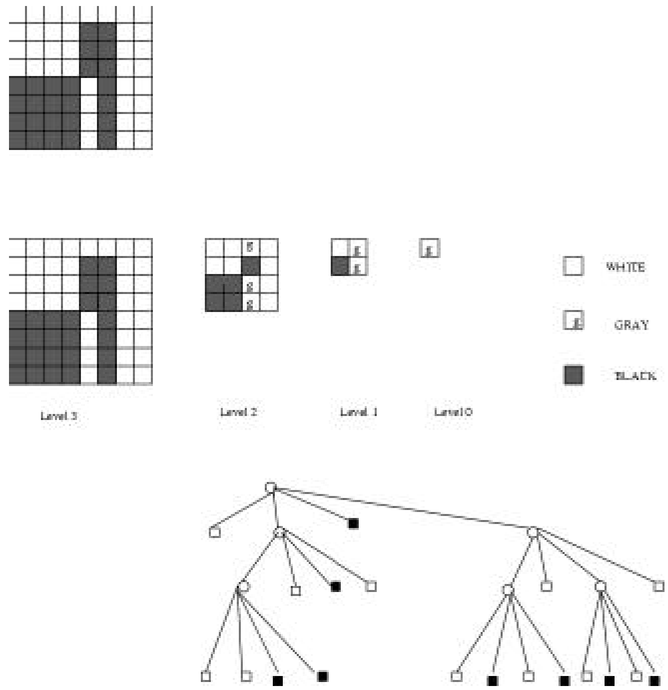
Lecture-15

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

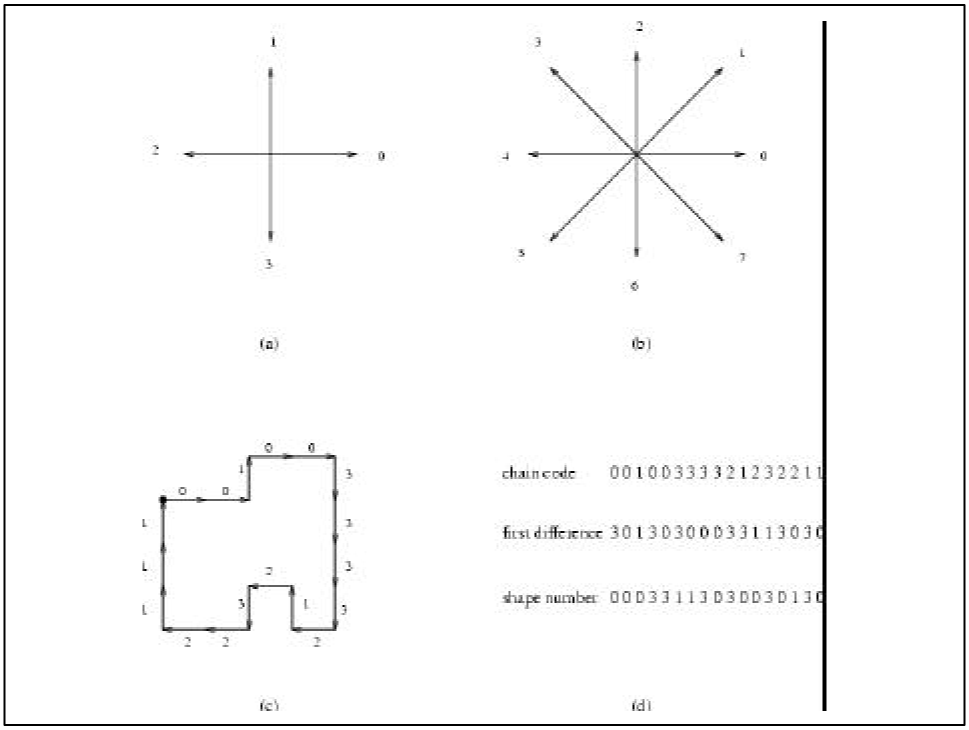
Quad Trees

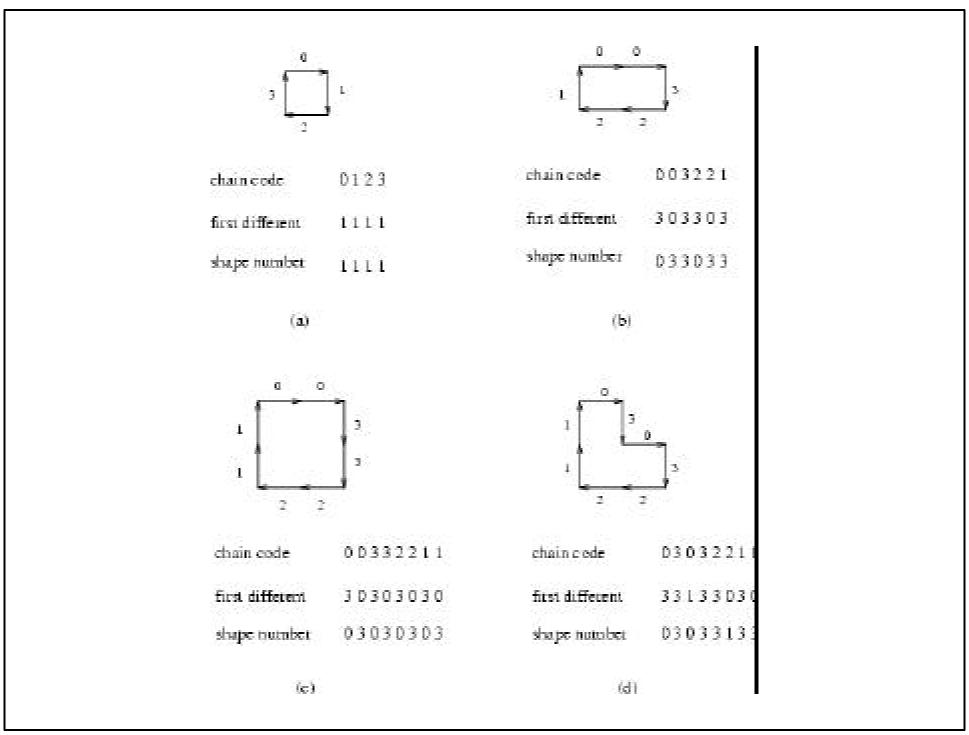
- Data structure to represent regions
- Three types of nodes: gray, black and white
- First generate the pyramid, then:
- If type of pyramid is black or white then return else
  - Recursively find quad tree of SE quadrant
  - Recursively find quad tree of SW quadrant
  - Recursively find quad tree of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

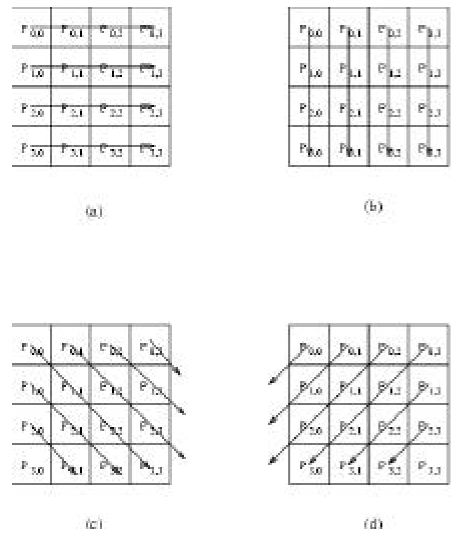

(a)
(b)
