



# Interactive Light System Design Based On Simple Gesture Recognition 基于动作识别的灯光交互娱乐装置设计

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Special Thanks To Yi Xiao 肖懿 (技术指导)

# Catalog

A

## Design Backgrounds 设计背景

- Culture 文化
- Technology 技术

B

## Design Process 设计过程

- My Design 设计方案
- Documents 文件

# Design Backgrounds

A

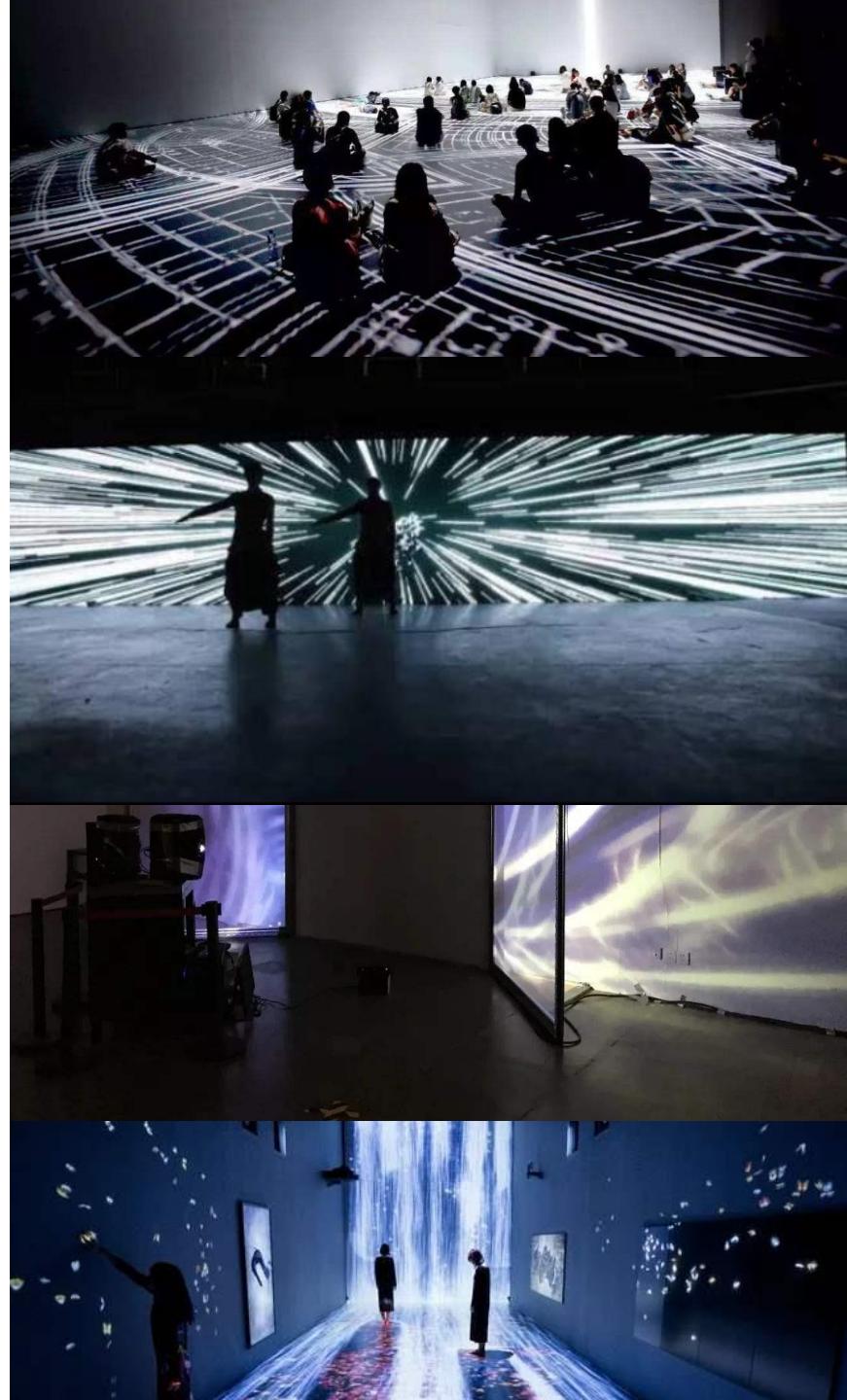
设计背景/文化

Culture

# Social

This project is based on the design project of the Sichuan Lingtong tele-communication company of China Aerospace Science & Industry Corp. The output of this project can be used in different exhibitions and museums without changing the core design.

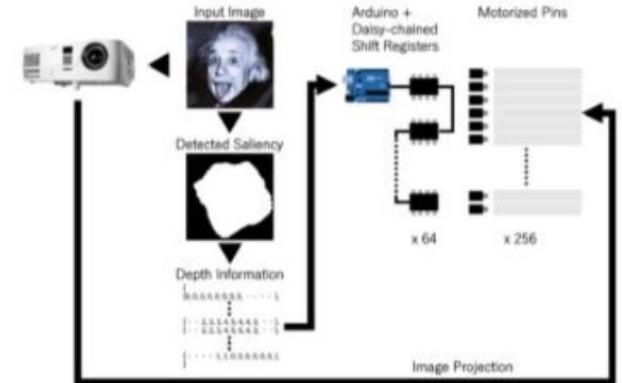
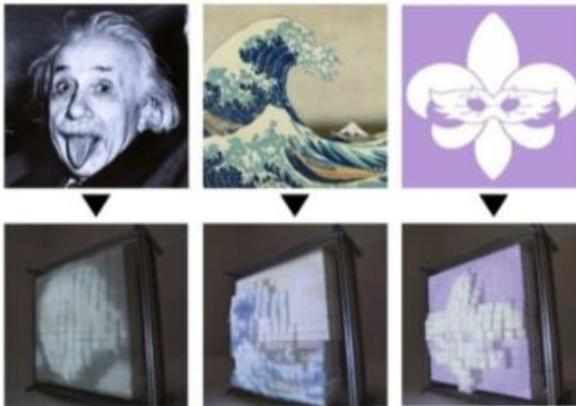
本课题系中国航天科工集团下属四川灵通电讯公司面向军民融合，基于物联网智能控制的人机交互终端展示装置方案设计课题，拟申请参展科博会。可以在本项目的成果基础上扩展成更大规模的展示装置方案，供各种会展和艺术，科技博物馆的交互装置使用。



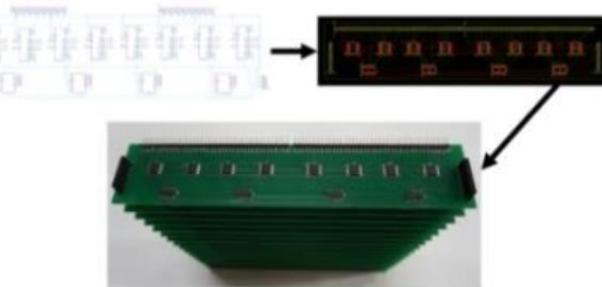
# Related Works



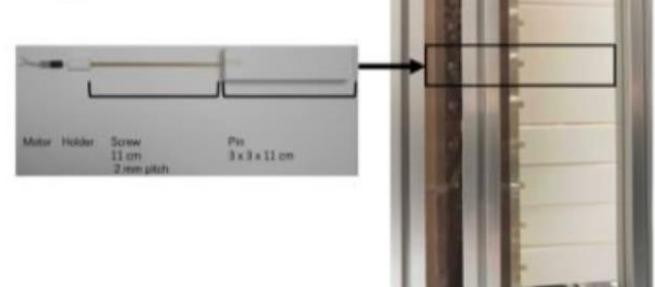
- Wooden Mirror [Rozin 1999]



Appendix: Control Circuits



Appendix: Motorized Pins



- Riku Arakawa et.al BulkScreen: Saliency-Based Automatic Shape Representation of Digital Images with a Vertical Pin-Array Screen ACM TEI 2020 Work-in-Process

## Related Works

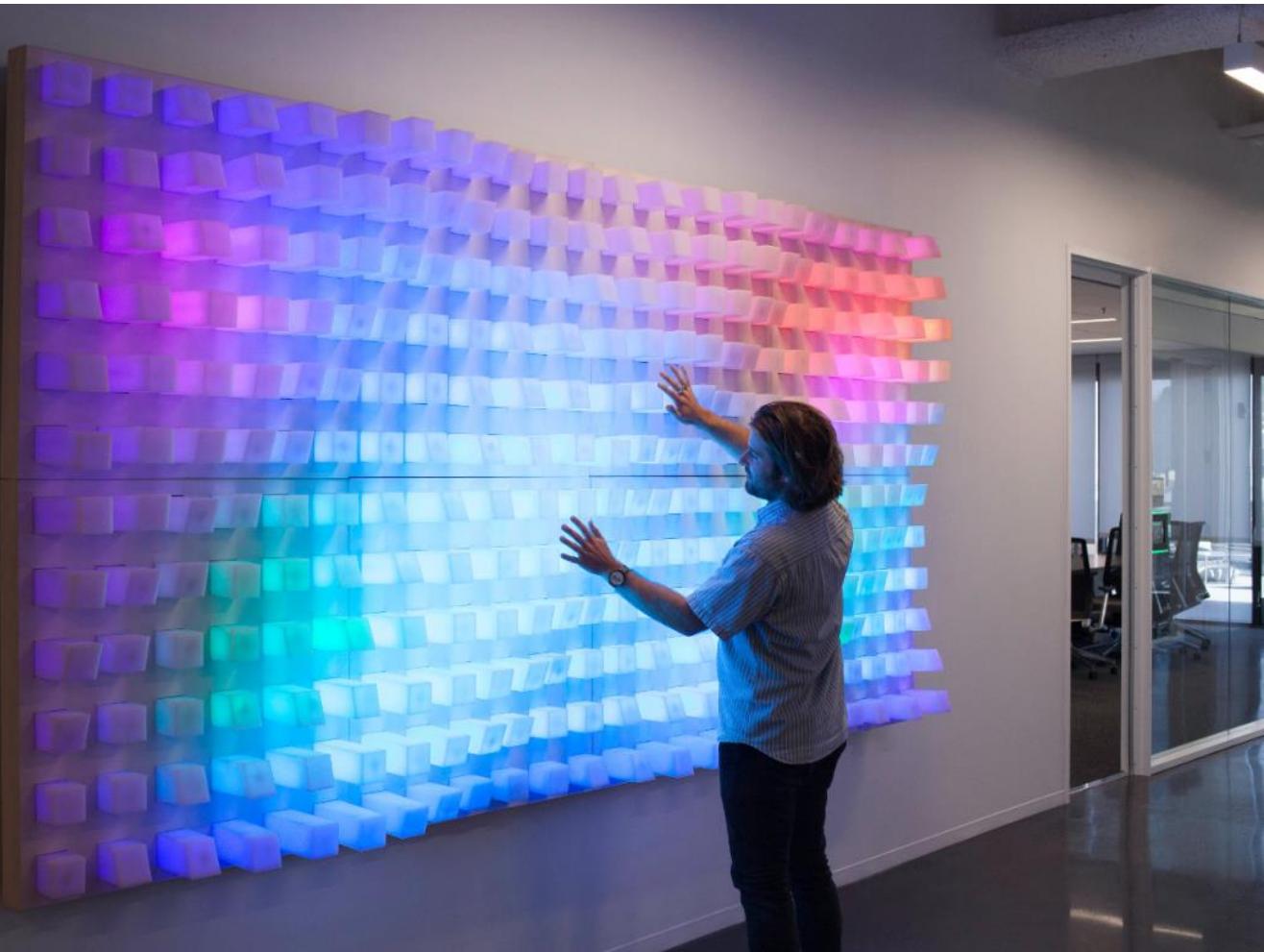


● Echo [BREAKFAST 2018]



● One Hundred and Eight [Nils 2010]

# Related Works

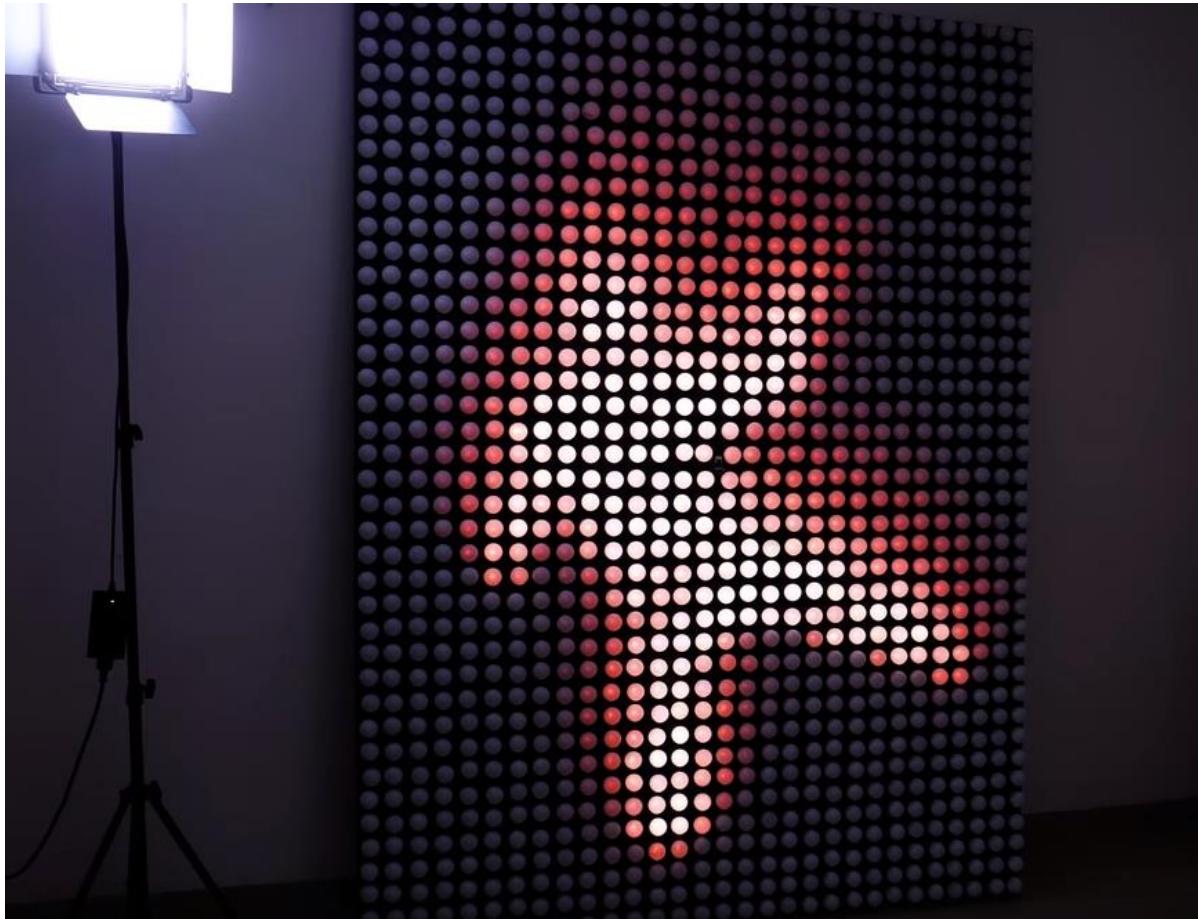


● Moment [Brannon 2015]

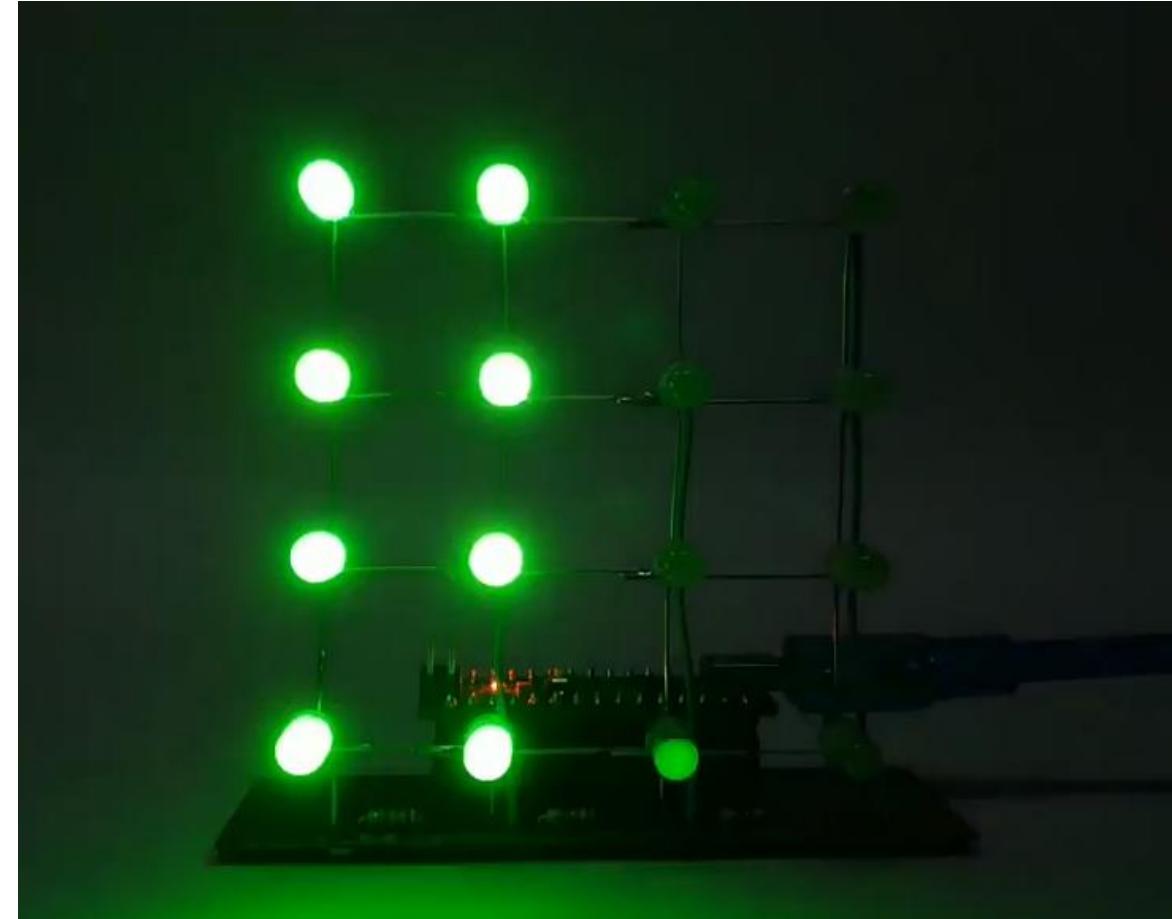


● LED INTERACTIVE WALL [Chris 2019]

