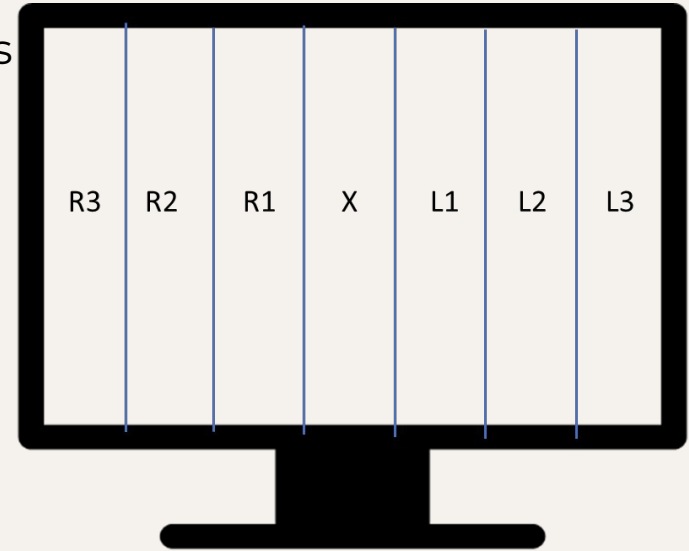RGB to YCbCr

Sobel Edge Detector

FIFO

FIFO

VGA Controller

VGA

FPGA Core

Skin Color Detection

1. Detect skin color pixels(133 <= Cr < 180 and 91 <= Cb < 112)
2. Find sections with the most skin color pixels
3. Send signals according to which section it is
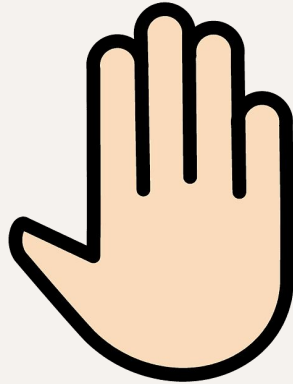
(L: Go left, X: Stay, R: Go Right)