chain code 0 0 1 0 0 3 3 3 3 2 1 2 3 2 2 1 1
first difference 3 0 1 3 0 3 0 0 0 3 3 1 1 3 0 3 0
shape number 0 0 0 3 3 1 1 3 0 3 0 0 3 0 1 3 0
(c)
(d)

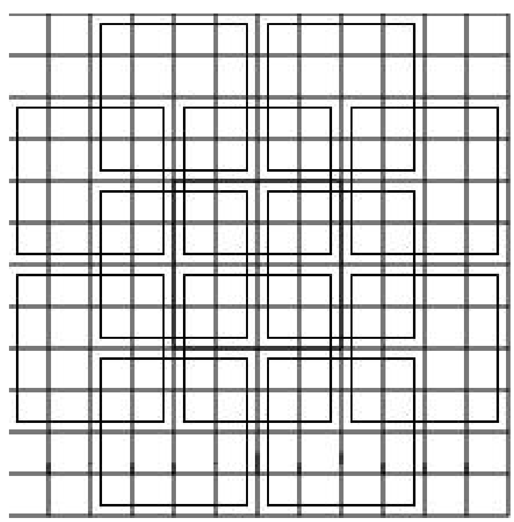

chain code 0 1 2 3
first different 1 1 1 1
shape number 1 1 1 1
(a)
chain code 0 0 3 2 2 1
first different 3 0 3 3 0 3
shape number 0 3 3 0 3 3
(b)
chain code 0 0 3 3 2 2 1 1
first different 3 0 3 0 3 0 3 0
shape number 0 3 0 3 0 3 0 3
(c)
chain code 0 3 0 3 2 2 1 1
first different 3 3 1 3 3 0 3 0
shape number 0 3 0 3 3 1 3 3
(d)

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 widow (point) is interesting.