## Related Works

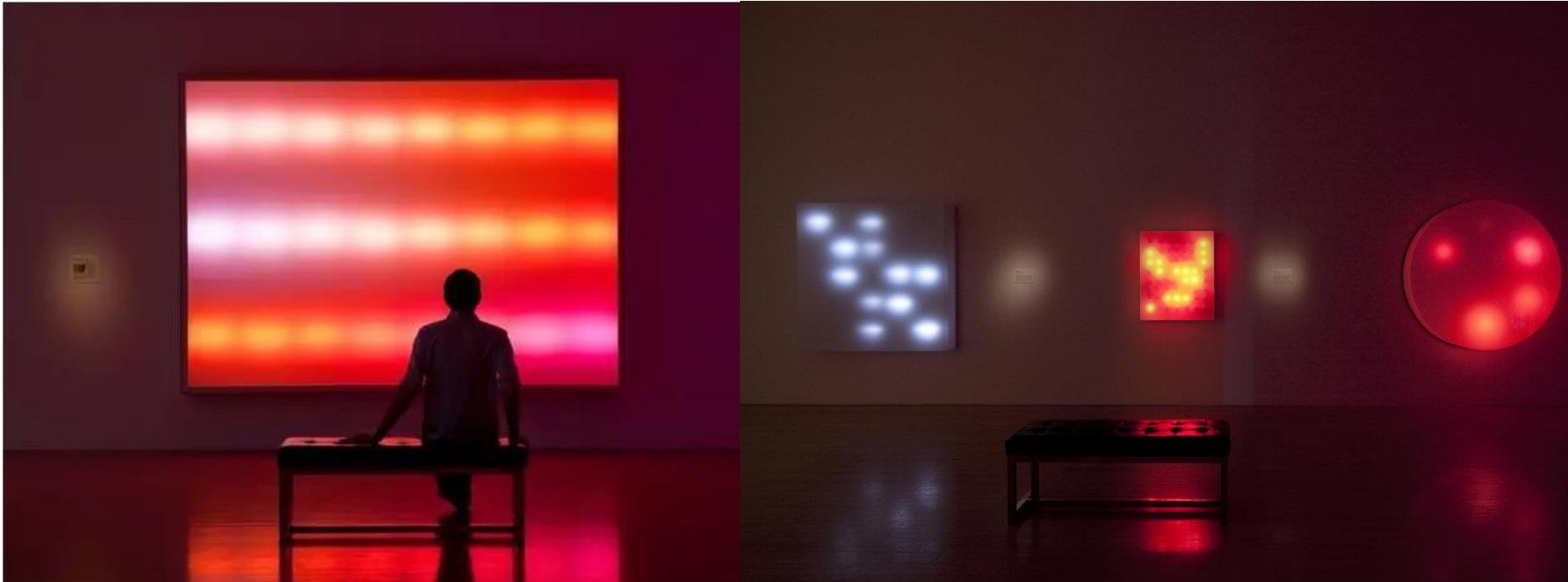


● LED Wall [bitluni's lab 2019]



● Amazing LED Wall [ES Tech knowledge 2019]

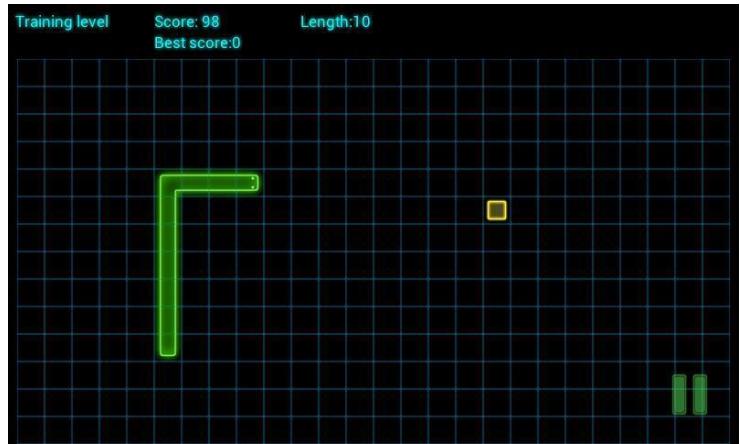
# LED Art



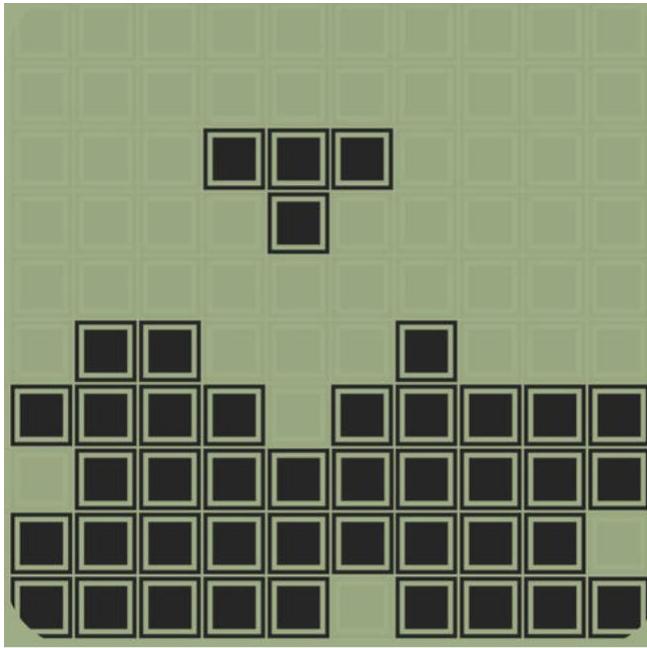
Leo Villareal is famous for creating simple and inspiring dynamic lighting works. Since the 2000's, Villareal has introduced LED and computer programming into his works. Creating images by changing light matrix in a specific rhythm, he surely inspires the visual and mental feeling of every audience.

Leo Villareal以创作简洁而极具启发性的动态灯光作品而闻名。自2000年代开始，Villareal将LED及电脑编程引入创作中，利用灯光矩阵创造出无限变化并有着独特节奏韵律的画面，以其开放性和空灵感激发观者的视觉及心理感知。

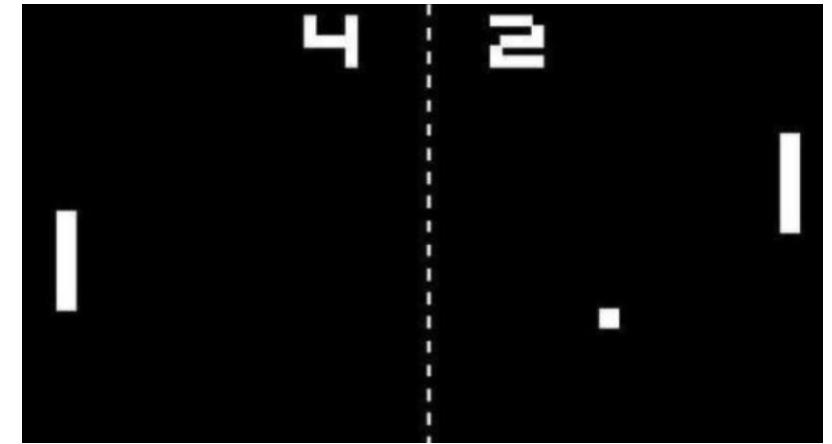
# Pixel Games



Snacks



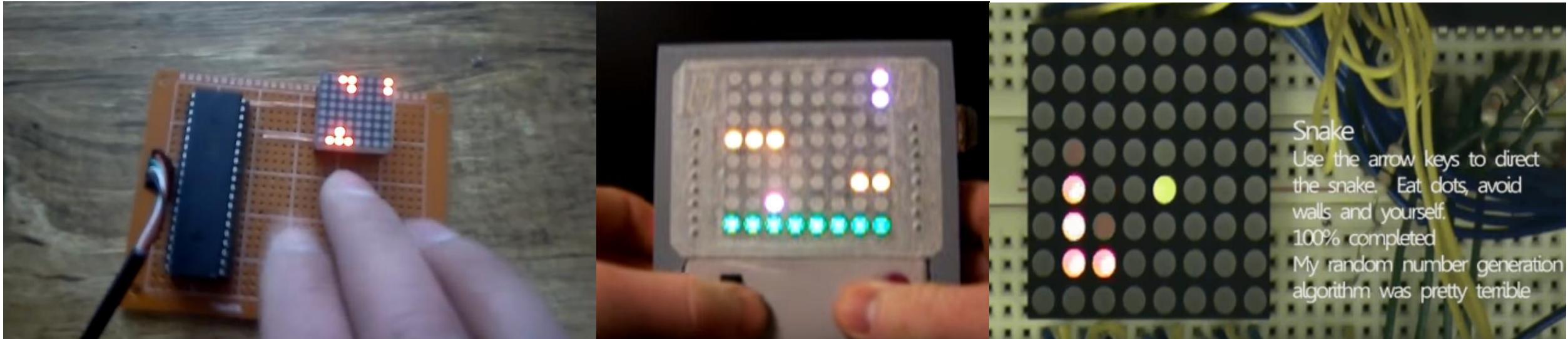
Tetris



Ping Pong

There are many easy pixel games born in the drawn age of modern video games, from the 1960s to the 1980s.  
上个世纪60-80年代是现代电子游戏的黎明期，诞生了诸多利用简易像素就可以表示操控的游戏。

# Pixel Games



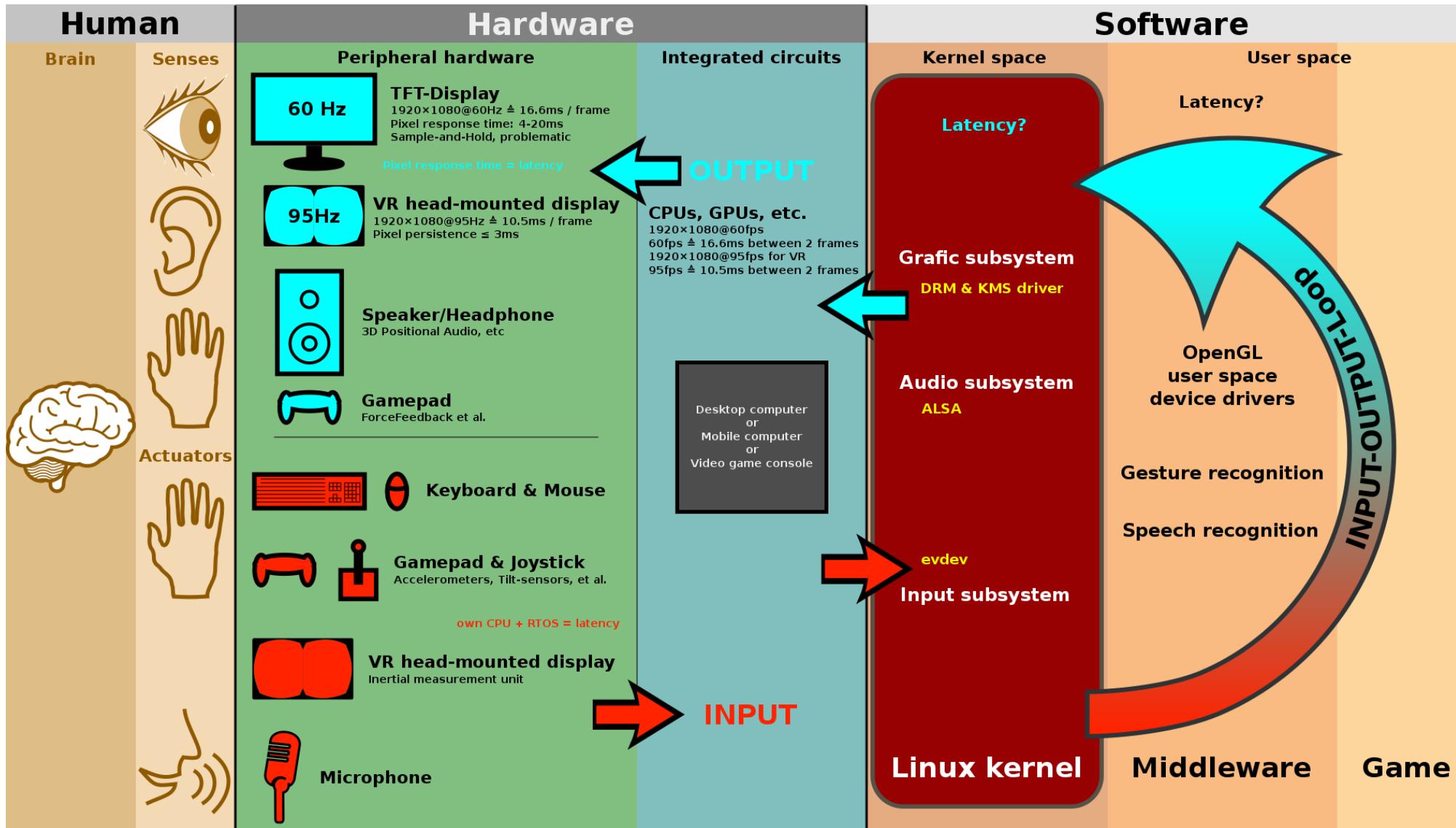
Nowadays many electronic geeks remake these classic pixel games even on a simple 9\*9 LED screen with a single chip computer.

这种像素游戏文化也催生出了诸多的利用基本9x9LED屏幕和单片机实现简易游戏操作的电子极客们。

# HCI System

This is a classic HCI system. The hardware reflects certain things to human based on the human behaviors intermediate.

硬件根据人的输入分析反馈做出处理再反馈给人，这将是一个典型的HCI系统。



# Design Backgrounds

A

设计背景/技术

Technology

# Kinect

Developed by Microsoft, Kinect uses RGB-D camera to get the human positions accurately. It can do valley bone recognition, deep inspection, face recognition and voice recognition successfully.

Kinect由微软开发，利用深度摄像头捕获人体的位置数据。  
它可以骨骼追踪，深度检测，人脸识别，语音识别。

## Kinect V2

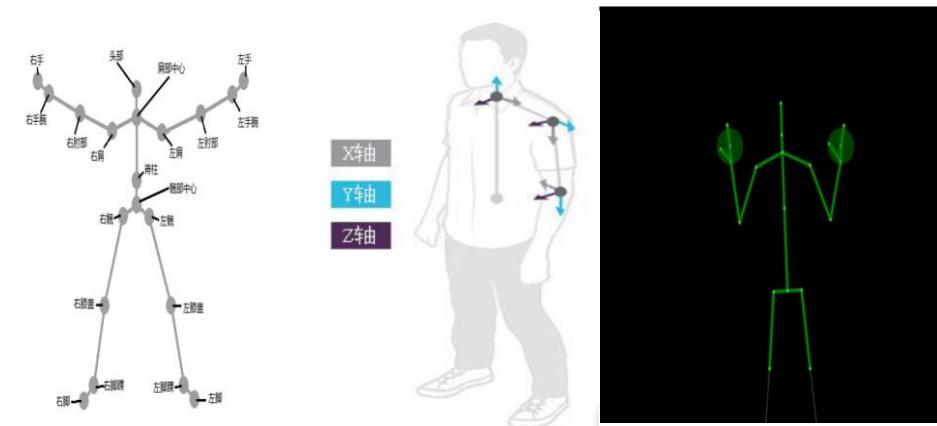
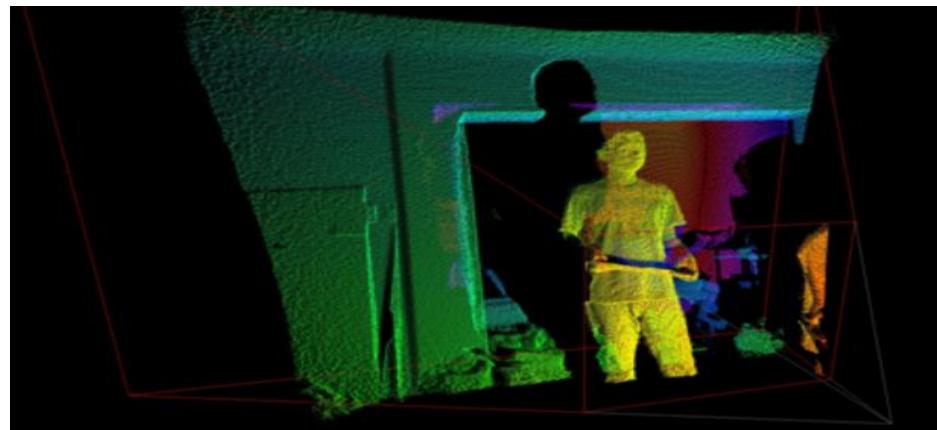
Color Resolution 颜色分辨率： 1920\*1080

Depth Resolution 深度分辨率： 512\*424

Max People 检测人数上限： 6

Joint Number 关节数： 25

Detection Distance 检测范围： 0.5—4.5m



# Kinect

At the same time we should consider the accuracy and distance for Kinect V2.