| R3 | R2 | R1 | X | L1 | L2 | L3 |

Gesture Detection

1. Edge detection for skin color pixels
2. Count edge pixel amounts to distinguish gestures

Volume Detection

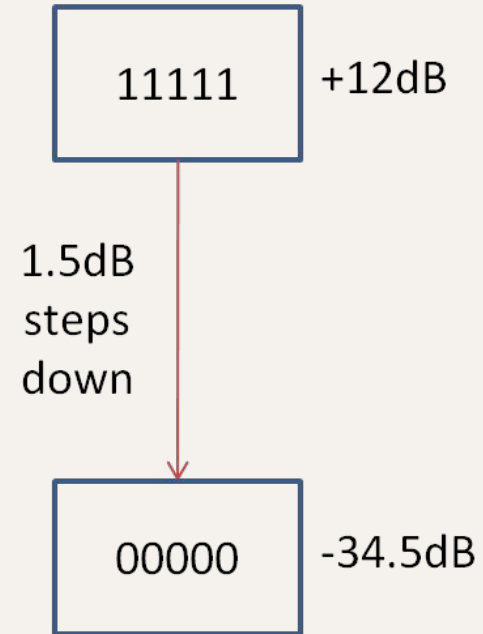# Volume Logic

1. WM8731 - 16-bit audio data input
2. [14:10] Line Input Volume

11111	+12dB

1.5dB steps down

00000	-34.5dB

03
Implementation

RGB to YCbCr

$Y = (0.257*R) + (0.504*G) + (0.098*B) + 16$

$Cr = (0.439 * R) - (0.368 * G) - (0.071 * B) + 128$

$Cb = - (0.148 * R) - (0.291 * G) + (0.439 * B) + 128$

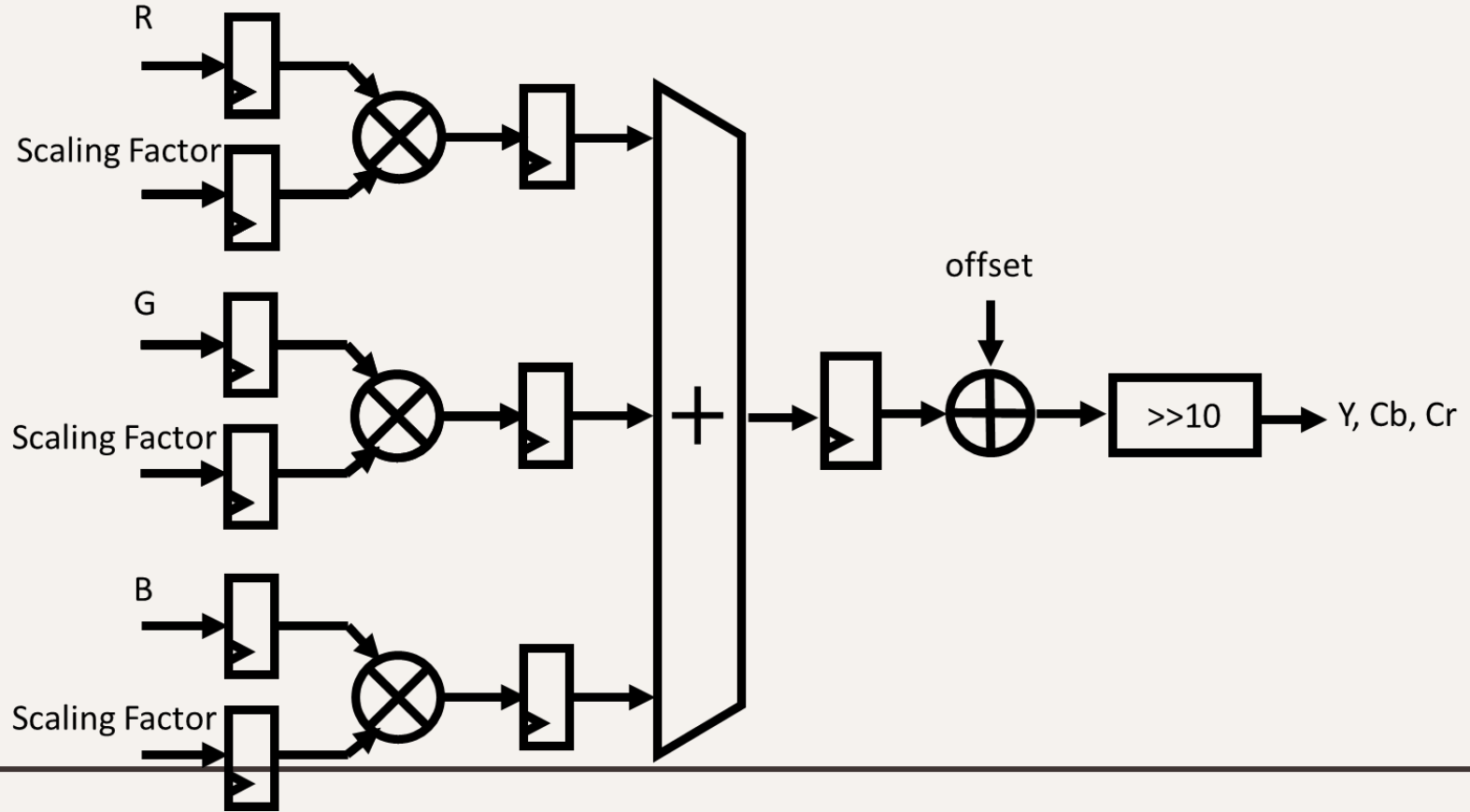Digital Representation:

