Lecture-15

Quad Trees, Chain Code, Shape number & Moravec’s interest operator

Quad Trees

- Data structure to represent regions
- Three types of nodes: gray, black and white
- First generate the pyramid, then:
- If type of pyramid is black or white then return else
  - Recursively find quad tree of SE quadrant
  - Recursively find quad tree of SW quadrant
  - Recursively find quad tree of NE quadrant
  - Recursively find quad tree of NW quadrant
  - Retrun
Chain Code

- A simple technique to represent a shape of boundary.
- Each directed line segment is assigned a code.
- Chain code is integer obtained by putting together the codes of all consecutive line segments.
- Shape number is a normalized chain code, which is invariant to translation and rotation.
(a) 

chain code: 0010033321232211
first difference: 30130100033113030
shape number: 00033113030000130

(b) 

chain code: 00221
first difference: 303303
shape number: 033033

(c) 

chain code: 0032211
first difference: 30303030
shape number: 03030303

(d) 

chain code: 0032211
first difference: 3032211
shape number: 03032211

(e) 

chain code: 00332211
first difference: 30303030
shape number: 03030303

(f) 

chain code: 00332211
first difference: 3032211
shape number: 03032211
Moravec’s Interest Operator

Algorithm

- Compute four directional variances in horizontal, vertical, diagonal and anti-diagonal directions for each 4 by 4 window.
- If the minimum of four directional variances is a local maximum in a 12 by 12 overlapping neighborhood, then that window (point) is interesting.
\[ V_a = \sum_{j=0}^{3} \sum_{i=0}^{2} (P(x+i, y+j) \bigotimes P(x+i+1, y+j))^2 \]

\[ V_c = \sum_{j=0}^{3} \sum_{i=0}^{2} (P(x+i, y+j) \bigotimes P(x+i+1, y+j+1))^2 \]

\[ V_d = \sum_{j=0}^{3} \sum_{i=0}^{2} (P(x+i, y+j) \bigotimes P(x+i+1, y+1+j))^2 \]
\[ V_h = \bigg( \sum_{j=0}^{3} \bigg( P(x+i, y+j) \bigg) \bigg)^2 \]

\[ V_v = \bigg( \sum_{j=0}^{2} \bigg( P(x+i, y+j) \bigg) \bigg)^2 \]

\[ V_d = \bigg( \sum_{j=0}^{2} \bigg( P(x+i, y+j) \bigg) \bigg)^2 \]

\[ V_a = \bigg( \sum_{j=0}^{2} \bigg( P(x+i, y+j) \bigg) \bigg)^2 \]

\[ V(x, y) = \min(V_h(x, y), V_v(x, y), V_d(x, y), V_a(x, y)) \]

\[ I(x, y) = \begin{cases} 0 & \text{if } V(x, y) \text{ local max} \\ 1 & \text{otherwise} \end{cases} \]
Books by Hans Moravec

- Robot Rover Visual Navigation
- Mind Children: The future of Robot and Human Intelligence
- Robot, Being
  - Website http://www.frc.ri.cmu.edu/~hpm/
New Book

Cart under SAIL
1979 and 1997 3D Maps from stereo

NAVLABS
Beast

Universal Delivery
Potsdam

Home Vacuum Cleaning Robot (Dustbot)
Home Vacuum Cleaning Robot (Dustbot)
Chess Machine Performance versus Processing Power

Chess Rating

- Kasparov
- Grand Master
- Senior Master
- Master
- Expert
- Class A
- Class B
- Class C
- Class D
- Beginner

Search depth, ply
- Chess positions/second
- Chess positions/second
- Chess positions/second
- Chess positions/second
- Chess positions/second
- Equivalent MIPS

- 1
- 10
- 100
- 10K
- 100K
- 1M
- 10M
- 100M