同时需要考虑Kinect的测量范围以及测量精度与距离的影响变化。

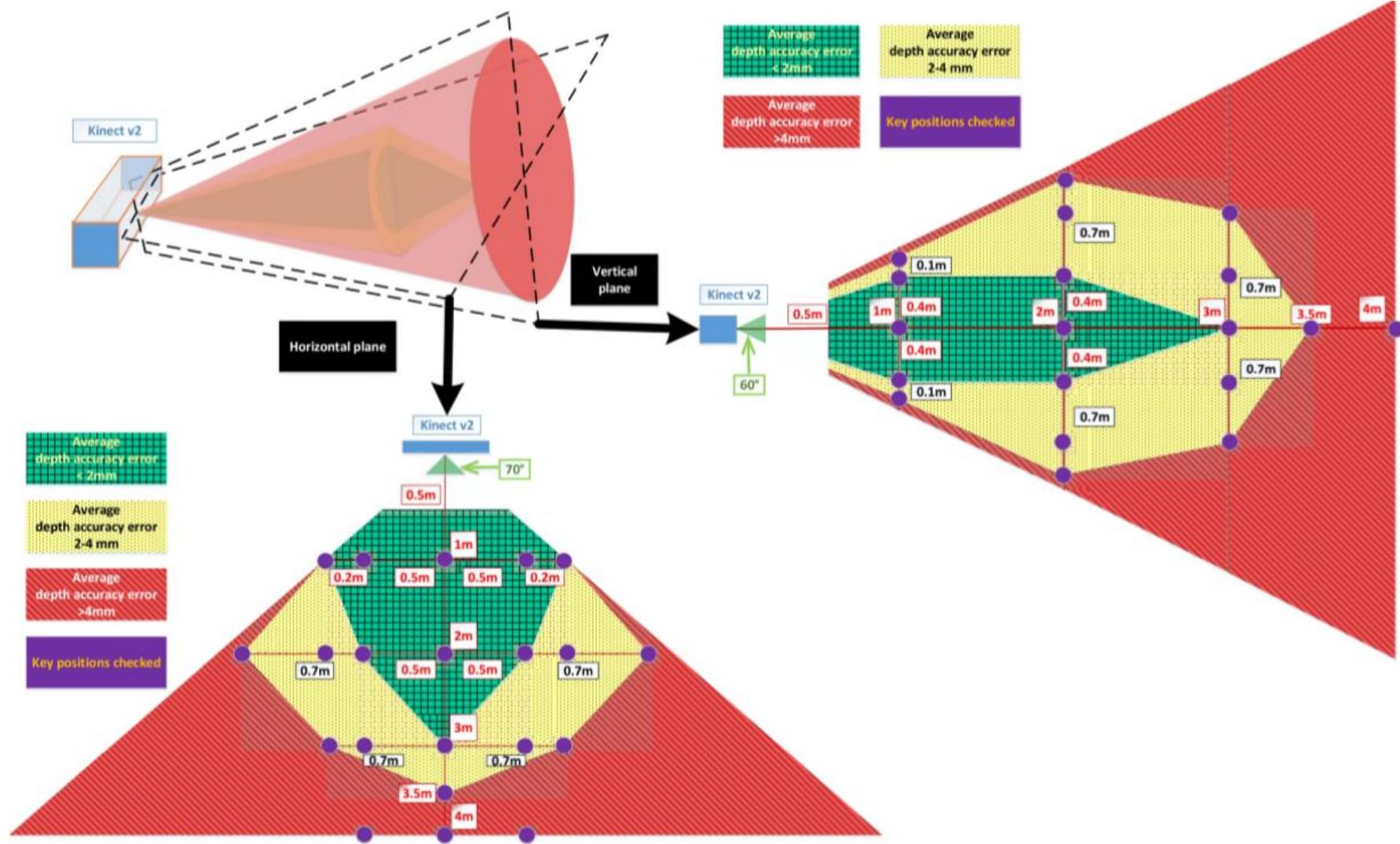


Fig. 6. Accuracy error distribution of Kinect for Windows v2.

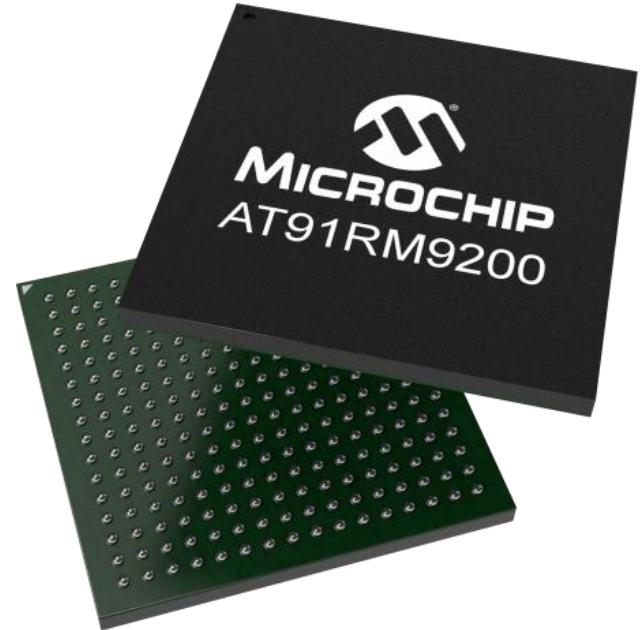
[1] Yang L , et al. Evaluating and Improving the Depth Accuracy of Kinect for Windows v2[J]. IEEE Sensors Journal, 2015, 15(8):4275-4285.

[2] Zennaro S , et al. Performance evaluation of the 1st and 2nd generation Kinect for multimedia applications[C]// IEEE International Conference on Multimedia and Expo (ICME). IEEE, 2015.

# Microprocessor

Compared with the normal Arduino or 51 SCM used by students, we choose AT91RM9200, with more powerful and standard computing ability.

1. Common in industrial world
2. Opensource hardware
3. Frequency 180MHz
4. Support real time operating system



AT91RM9200

相比学生常用的Arduino和51 SCM, 选用了性能更强大稳定的AT91RM9200微处理器, 优势如下。

1. 大规模成熟地工业控制应用
2. 开源资源丰富
3. 主频180MHz, 处理能力强
4. 实时操作系统支持

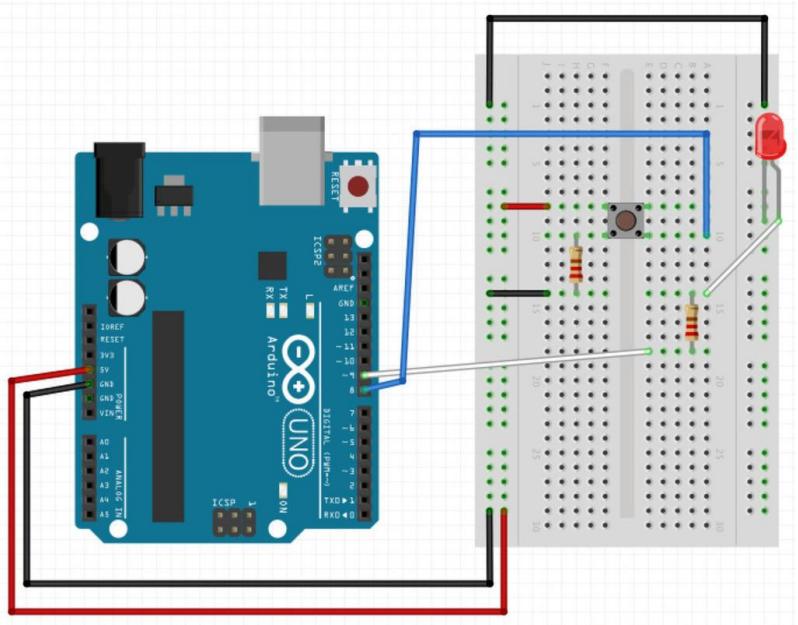


Arduino



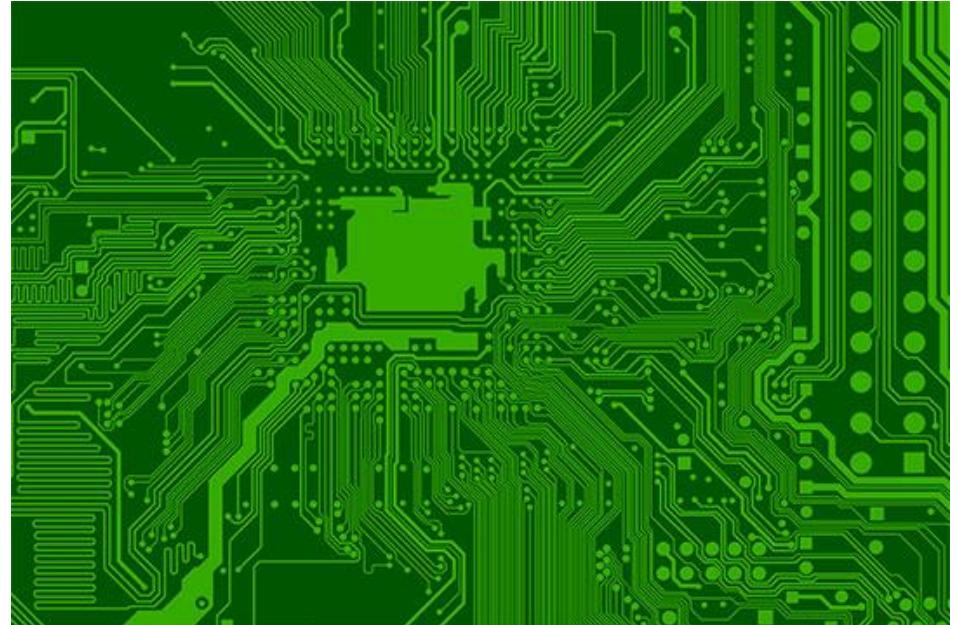
51 SCM

# Printed Circuit Board



传统面包板布线

Traditional Bread Board Wring



PCB印刷电路板

PCB Printed Circuit Board

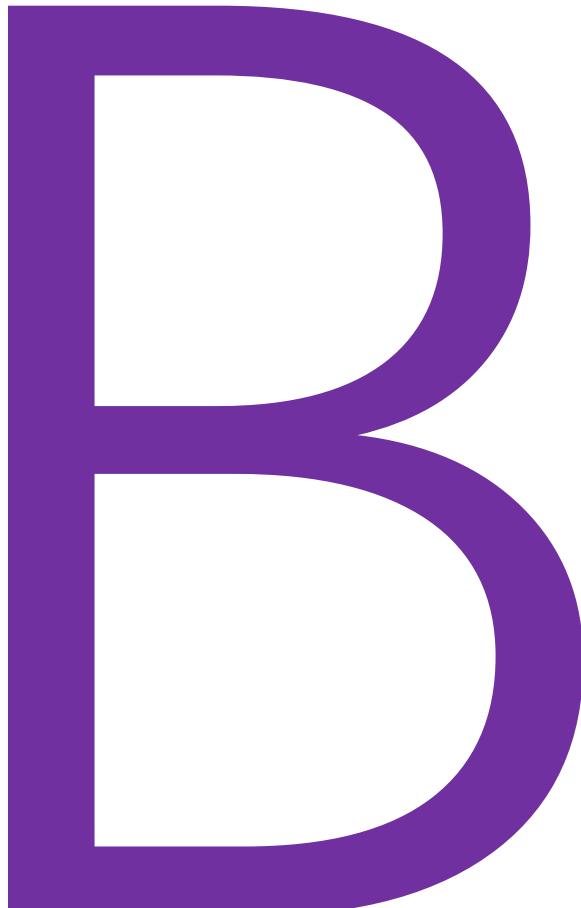
It is quite hard to use the traditional bread board wiring technology to achieve a complex project. Here we use multilyer PCB printed circuit board with BGA technology to achieve the industrial standard.

传统手工连线面包板在复杂度到达一定程度后信号质量和可连接信号线密度都存在明显瓶颈。故使用了多层的PCB布板技术, BGA技术, 结合高密度的模块化设计达到工业化水准。

# Design Process

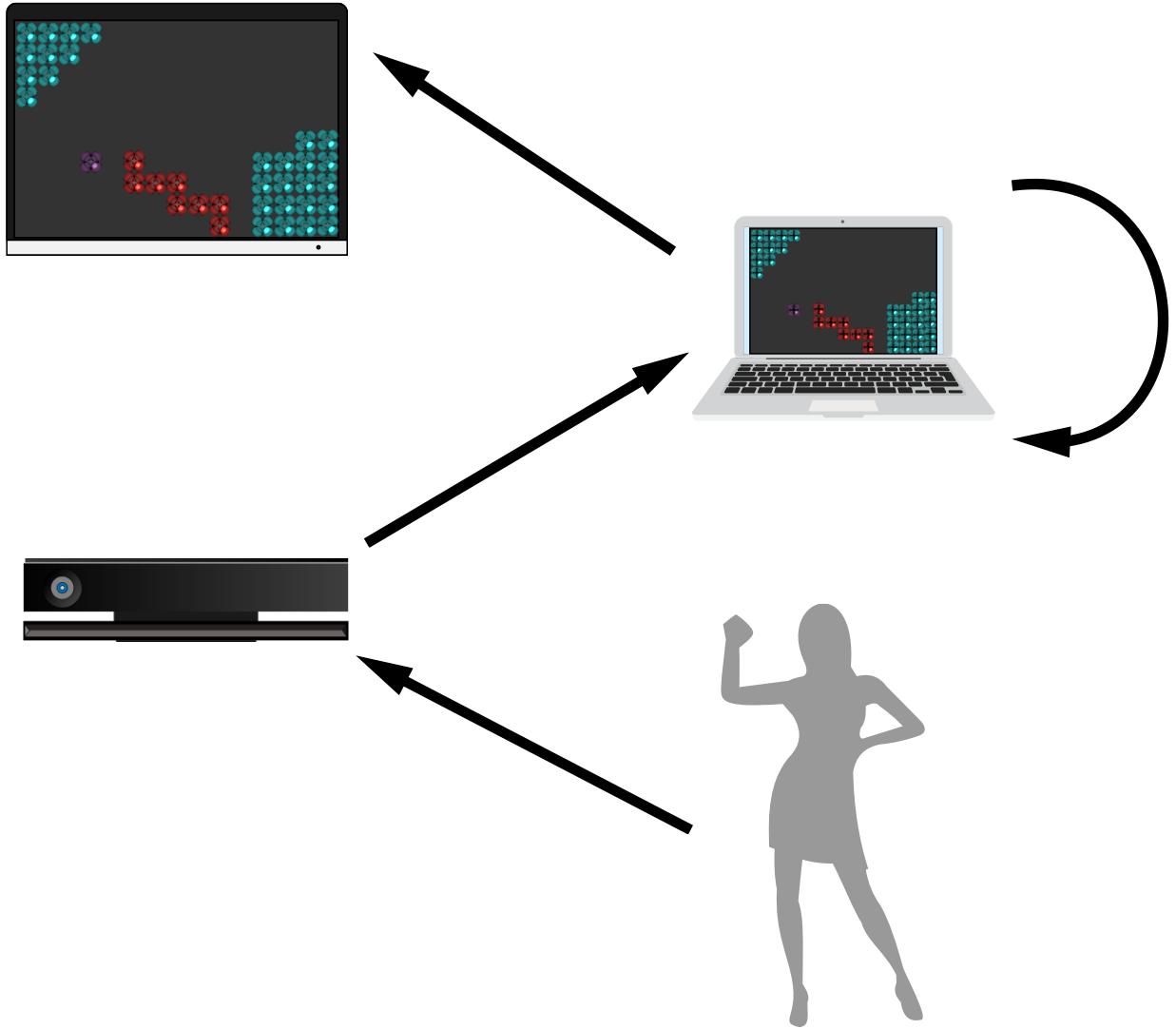
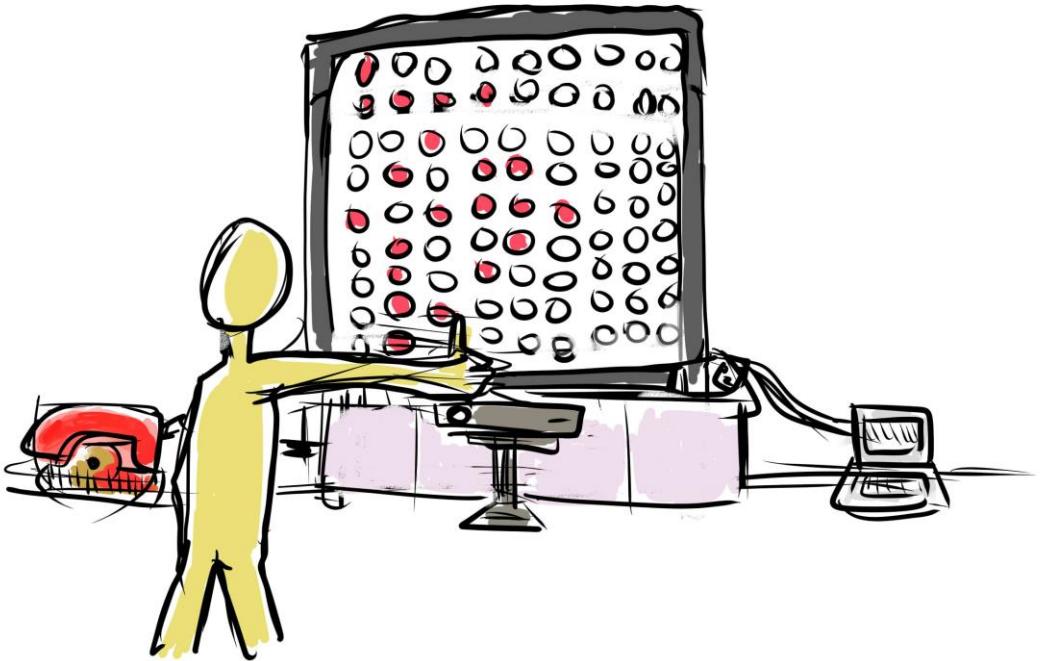
设计过程/方案