$Y << 10 = (263 * R) + (516 * G) + (100 * B) + 16384$

$Cr << 10 = (450 * R) - (377 * G) - (731 * B) + 131072$

$Cb << 10 = - (152 * R) - (299 * G) + (450 * B) + 131072$

RGB to YCbCr

R

Scaling Factor

G

Scaling Factor

B

Scaling Factor

offset

\>\>10

Y, Cb, Cr

Skin Color Detection Result

Sobel Edge Filter

Gx

-1	0	+1
-2	0	+2
-1	0	+1

Gy

+1	+2	+1
0	0	0
-1	-2	-1

Sobel Edge Detector
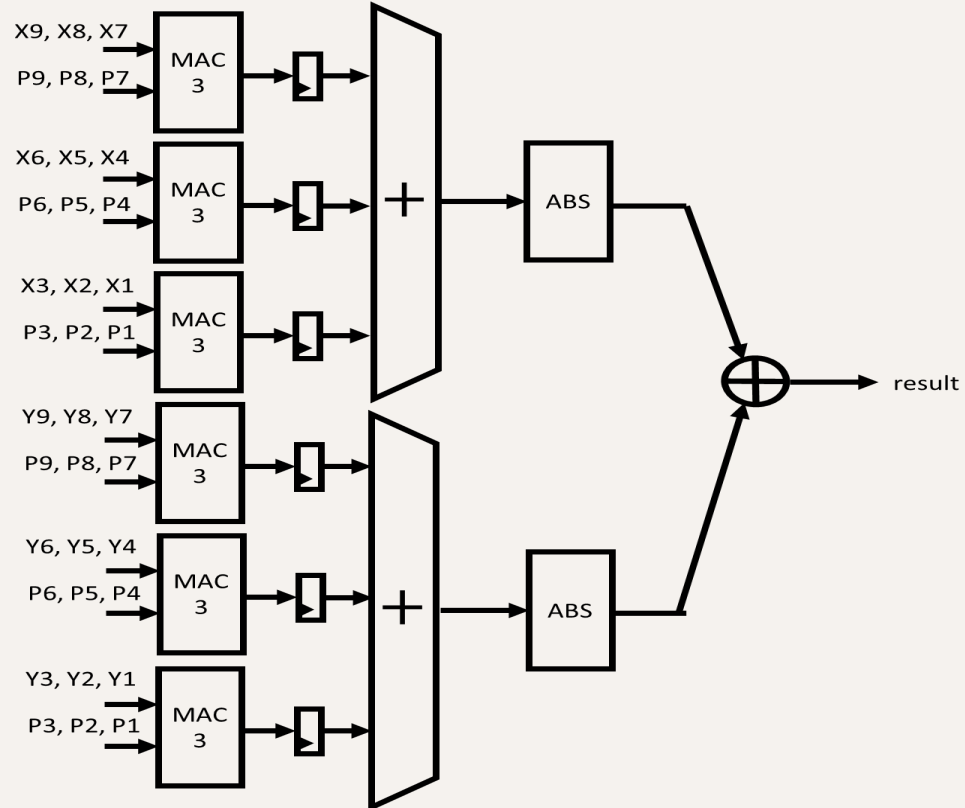
Edge Detection

Binary

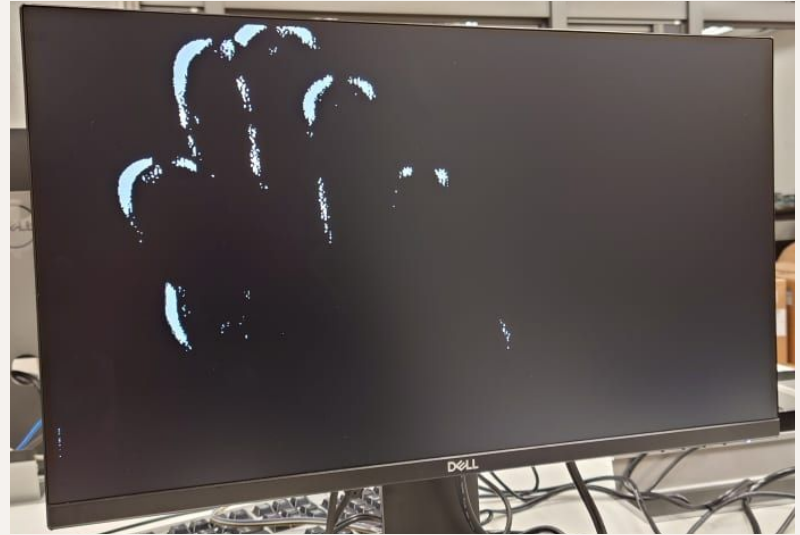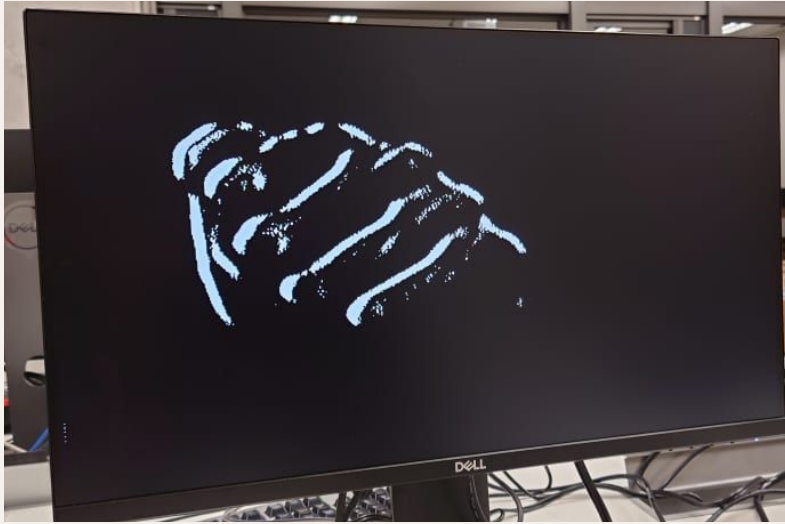Adjustable threshold to binarize the image