(a)
(b)
(c)
(d)



$$V_h = \sum_{j=0}^{3} \sum_{i=0}^{2} (P(x+i, y+j) - P(x+i+1, y+j))^2$$

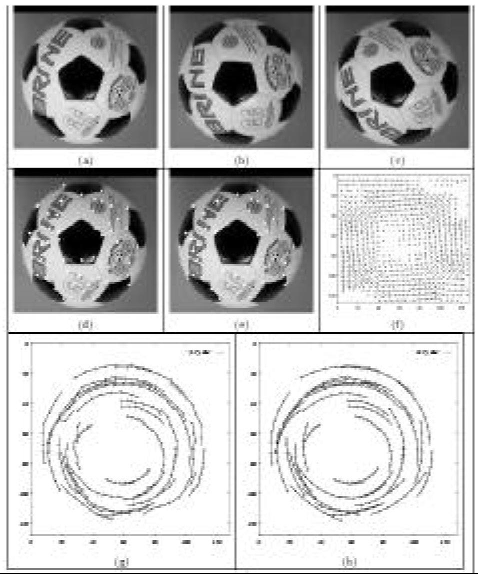
$$V_v = \sum_{j=0}^{2} \sum_{i=0}^{3} (P(x+i, y+j) - P(x+i, y+j+1))^2$$