My Design



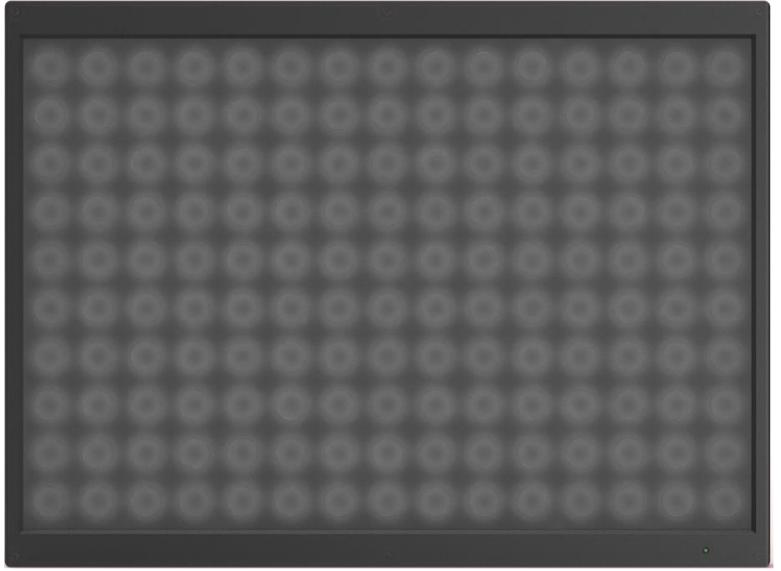
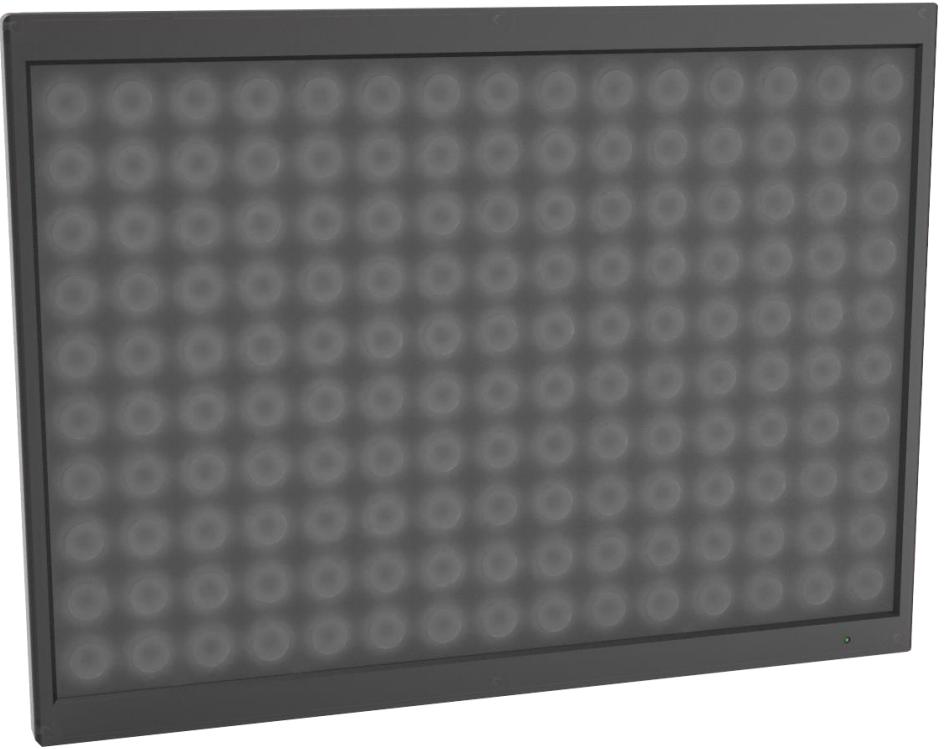
# Big Picture

Sketch  
概念草图



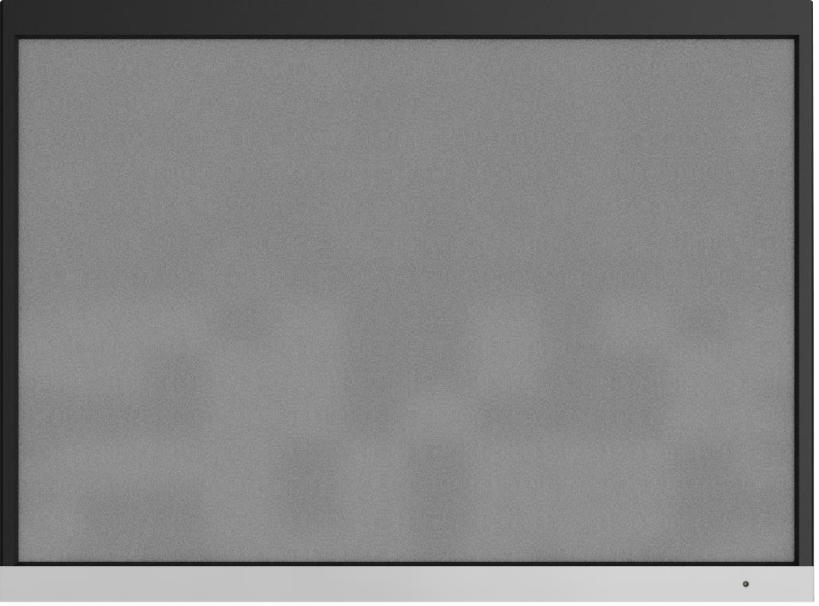
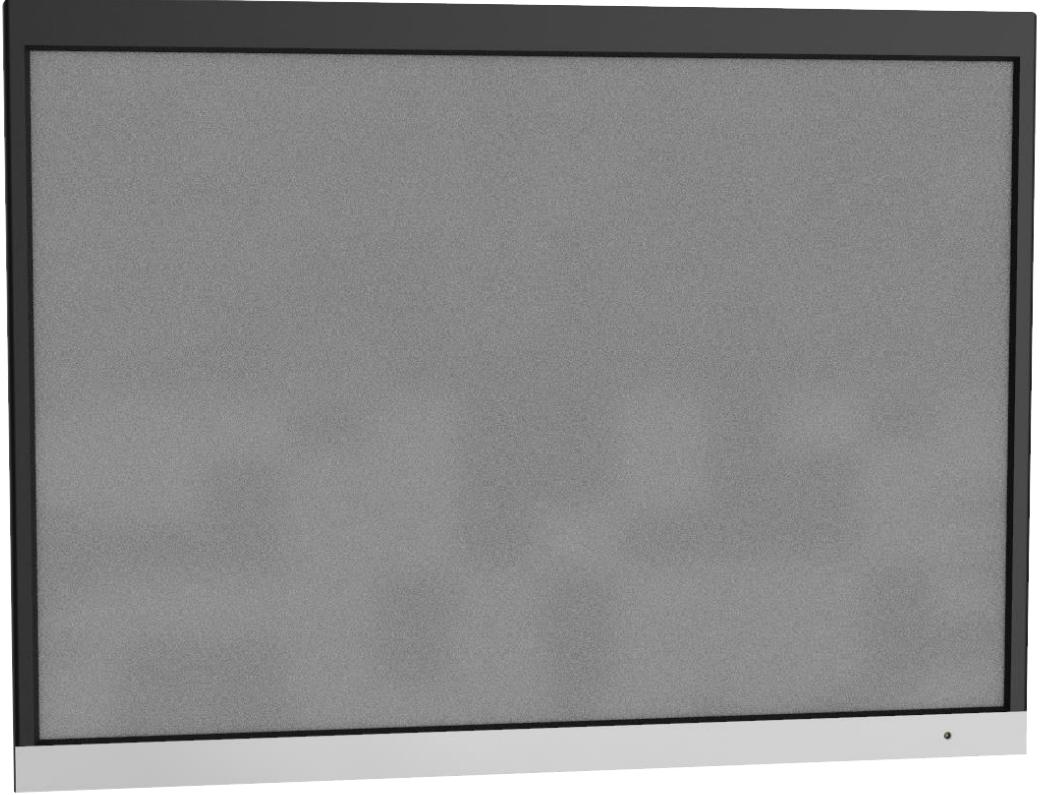
A Journey Map  
一次输入输出图

# Hardware Model



Hardware Model 1<sup>st</sup> Edition  
硬件建模初稿

# Hardware Model



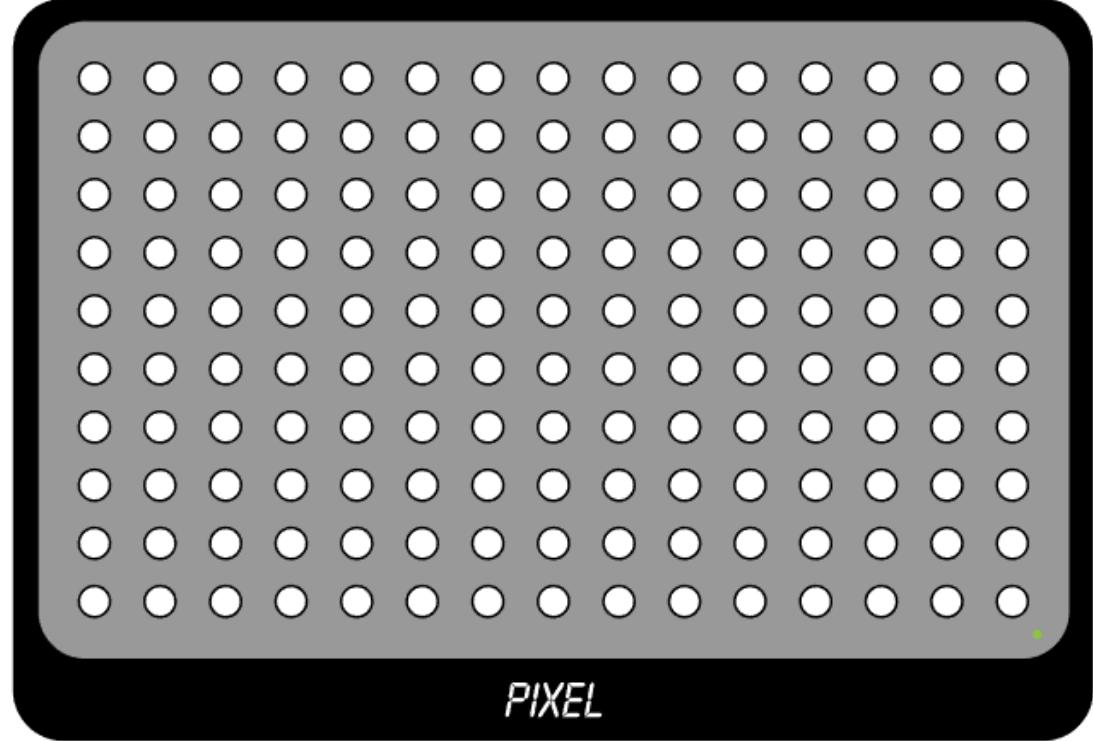
more concise, more ventilation holes

相比初稿更简洁的风格，更密集的排气孔

# Hardware Design

Size  
尺寸

40 cm

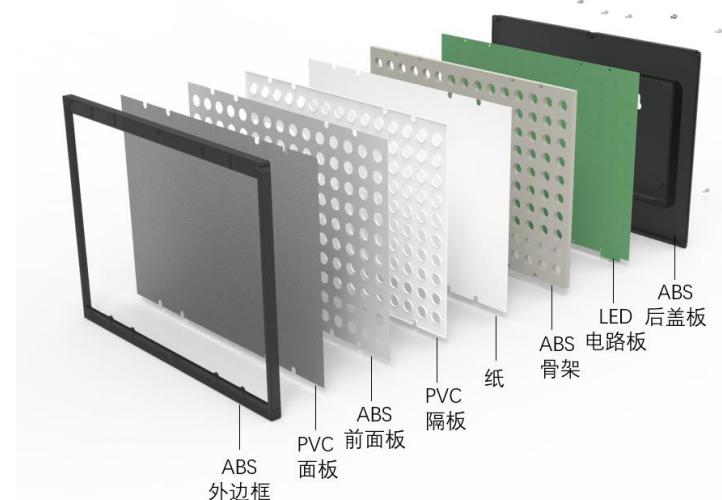


15\*16 Pixels, with 2.3 cm wide each, 3.25cm between each  
15\*10个像素，像素间距3.25cm，像素孔径2.3cm

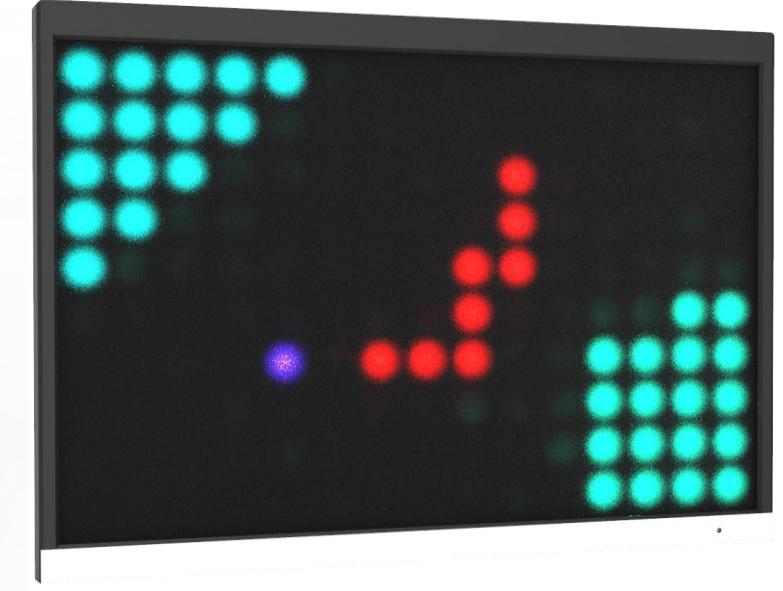
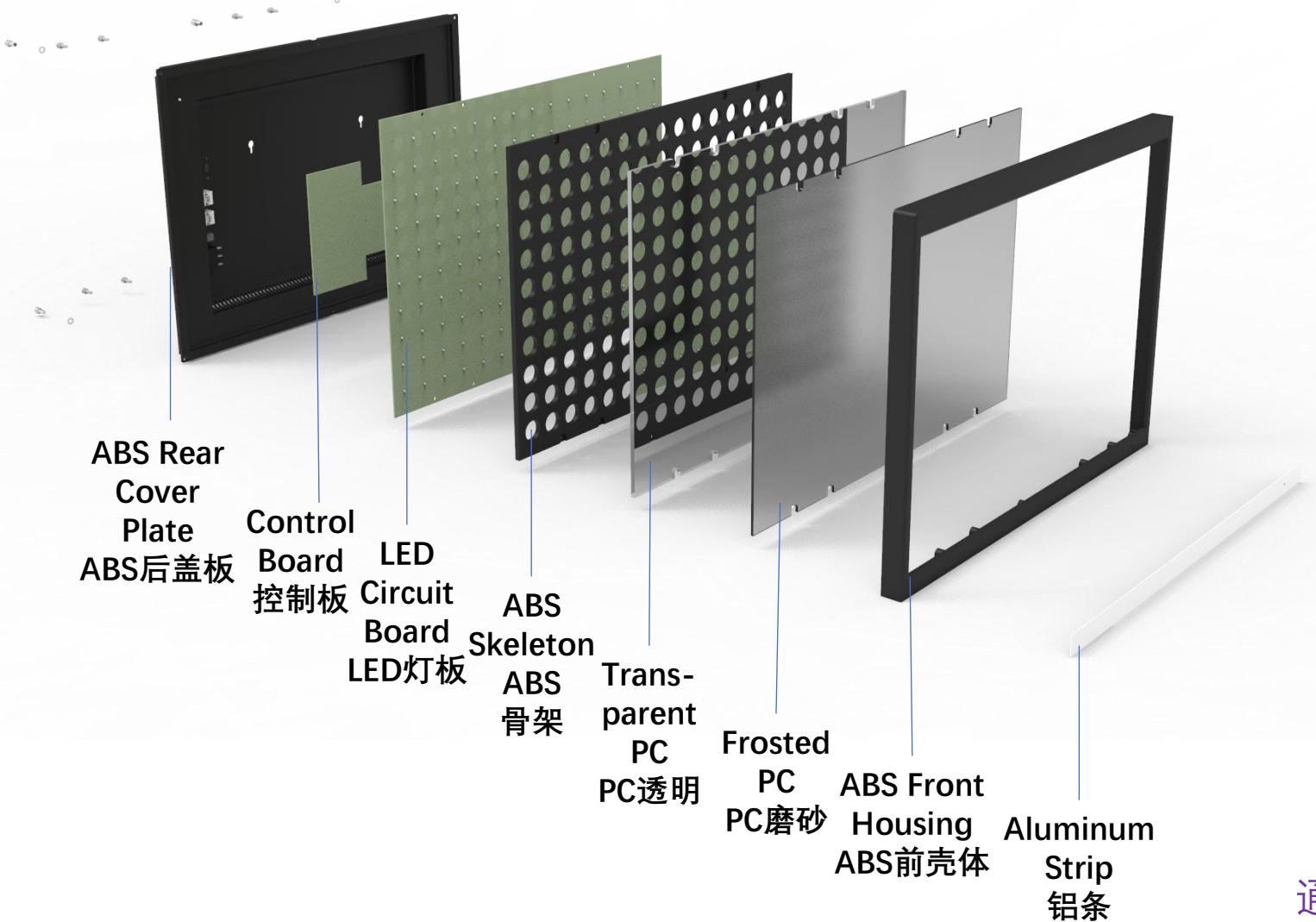
Human-machine Scale  
人机尺度