Skin Color Segmentation

Delete non-skin-colored pixels

Purify

Set center pixel to 0 if all surrounding pixels are 0

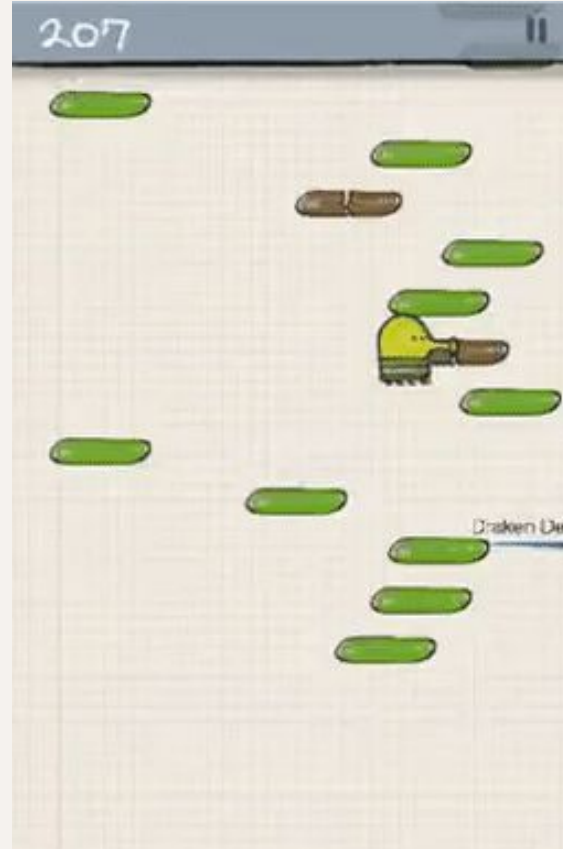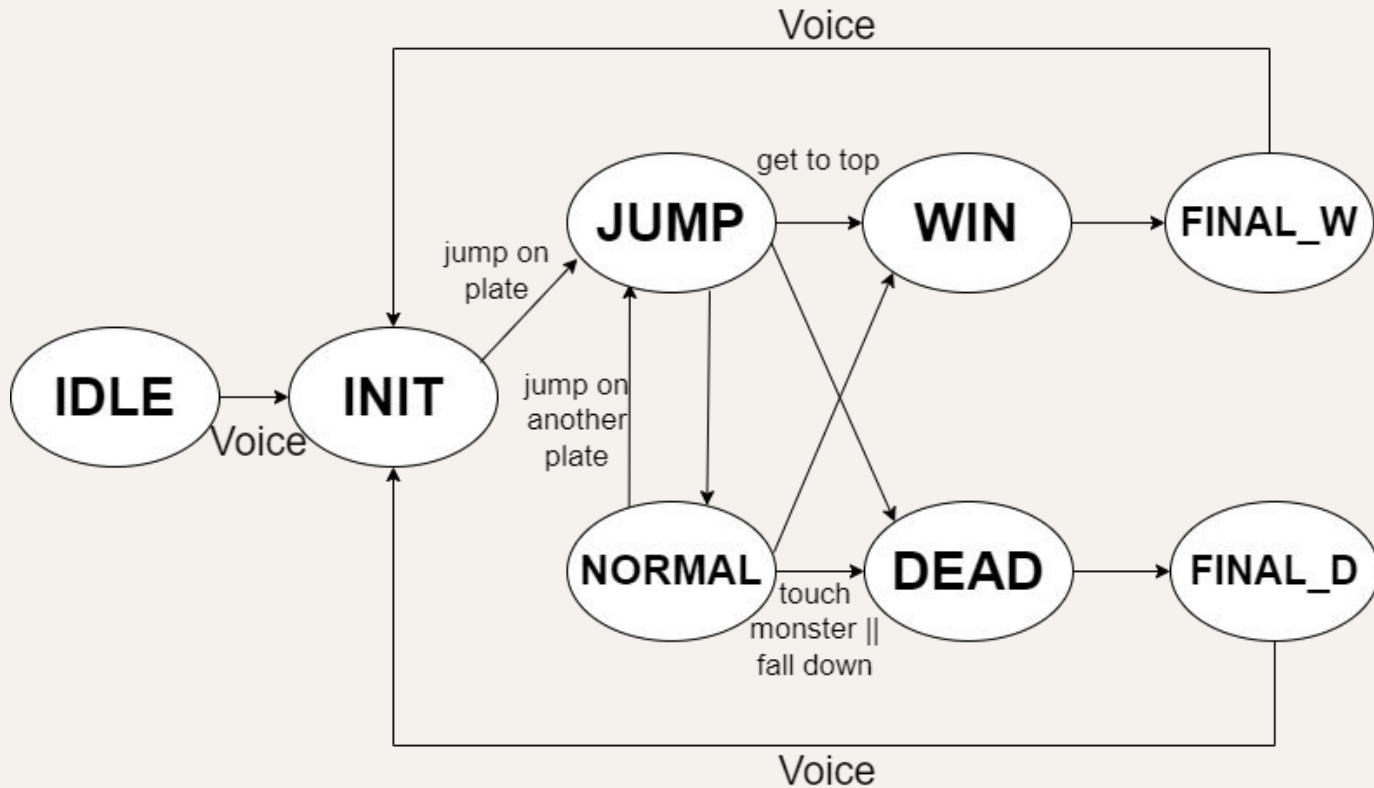| 0	1	2
3	4	5
6	7	8

