ChessBoardGame

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Motivation and Introduction

- Chessboard Game is always a good way to develop your interest and intelligence
- It can also provide some social network and communication opportunities
- There are many kinds of chessboard game and we are doing one called "gobang"
Assumptions

• **Light Condition:**
  the light should be as stable as possible.

• **Camera Condition:**
  the camera can't be moved or reset after the first set up.

• **Paper Condition:**
  1. paper needs to stay completely under the camera.
  2. paper can only be moved after the chess piece being put

• **Player Condition:**
  1. two players need to put a green or blue fingerstall separately and green starts first
  2. stay one second for detecting touching
  3. finger move out of camera view for next step of another player
Approach

• Color Detection

• Corner Detection

• Touch Detection

• Movement Detection

• Button Function and How to Play
Approach

• Color Detection

• Corner Detection

• Touch Detection

• Movement Detection

• Button Function and How to Play
Approach
-- color detection

Similar to YCbCr:

In RGB domain
if \((G/R)\geq 2\):
    \textit{Green pixel}
if \((B/R)\geq 2\):
    \textit{Blue pixel};
else:
    \textit{everything else};

Pros:
Consistent under dark, bright and normal lighting conditions

Cons:
Mistake some pixels as green or blue
Approach
-- color detection

Threshold
*In RGB domain*

\[
\begin{align*}
\text{if } & ( (r>60) \land (r<100) \land (g>200) \land (b>100) \land (b<150)) \\
\text{Green pixel} \\
\text{if } & ( (r<100) \land (g>120) \land (g<140) \land (b>190) ) \\
\text{Blue pixel;} \\
\text{else:} & \\
\text{everything else;}
\end{align*}
\]

**Pros:**
Avoid mistaking some pixels to be blue or green

**Cons:**
Not robust to the light condition
Some pixels may not be able to be detected

**Complexity:** $O(n^2)$
Approach

• Color Detection

• Corner Detection

• Touch Detection

• Movement Detection

• Button Function and How to Play
Approach
-- corner detection

Perfect Binarization

Real-time Binarization
Approach
-- corner detection

Real-time distortion
Real-time Binarization
Approach
-- corner detection

![Diagram showing corner detection process](image)
Approach
-- corner detection

Approach: corner detection

\[ d \]

- If \( d < \text{threshold} \), it is not tilted
- If \( d > \text{threshold} \), it is tilted

Complexity: \( O(n^2) \)
Approach

• Color Detection

• Corner Detection

• **Touch Detection**

• Movement Detection

• **Button Function and How to Play**
Approach
-- touch detection

Using block Centers rather than block Boundaries

• Reason:
  - When paper is tilted, it is hard to define the boundaries
  - Robust for orientation and Easy to implement

Computing the distances between touched point and each microblocks

• Board size detection
• Microblock center detection
Approach
-- boardsize detection

- $t =$ Exterior bounding box size / interior bounding box size
  
  if $t > T_{\text{boardsize}}$, $\text{boardszie} = 7$
  if $t \leq T_{\text{boardsize}}$, $\text{boardszie} = 3$

-- microblock center detection

- derived from the 4 board corner coordinates, board center coordinates and boardsize
  
  $\text{block\_center}[i][j] = \text{block\_center}[0][j] + i \ast$
  \((\text{block\_center}[\text{boardszie}-1][j] - \text{block\_center}[0][j]) / \text{size};\)
Approach
-- touch detection

- find the shortest touch_distance

\[ \text{touch_distance}[i] = \text{the distances between finger and each microblock centers} \]

at the same time, satisfies 3 conditions
- at least
  1. the touch_distance is less than 10 pixels for 7*7 chessboard/ 35 pixels for 3*3 chessboard;
  2. it keeps for at least 15 continuous frames (stay in same block for at least 1 second) as the shortest one;
  3. untouched before;

Complexity:
\[ O(b^2) \approx \text{constant time, } b \text{ is block number} \]
Approach

• Color Detection

• Corner Detection

• Touch Detection

• Movement Detection

• Button Function and How to Play
Approach
-- movement detection

Horizontal and vertical movement

Rotation

Geometrical Modification is not a good idea
Approach
-- movement detection

Original
Center position: 
\((x_0,y_0)\)

Paper Movement
Center position: 
\((x_0,y_0)\)

After tracking
Center position: 
\((x_1,y_1)\)
Approach
-- movement detection

For blocked area

\{ hand, shadow \}

Time consuming

Only keep tracking of the four corners

Consider the situation that one center of the four corners is covered

Complexity:
$O(m^2)$, $m$ is boardsize
Approach

• Color Detection
• Corner Detection
• Touch Detection
• Movement Detection
• Button Function and How to Play
Approach
-- button function and how to play

DIP 3: regret button
- press down: return to last modification
- pull up: ready for next regretion

DIP 1: locate button
- press down: start to detect the centers
- pull up: ready for game

DIP 0: reset button
- press down: reset all the touched information
- pull up: ready for game
Approach
-- button function and how to play

1. Press down DIP 0 to reset all the touched information

2. Press down DIP 1 to detect the centers of macroblock and then pull up

3. Game start and the finger with green fingerstall puts the finger to the desired block, and stays in the block for over 15 frames for touching

4. Blue and green take turns to put the finger under the camera and in the desired block

5. Win condition is 4 (7*7) and 3 (3*3).

note: After touching, player can move the paper. For slow motion, all the chesspiece can move accordingly. For fast motion, when the hand is off the camera, the chesspiece will return to its correct position
General Conclusion

Light Conditions
Try and error to define the threshold for two markers

Low resolution and Some distortion
1. Two different ways to find the corner
2. Try and error to define better threshold for touching

Real-time and Limited memory
1. Avoid using external memory and carefully distribute internal memory
2. Use tracking method while the paper moves instead of scanning the image all the time
3. Use function calls to avoid doing all the procedure at the same time
Future Work

• Bigger board
• More robust color detection
• Better touching detection stratagem
Thank You!

Q & A