Inner Structure 1<sup>st</sup> Edition  
初稿内部结构

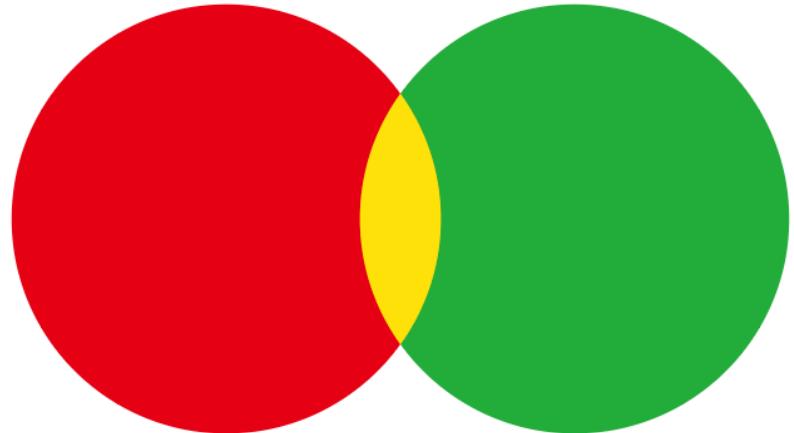


# Hardware Design



The light effect is produced by different materials and thickness of different panels.  
通过不同层的厚度和材料来实现透光的效果

# Circuit LED Design



Red+Green=Yellow



Real Lighting LED

实际的发光LED

Spread To Be A Whole Part

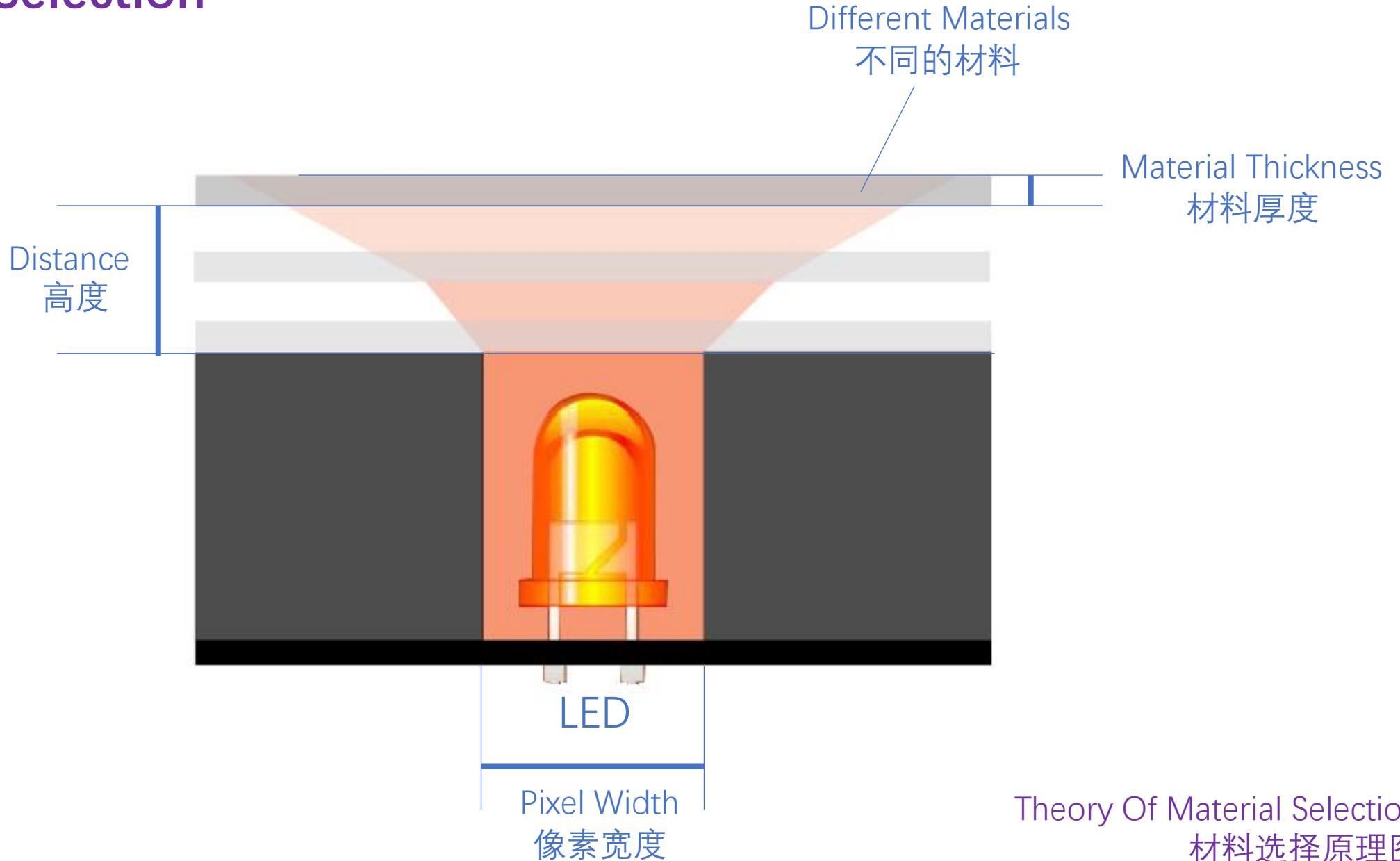
扩散后形成整体效果



With the consideration of power limitation, the single color LED are used in parallel, 6 in a group. It can then spread to be a whole lighting part. The third color can be produced by mixing two basic colors. In the end, there are  $6 \times 15 \times 10$  LED in total embedded on the printed circuit board.

考虑电路板功率限制，采用单色LED小灯泡并联，6个一组，再透过上方一定距离的聚光材质形成一个整体的发光效果。通过两种基本颜色的混色产生第三种颜色。6\*15\*10个LED被嵌在印刷电路板上。

# Material Selection

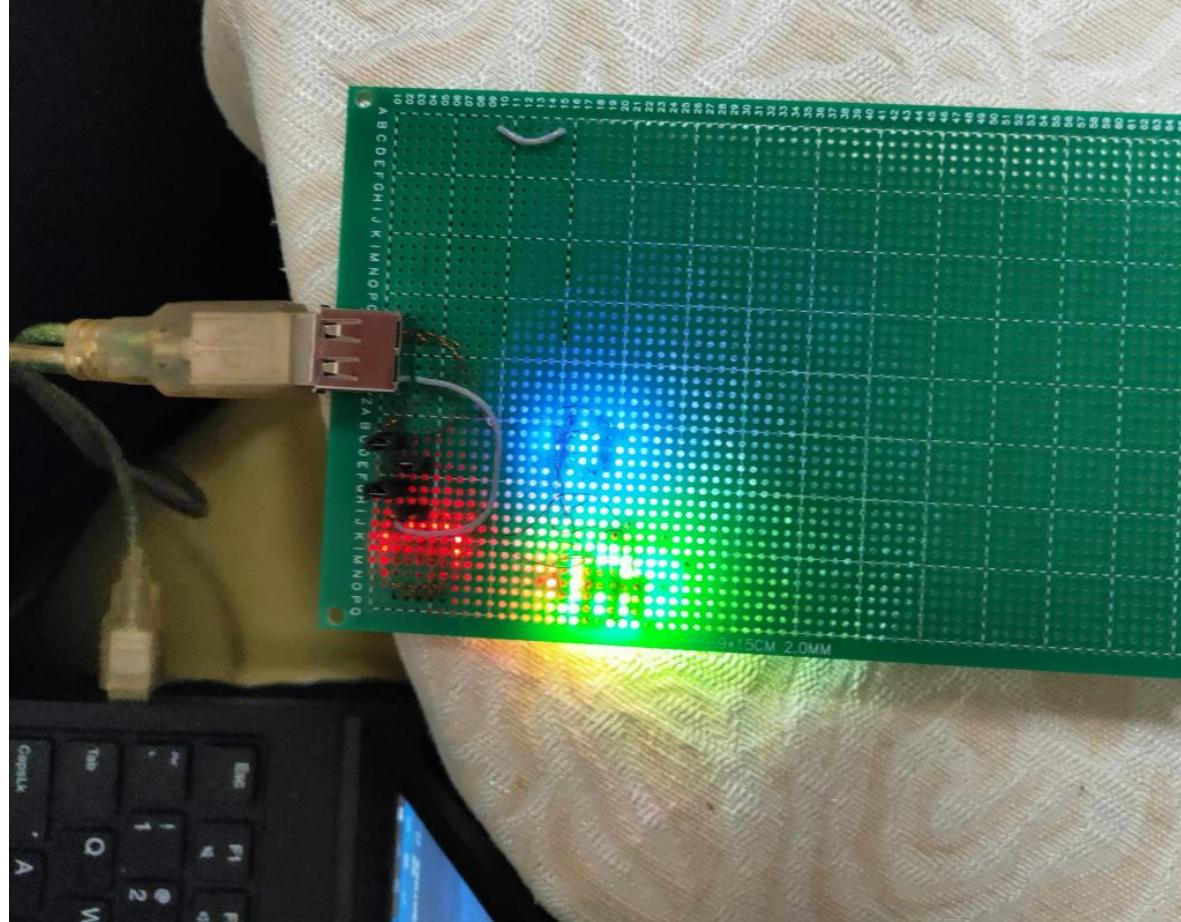


Theory Of Material Selection  
材料选择原理图

# Material Selection

We tested different materials with our little prototype under different distances, which includes: glasses, PC, PVC, PET and papers.

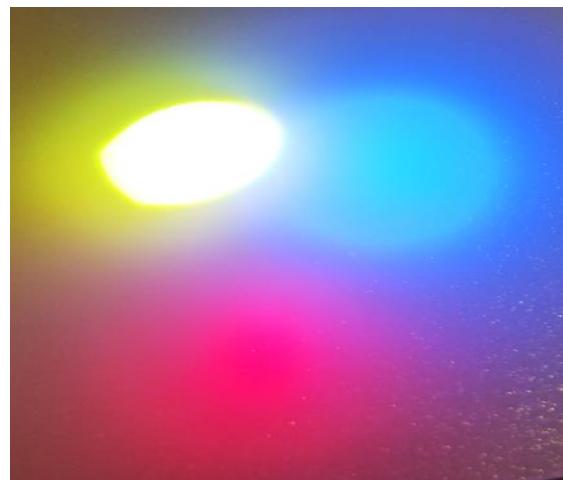
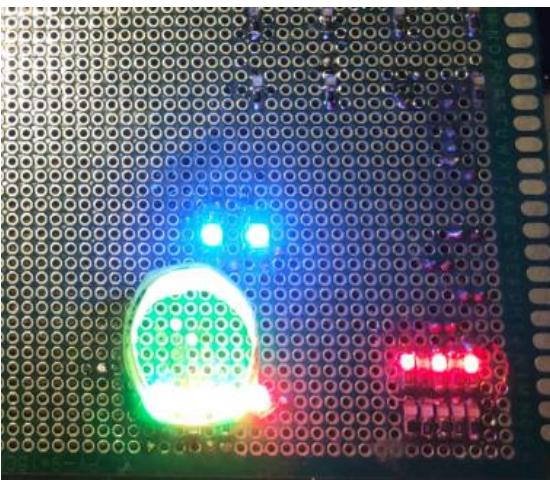
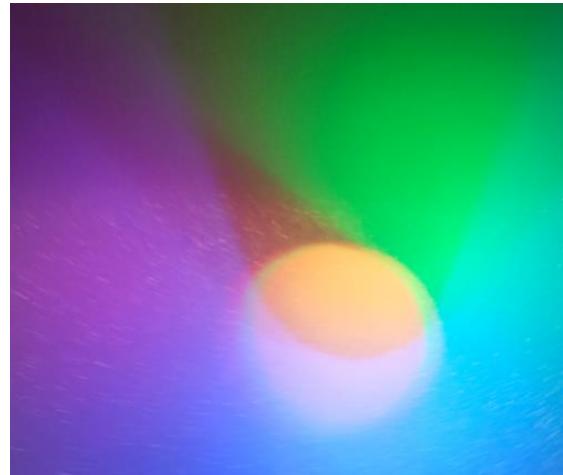
我们通过小的样板原型，对多种材质的散光效果进行了测试。包括：  
不同厚度的普通玻璃，  
聚碳酸酯，聚氯乙烯，涤纶树脂，纸



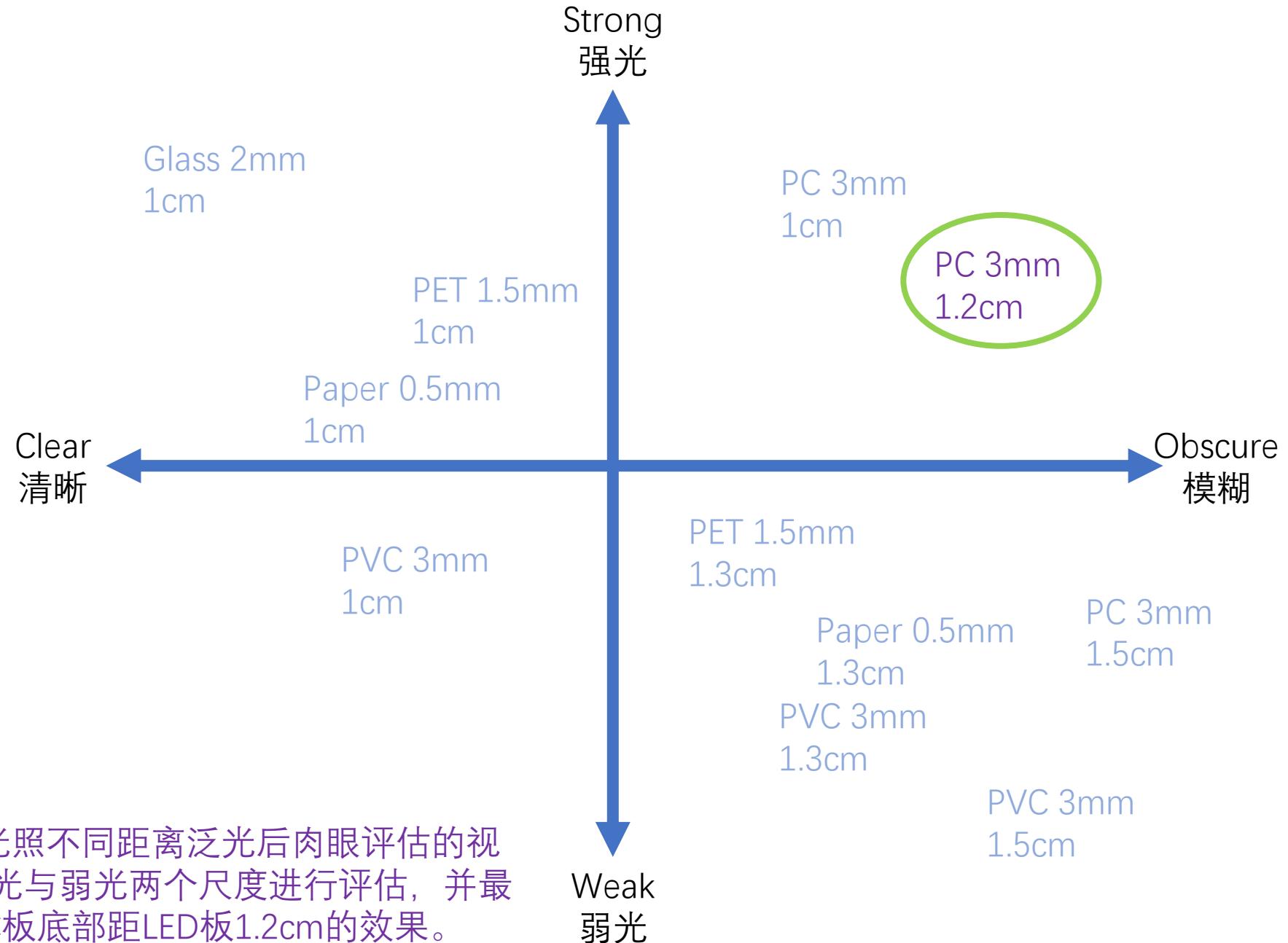
# Material Selection

Different materials under different distances appear to have different lighting effects.

