State Determination of Grid Based Board Games

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CSCE 867
Opportunities for board game based software:
• strategy / playing
• recording
• analysis

Often requires the use of a cumbersome interface.
Physical Game

User

Computer Program

Vision System

Robotics

Interface

Computer Program

User

Vision Approach
Method Overview

Input:
- Image of current game board
- Image of each unique game piece

Output:
- Text representation of each grid location and its contents

Diagram:
- Determine Location of Grid Lines
  - Find Grid Blocks with Contents
    - Calculate Best Fitting Game Piece
Determine Location of Grid Lines
Horizontal response of simple edge detection

\[ \begin{array}{ccc} 
1 & 1 & 1 \\
0 & 0 & 0 \\
-1 & -1 & -1 
\end{array} \times \begin{array}{c} \end{array} = \begin{array}{c} \end{array} \]

(after median filter and normalization)
Determine Location of Grid Lines
Vertical response of simple edge detection

\[
\begin{array}{c}
\begin{array}{ccc}
1 & 0 & -1 \\
1 & 0 & -1 \\
1 & 0 & -1 \\
\end{array}
\end{array}
\]

(after median filter and normalization)
Determine Location of Grid Lines

Scan across the gradient to find values above threshold.

This may identify too many points.
Determine Location of Grid Lines

Need to determine which identified pixels are on a vertical line.

Trace each point up and down by finding connected pixels.

If it cannot get far across the image, it is probably not on a grid line.
Determine Location of Grid Lines
Find Grid Blocks with Contents

Sum the gradient values in each grid block.

Notice the clear distinction between an empty block and a block with contents.
Calculate Best Fitting Game Piece

Red Piece (r)

Black Piece (b)

Iterate over each block to find the minimum absolute difference.

The piece with the smallest minimum difference has the best fit.
Results

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|   | r |   | r |   | r |   | r |
---
| r |   | r |   | r |   | r |   |
---
|   | r |   | r |   | r |   | r |
---
|   |   |   |   |   |   |   |   |
---
|   |   |   |   |   |   |   |   |
---
| b |   | b |   | b |   | b |   |
---
|   | b |   | b |   | b |   | b |
---
|   | b |   | b |   |   |   | b |
---
| b |   | b |   | b |   |   | b |
---
|   |   |   |   |   |   |   | b |
---
| b |   | b |   | b |   | b |   |
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Issues and Difficulties

Specular surfaces.
Assumes orthographic projection.

Game pieces must be distinctly different from background.
Possible Extensions

Correct for shifted orientation.

Apply a series of rotated kernels to find the directions of greatest edge response.

Video stream processing.

Wait for occlusion of the grid, then reevaluate the board.