$$V_d = \sum_{j=0}^{2} \sum_{i=0}^{2} (P(x+i, y+j) - P(x+i+1, y+j+1))^2$$

$$V_a = \sum_{j=0}^{2} \sum_{i=1}^{3} (P(x+i, y+j) - P(x+i-1, y+j+1))^2$$

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

$$I(x,y) = \begin{cases} 1 & if V(x,y) local \max \\ 0 & 0therwise \end{cases}$$

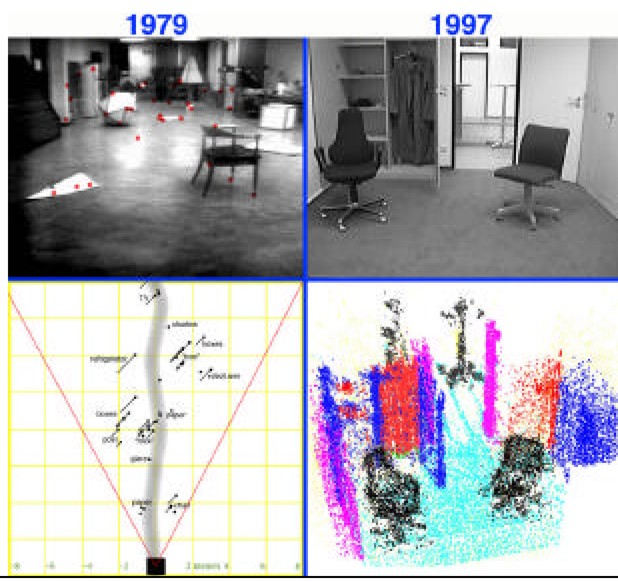


Books by Hans Moravec

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

Cart under SAIL

1979 and 1997 3D Maps from stereo

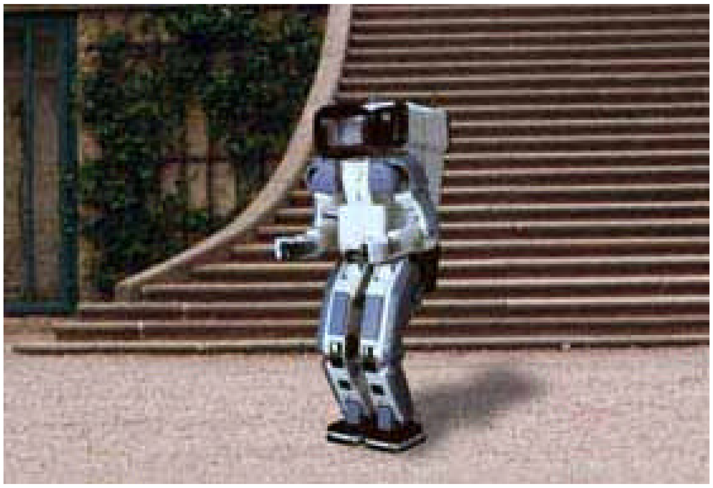


NAVLABS

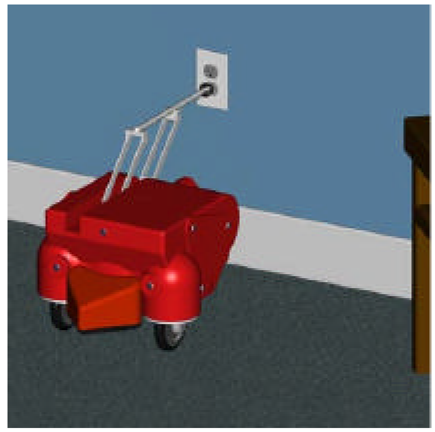
Beast

Universal Delivery

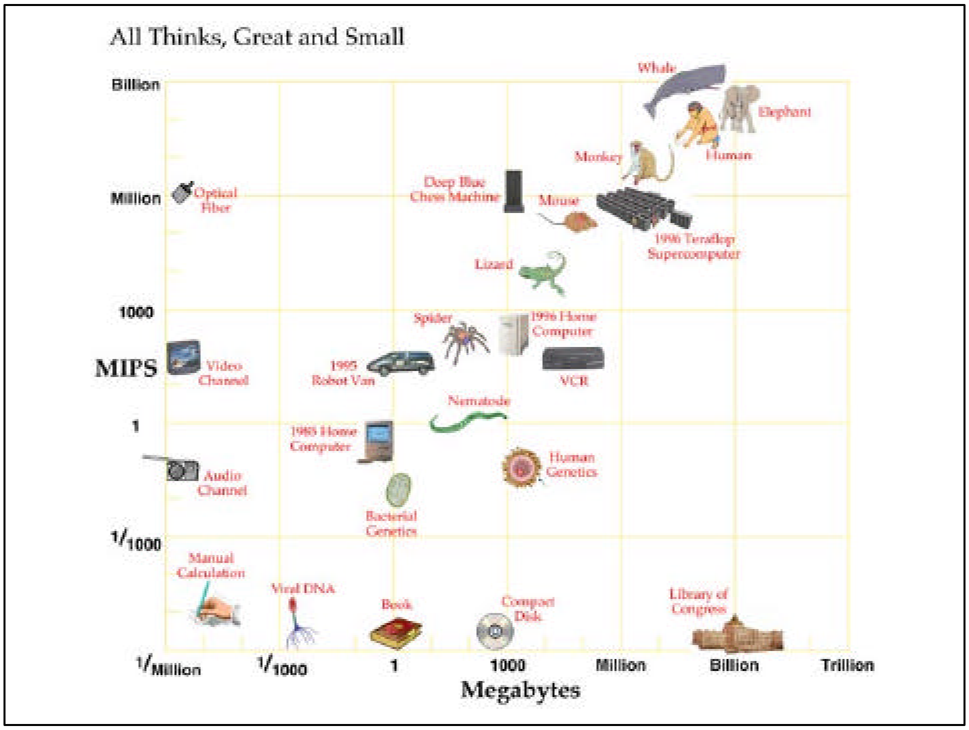
Potsdam

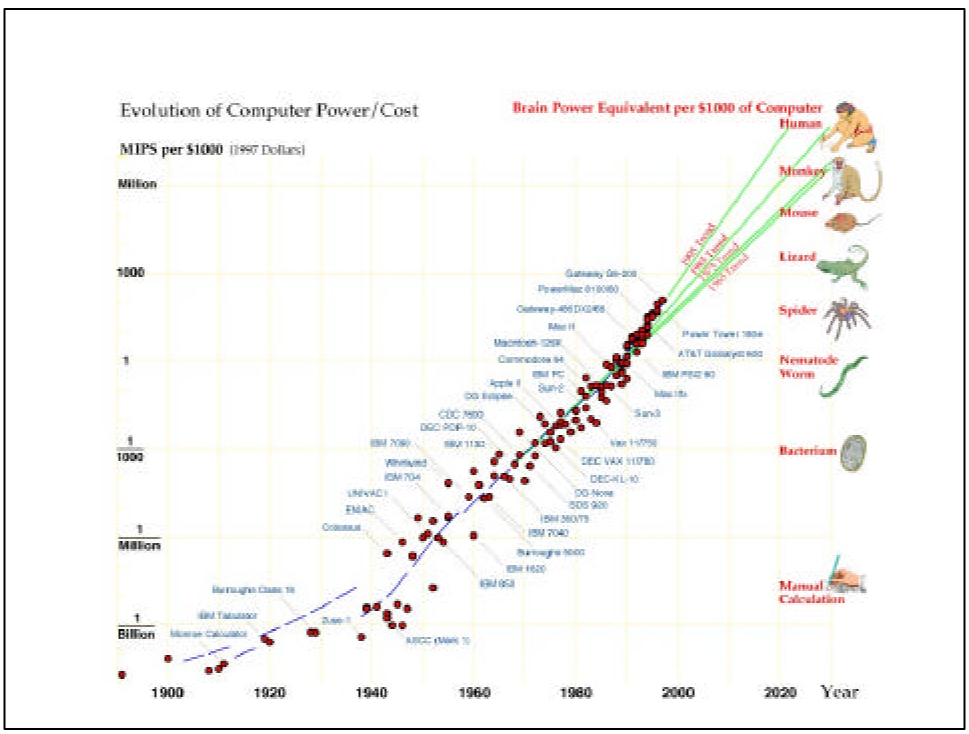


Home Vacuum Cleaning Robot (Dustbot)

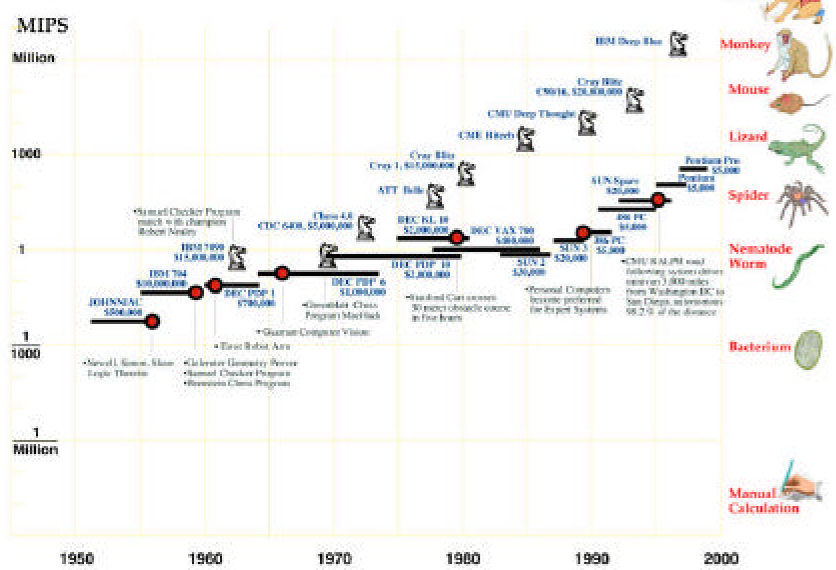


Home Vacuum Cleaning Robot (Dustbot)


All Thinks, Great and Small
Billion
Million
1000
MIPS
1
1/1000
1/Million
1/1000
1
1000
Million
Billion
Trillion
Megabytes
Whale
Elephant
Human
Monkey
Deep Blue Chess Machine
Mouse
1996 Teraflop Supercomputer
Optical Fiber
Lizard
Spider
1996 Home Computer
Video Channel
1995 Robot Van
VCR
Nematode
1985 Home Computer
Human Genetics
Audio Channel
Bacterial Genetics
Manual Calculation
Viral DNA
Book
Compact Disk
Library of Congress


Evolution of Computer Power/Cost
Brain Power Equivalent per $1000 of Computer
MIPS per $1000 (1997 Dollars)
Million
1000
1
1/1000
1/Million
1/Billion
1900
1920
1940
1960
1980
2000
2020
Year
Human
Monkey
Mouse
Lizard
Spider
Nematode Worm
Bacterium
Manual Calculation

Computer power available to AI and Robot programs



Chess Machine Performance versus Processing Power