不同材质在不同距离会体现出不同程度的透光效果。



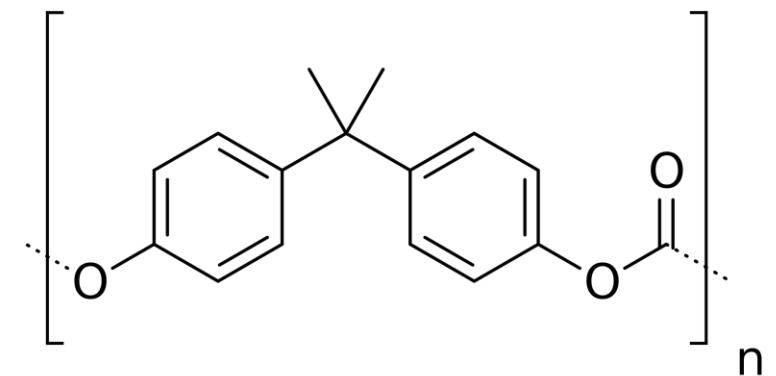
# Material Selection



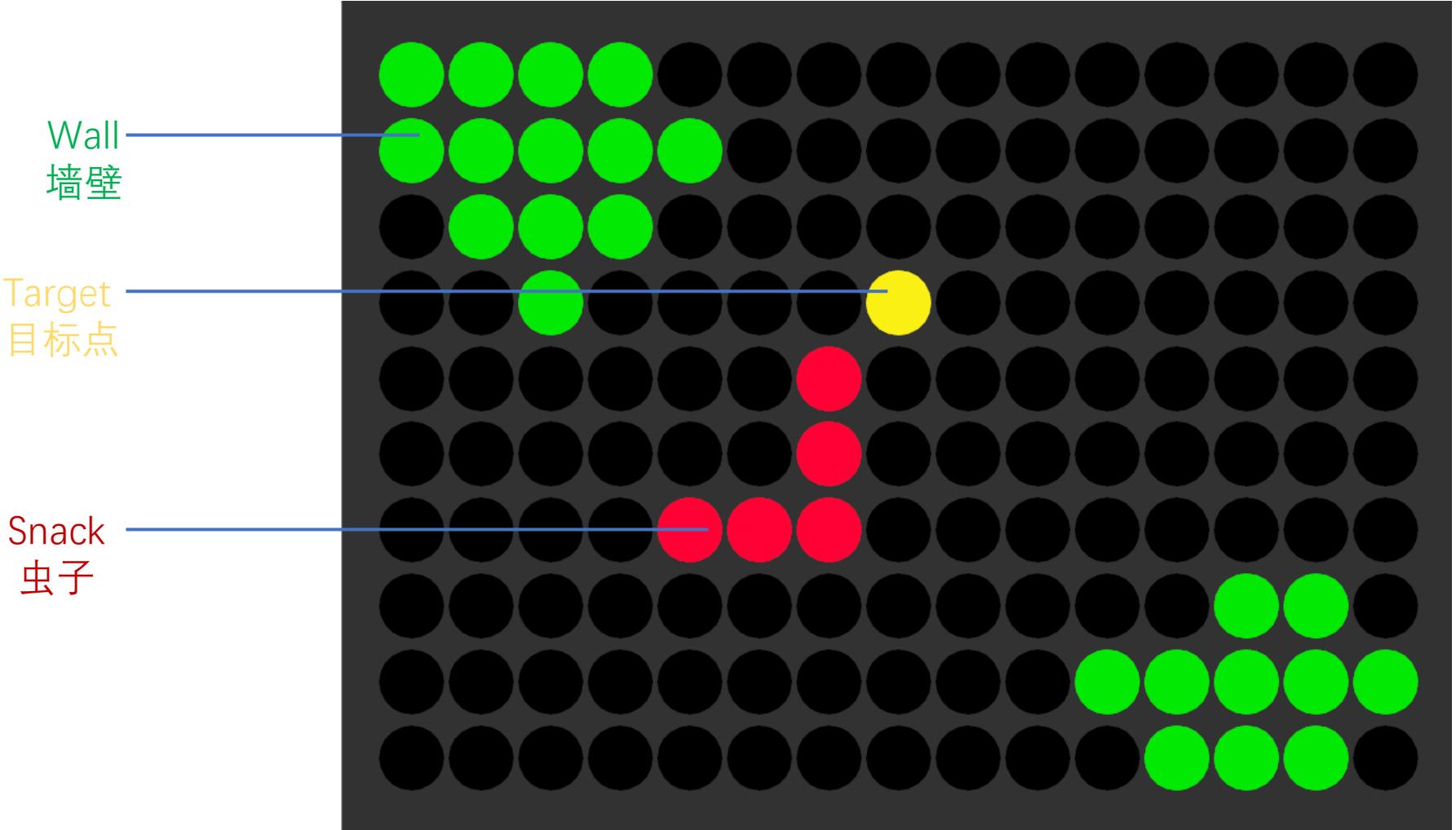
# Material Selection

Grinding PC board includes smooth surface and sanding surface. The highest light transmittance of the grinding surface is 85% and that of the smooth surface is 65%. At the same time, the diffusing agent is added to evenly distribute on the board surface so that when the light passes through the board, it collides with the diffusing agent particles to produce refraction, reflection and scattering effects. Finally, the light can pass through the plate evenly without exposing the light source, so as to achieve the change from point light source to surface light source.

PC磨砂板包含光面和磨砂面，磨砂面最高透光率高达85%，光面透光率65%，同时加入扩散剂均衡分布于板面，使光线经过板材时碰撞到扩散剂颗粒产生折射，反射和散射的效果。最终光线可以均匀地透过板材但又不会露出光源，达到从点光源到面光源的变化。

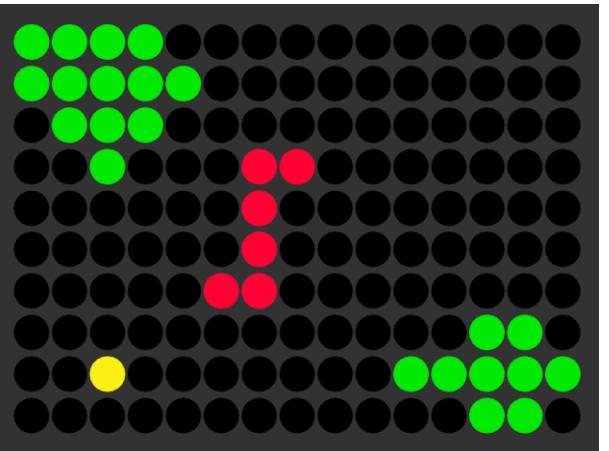
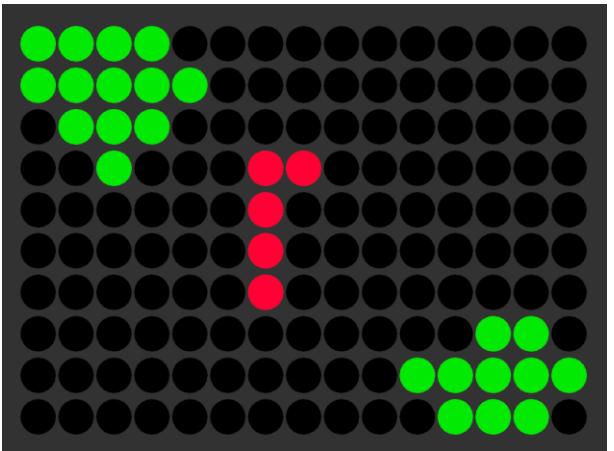
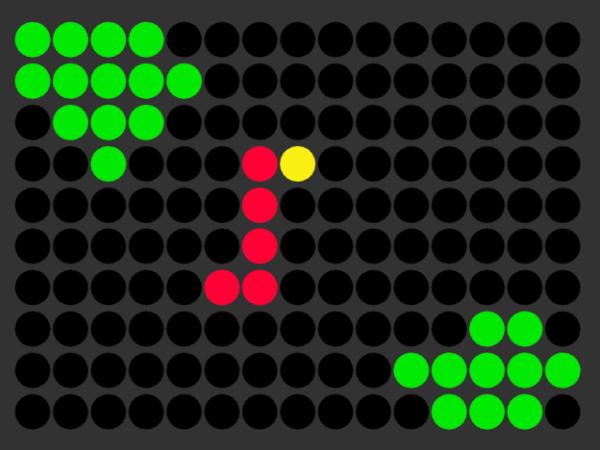
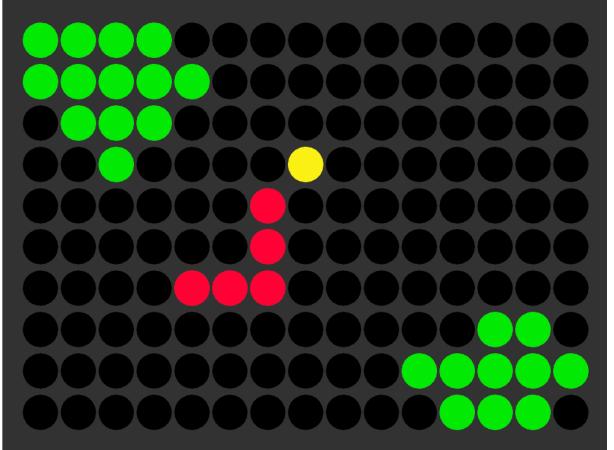


# Game Design



The hardware outputs a simple pixel game, SNACK!  
硬件上呈现的是一个简单的贪吃蛇游戏。

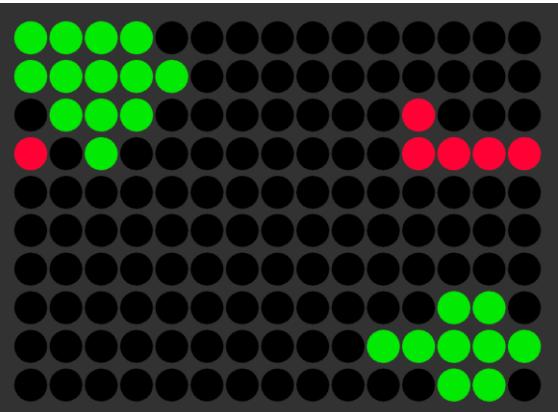
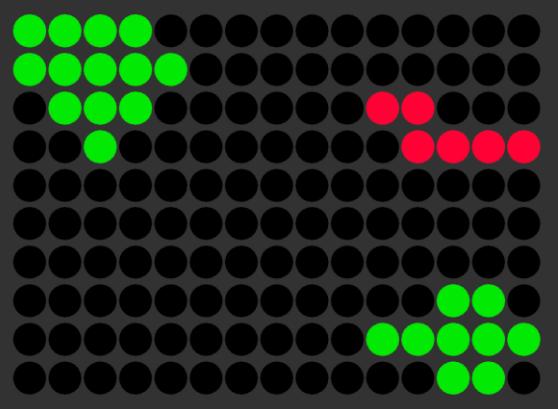
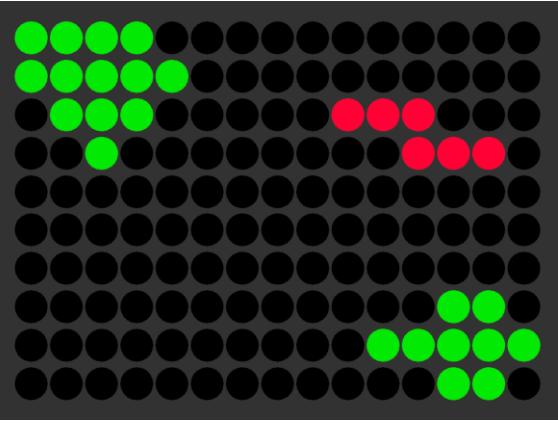
# Game Design



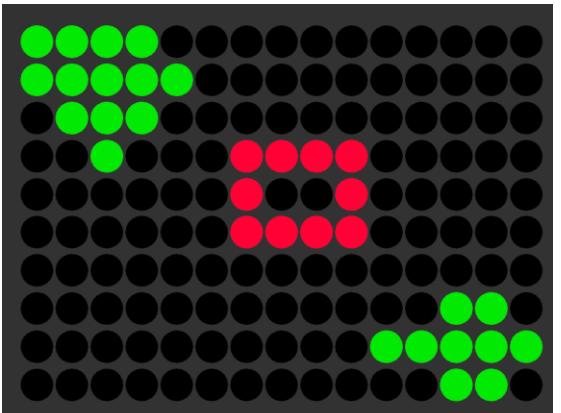
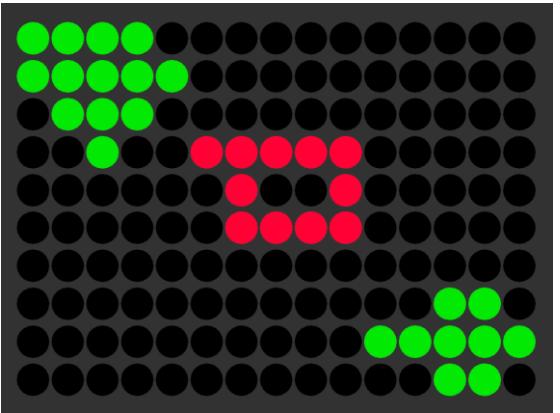
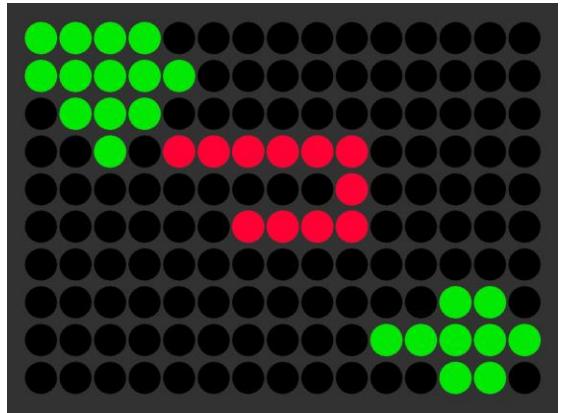
The snack grows after eating the target, while at the same time new target appears randomly.  
吃掉目标后虫子的尾部增长，同时随机产生新的目标点。

When the snack reaches the boundary, it just passes through it.