Edge Detection Result

Game Design

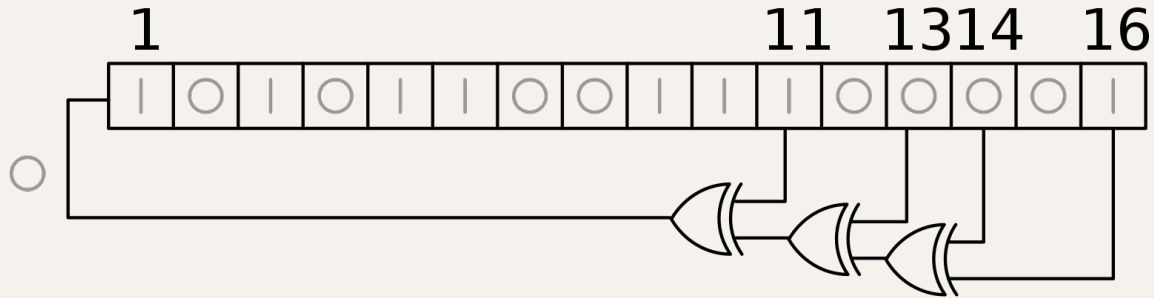**Doodle Jump**

- Direction control
- Fire bullet
- Start / Restart

Game FSM

Random Level

Fibonocci Linear-Feedback Shift Register

- Cycle: $2^{16} - 1$

DEMO

04
Difficulties

Difficulties

- Estimating PERIMETER of hand via Edge Detection can be inaccurate if the background is not homogeneous.

- **Solution**: Only consider skin color pixels for estimating PERIMETER.

Difficulties

- Calculating the ratio of (PERIMETER^2) and AREA of the hand can lead to distance-proof result for gesture distinguishment.

- PERIMETER and AREA are postively correlated. Calculating the ratio will reduce the difference for distinguishing gestures, especially for real time distinguishing.

- **Solution**: Only consider PERIMETER of hand for gesture distinguishing and limit the player's distance from camera.
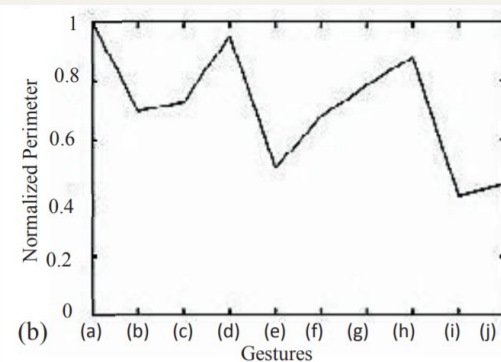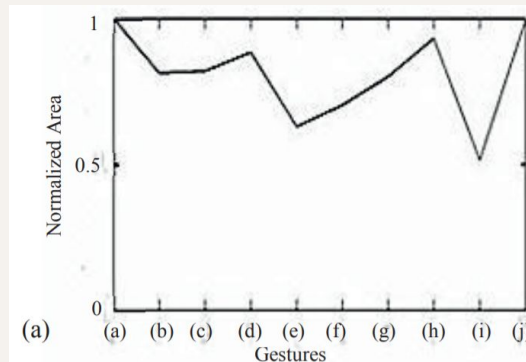
Difficulties

- The clocks of two FPGAs are asynchronous and have different frequencies, which may cause errors when the signal triggering
- The clock frequencies are 12MHz and 25MHz

- **Solution**: Make the triggering signal stay longer (2 or 3 cycles) to make sure the other FPGA receive it correctly

Reference

- Design of Color Recognition System Based on FPGA

  https://www.researchgate.net/publication/303481540_Design_of_Color_Recognition_System_Based_on_FPGA

- Digital Camera: OV7670 CMOS camera + DE2-115 FPGA board + LandTiger 2.0 board

  http://www.dejazzer.com/eigenpi/digital_camera/digital_camera.html

- User Manual-CMOS TRDB-D5M Camera and 8MB SDRAM A2V4S40CTP

  https://home.isr.uc.pt/~jfilipe/files/User_Manual_EN_Group11.pdf?fbclid=IwAR07VRjNEj02Ty9CvWN6vitdExqpl85Tfx9x_j9xednEXKcfrZKz4iilT7I