达到边界后虫子会穿过边界到达对岸。



# Game Design

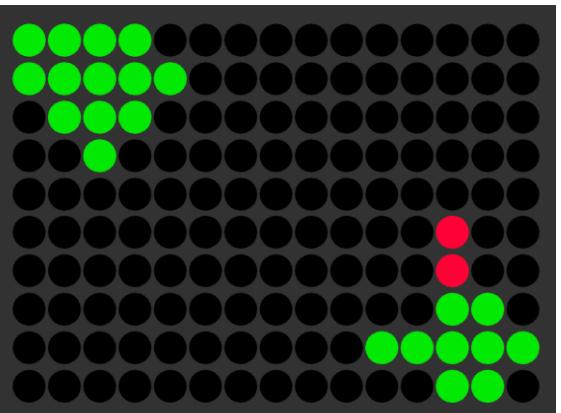
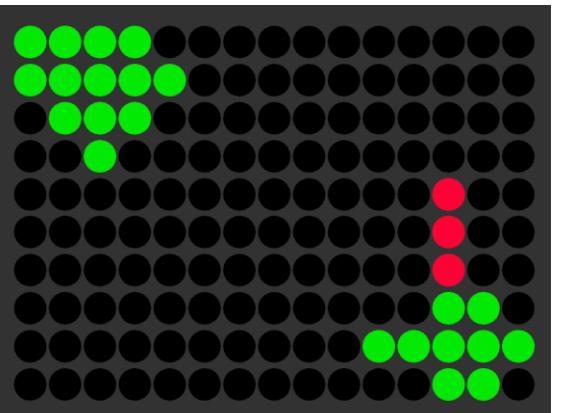
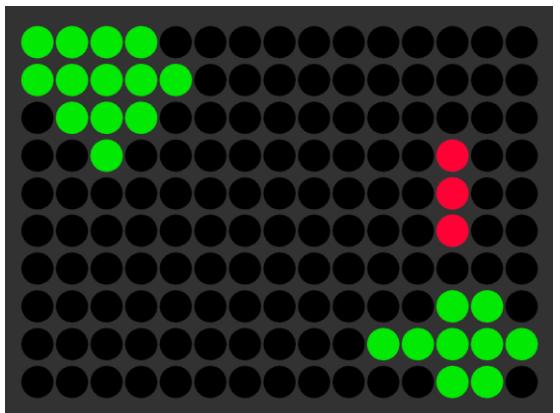


When the snack eats itself,  
GAME OVER~

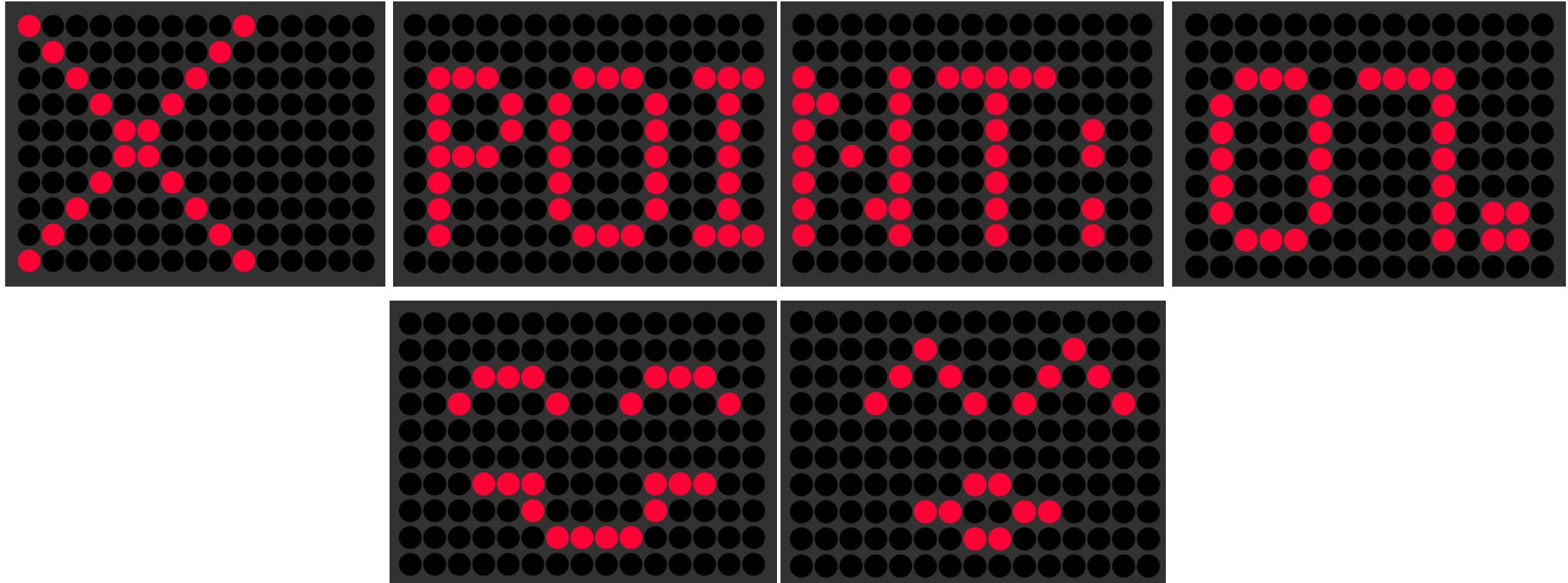
当虫子吃到自己身体的时候，  
游戏结束。

When the snack crashes the  
wall, GAME OVER~

当虫子身体撞击到墙壁的时  
候，游戏结束。



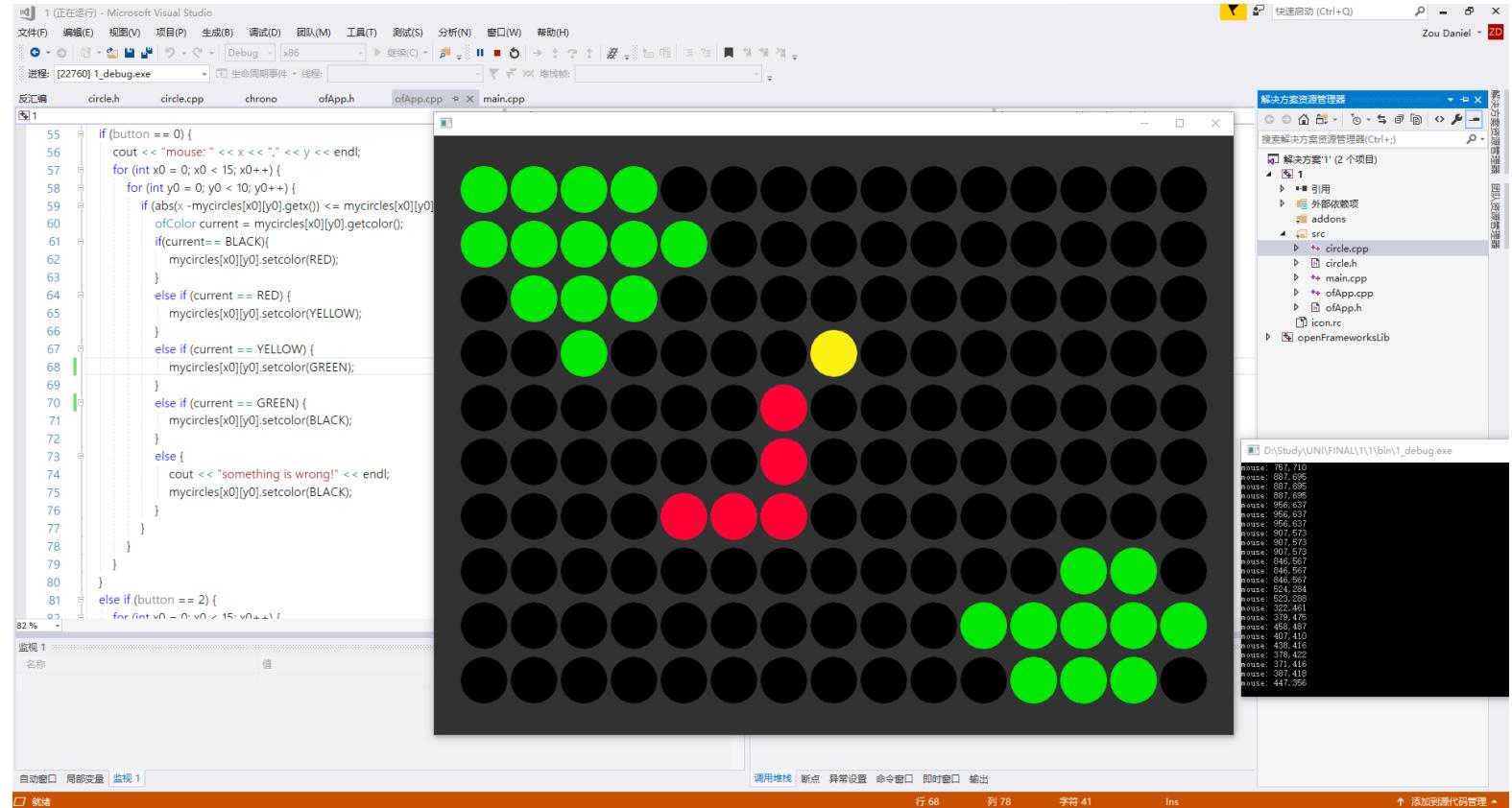
# Game Design



Messages like scores together with dynamic pixel images can be shown.

可以以滚动文字的形式传递出分数等必要信息，也可以展示出一些动态图像。

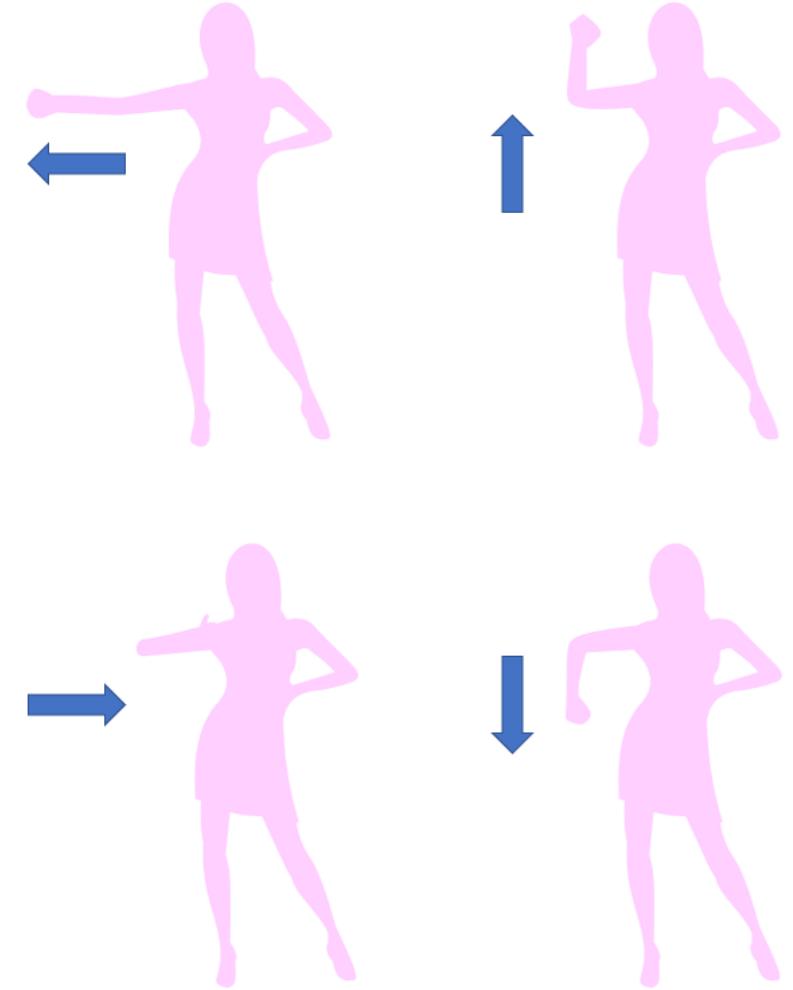
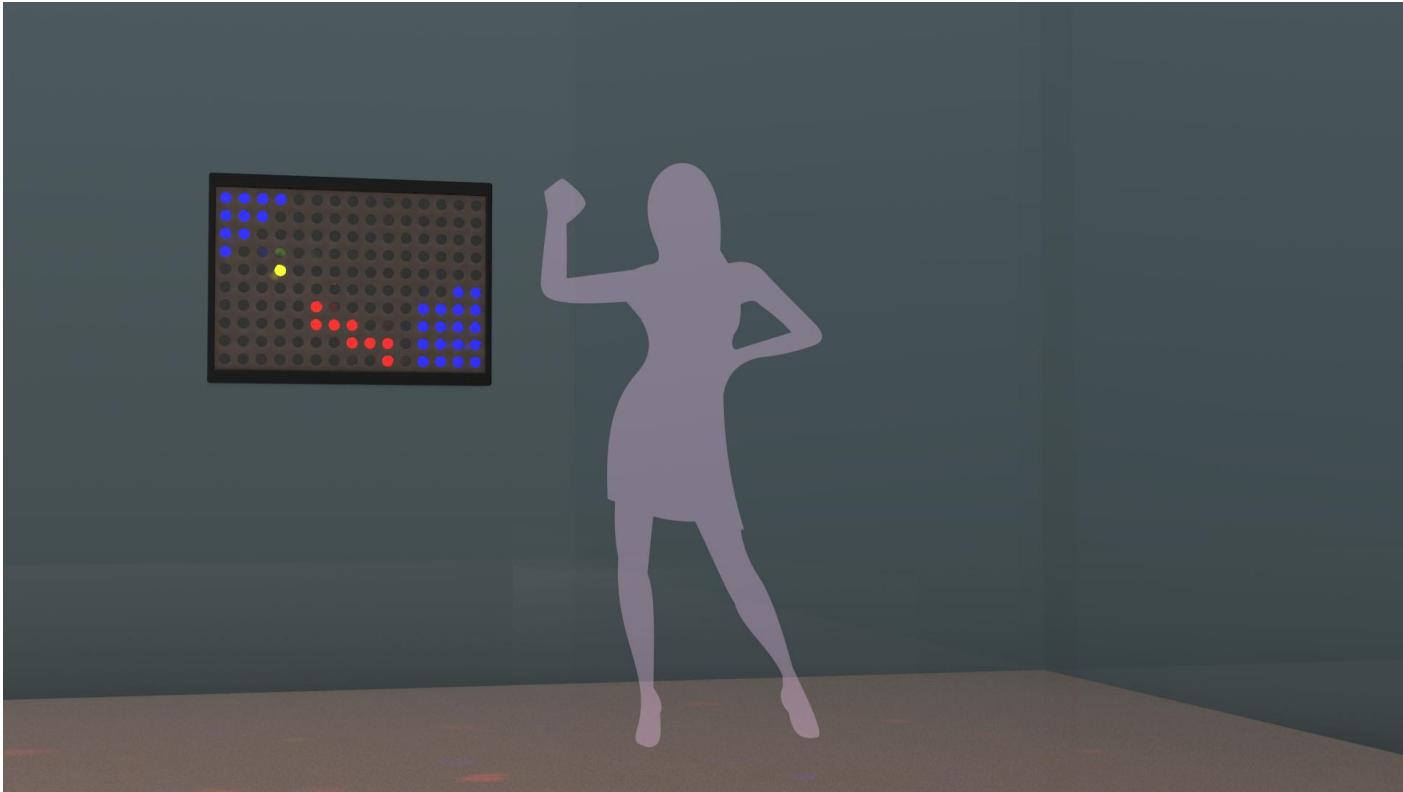
# Software Design



The software is developed under the Openframeworks, a creative coding framework based on C++. At the same time, the data from Kinect is detected intermediately. The computer communicates with the hardware by UDP.

在C++上利用Openframeworks创意编程框架编写电脑的模拟输出，同时实时处理Kinect端口检测到的数据，并且和硬件通过UDP协议串口通信控制装置发光。

# Control Design



Kinect V2 can detect only the upper half of human body within 2 meters. Therefore we consider to use the direction of human arm to control the movement of the snack.

经过讨论Kinect V2在2米范围内只能识别到人体上半身，故考虑通过人体手臂的方向来控制虫子的移动方向。

# Design Process

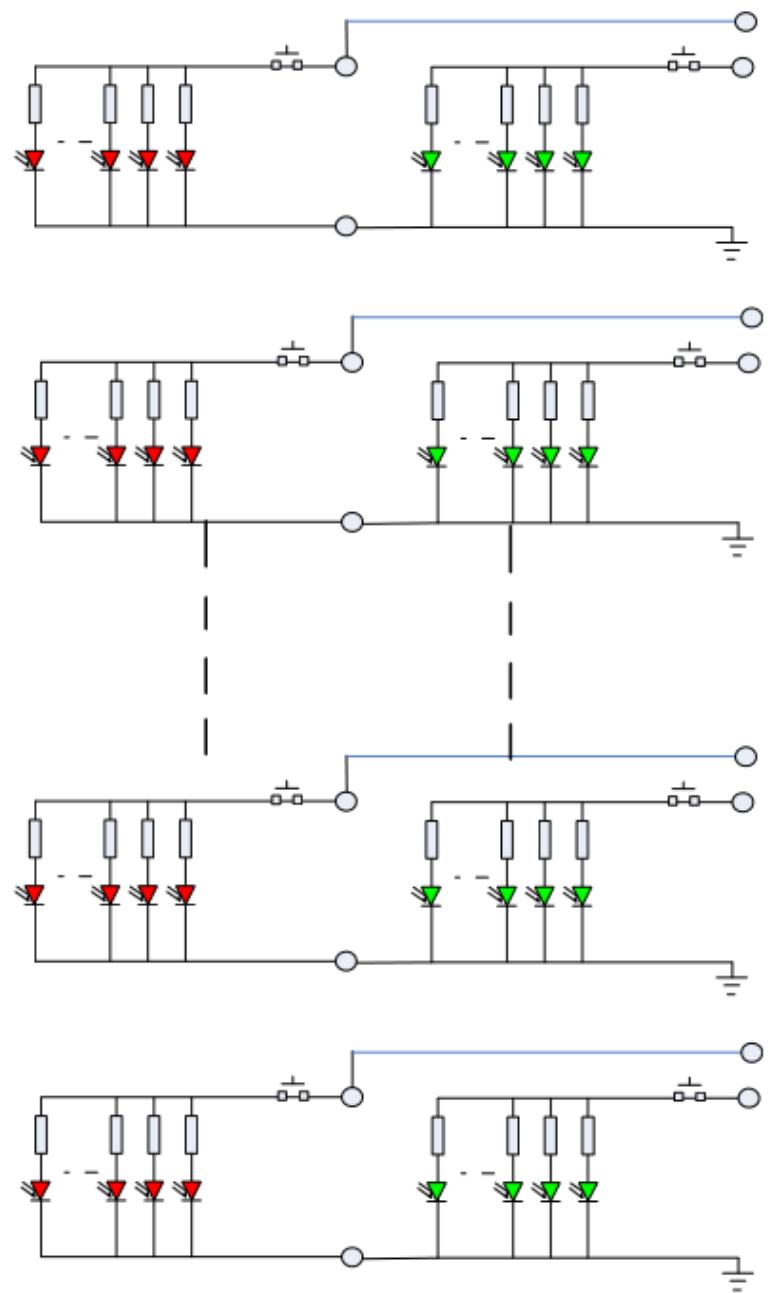
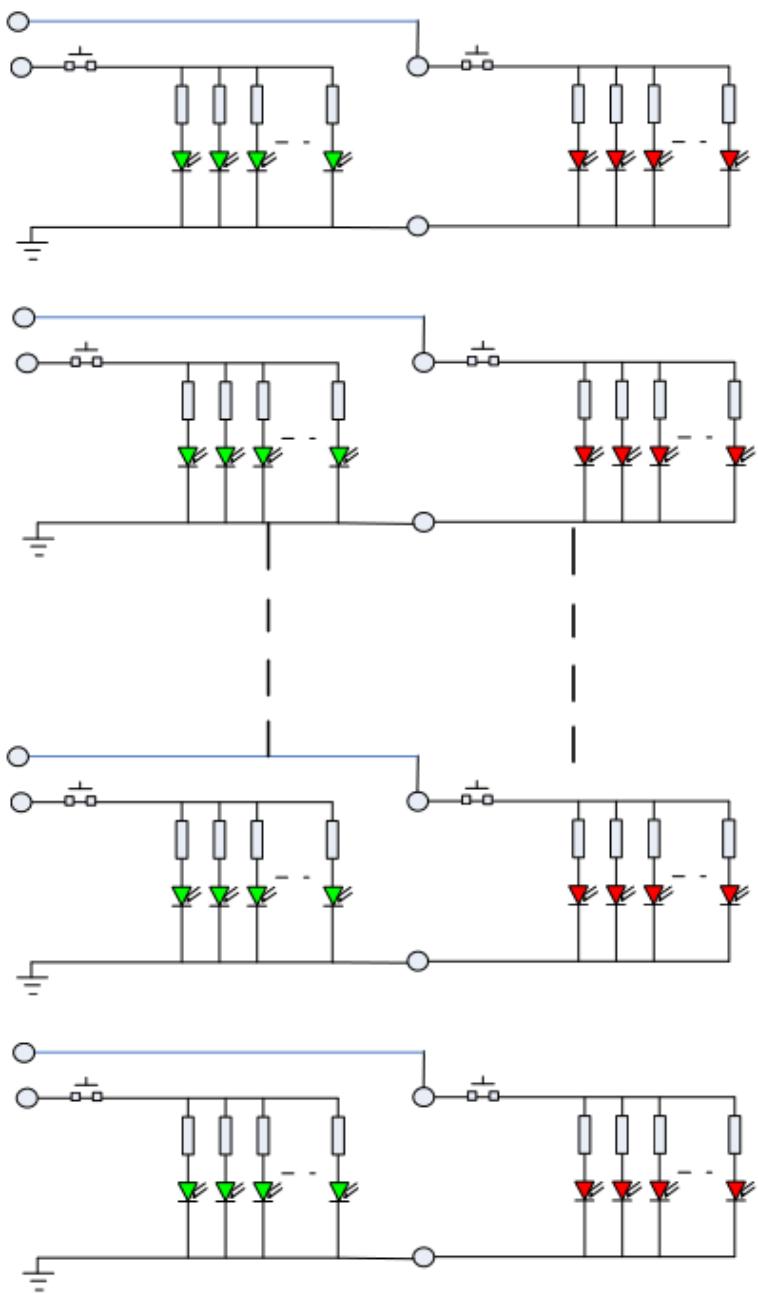
设计过程/文件

Documents

B

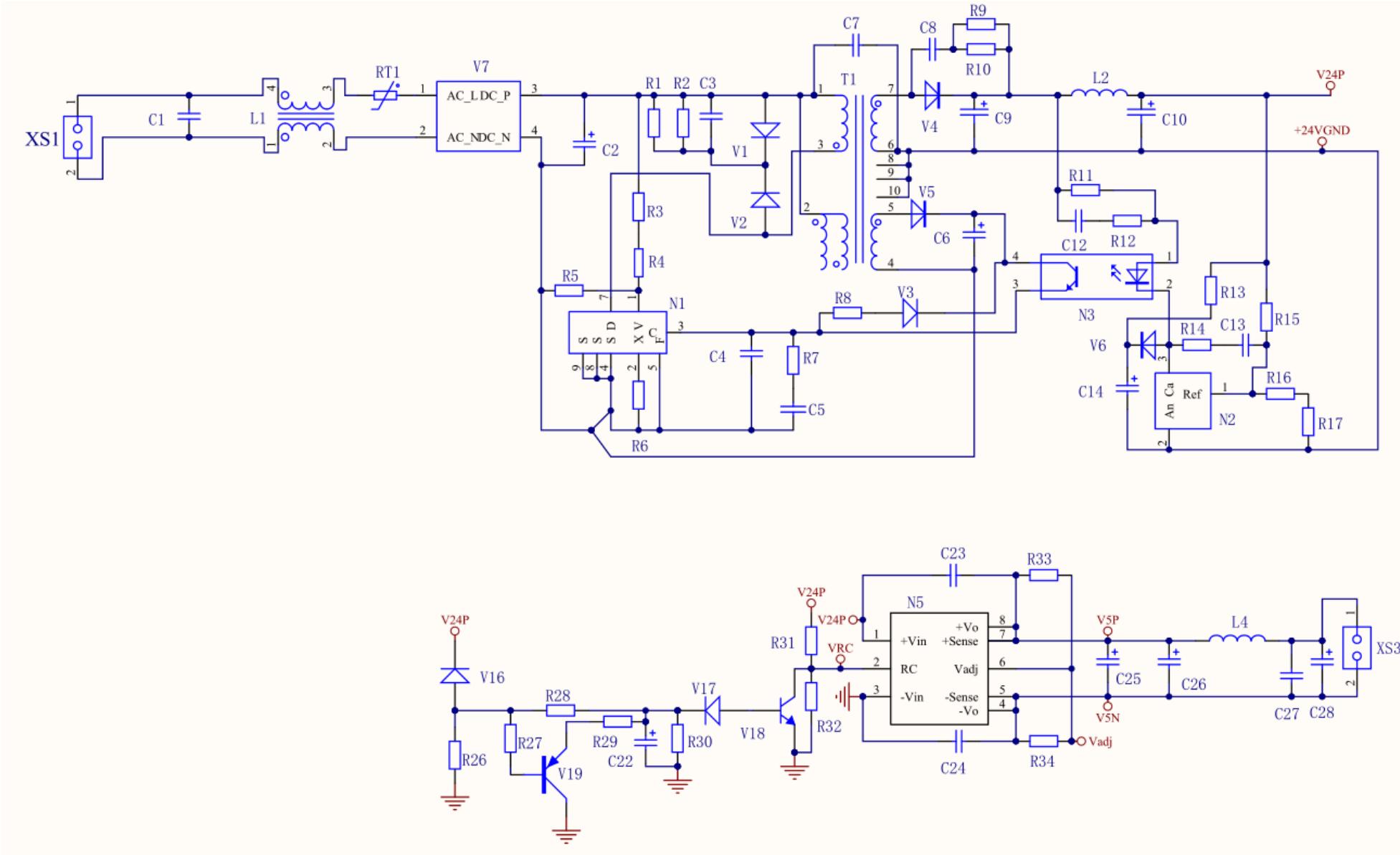
# Documents

The Design of LED Circuit  
LED电路设计图

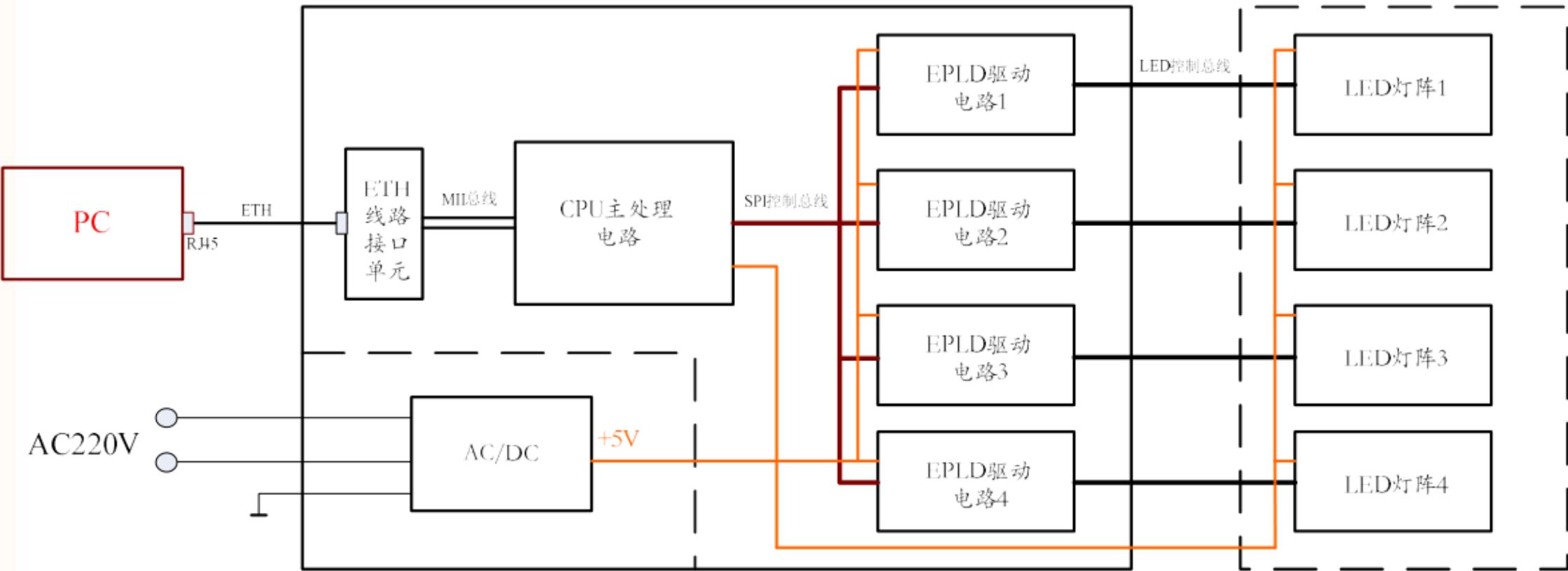


# Documents

Power Circuit  
电源电路图



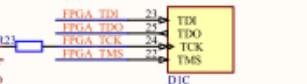
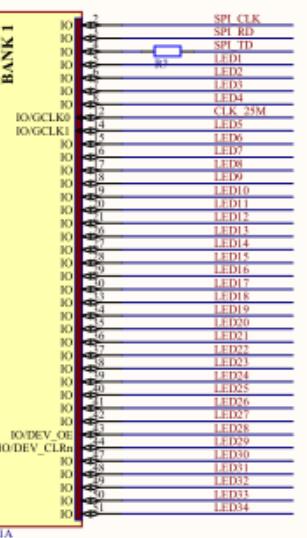
# Documents



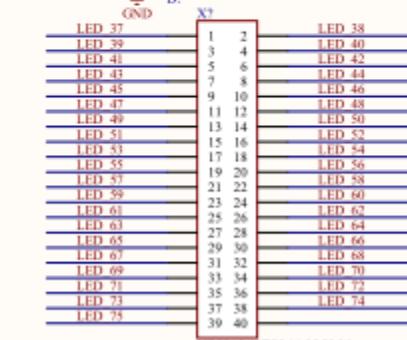
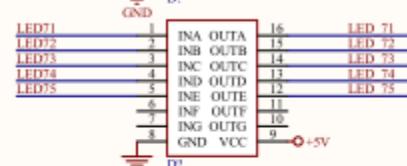
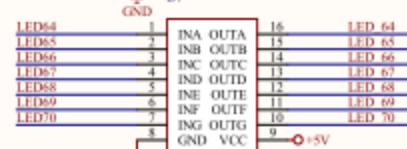
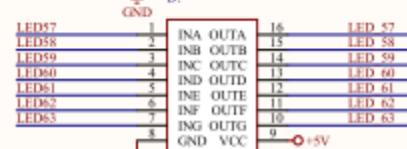
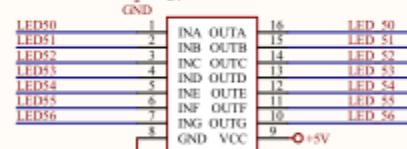
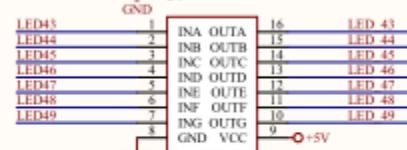
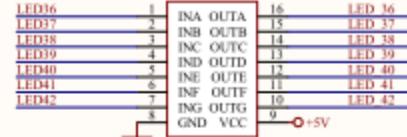
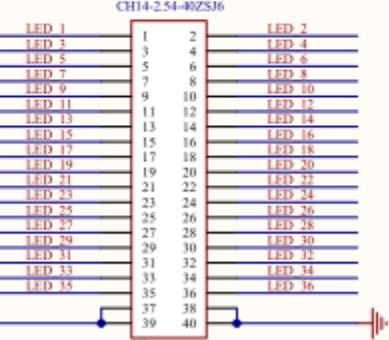
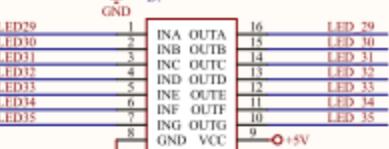
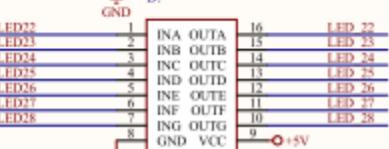
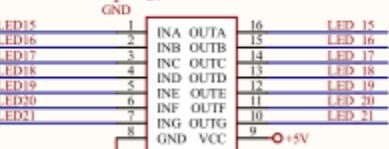
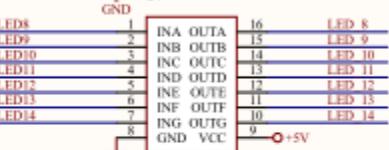
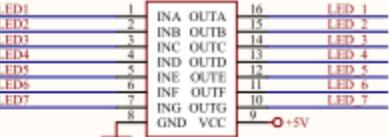
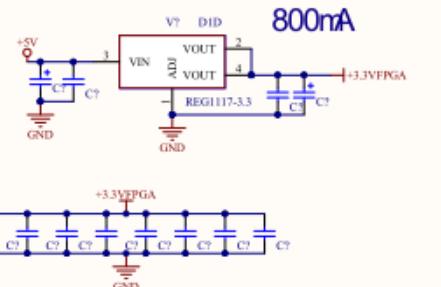
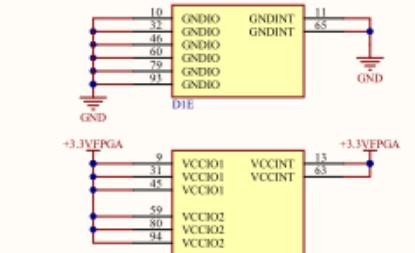
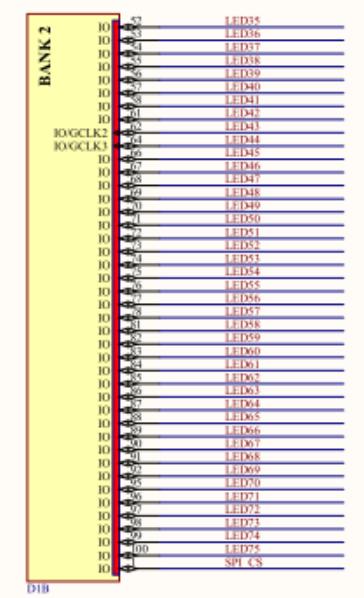
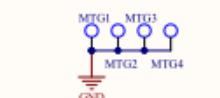
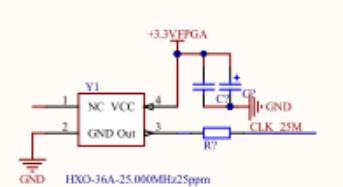
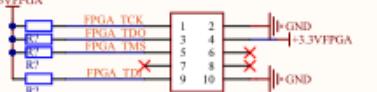
Big Picture of Hardware System  
系统原理框架图

# Documents

Main Processing Drive  
Circuit Diagram  
主处理驱动电路图



FPGA 在线调试





# Thank You!

Xuedan Zou 邹雪丹

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