

# **Motion Estimation**

## **— BMA**

*Dr. Xigun Lu*

*College of Computer Science*

*Zhejiang University*

# Outline

- Optical Flow (Pixel-level)
  - What is optical flow?
  - Lucas-Kanade algorithm (LK) [2]
  - Horn-Schunck algorithm (HS) [3]
- BMA (Block-level)
  - The principle of BMA
  - Full search scheme
  - Three step search [4]
  - New three step search [5]
  - Four step search [6]
  - Diamond search scheme [7]

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  - Diamond search scheme [7]

# Four-Step Search: FSS [6]

- 1) For the maximum motion displacement of  $\pm 7$ , the proposed FSS algorithm utilizes a center-biased search pattern with 9 checking points on a  $5 \times 5$  window in the first step.
  - If the minimum BDM point is found at the center of the search window, go to step 4; otherwise go to step 2.
- 2) The search window is kept as  $5 \times 5$ . But the search pattern will depend on the position of the previous minimum BDM point.
  - If the previous minimum BDM point is located at the **corner** of the previous search window, 5 additional checking points are used.
  - If the previous minimum BDM point is located at the **edge** of the previous search window, 3 additional checking points are used.
- 3) The searching pattern strategy is the same as step 2, but finally it will go to step 4.
- 4) The search window is reduced to  $3 \times 3$ .

# Four-Step Search: FSS [6]

- The total number of checking points is varied from  $(9+8) = 17$  to  $(9+5+5+8) = 27$ . The worst case computational requirement of the FSS is 27 block matches.

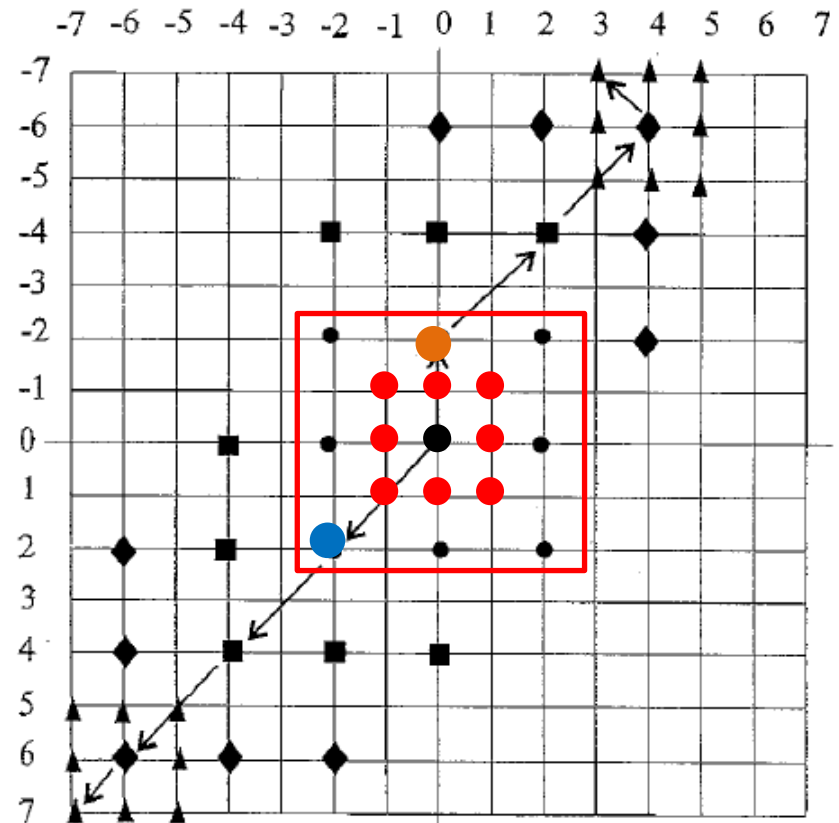


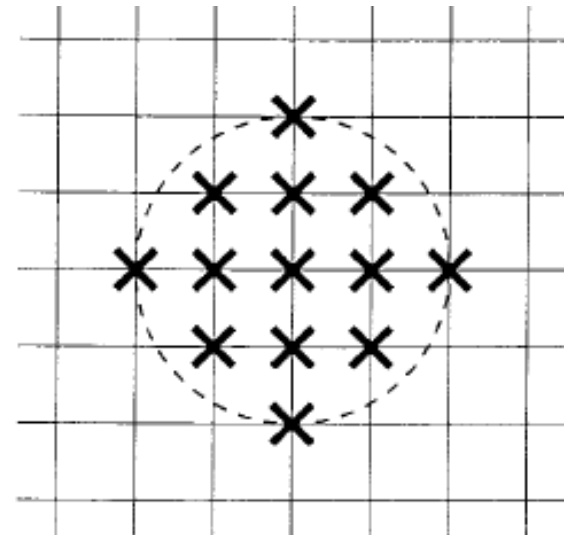
Fig. 3. Two different search paths of 4SS.

Corner Point

Edge Point

# Diamond Search Algorithm: DS [7]

- **The error surface is usually not monotonic:**
  - Small search pattern → quite likely to be trapped into local minimum for those video sequences with large motion.
  - Large search pattern → most likely to mislead the search path to a wrong direction.
- **Center-biased:** the distribution of the global minimum points is centered at the position of zero motion.



# Diamond Search Algorithm: DS

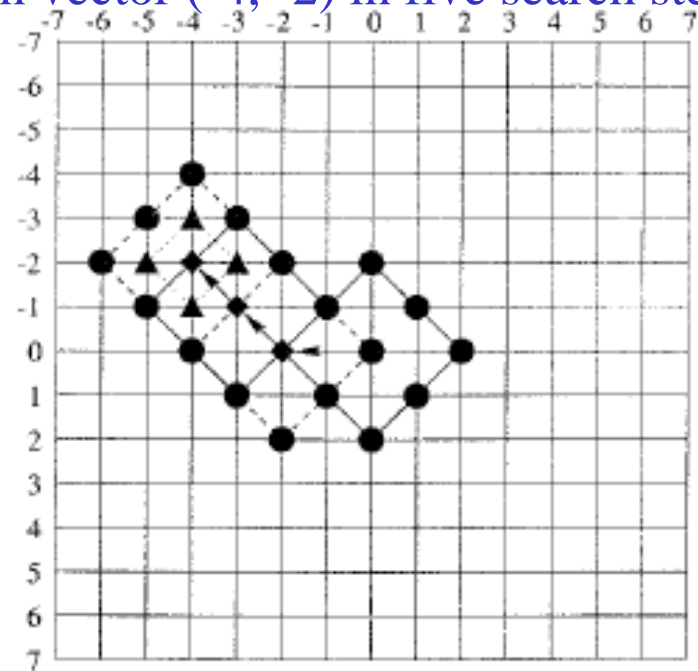
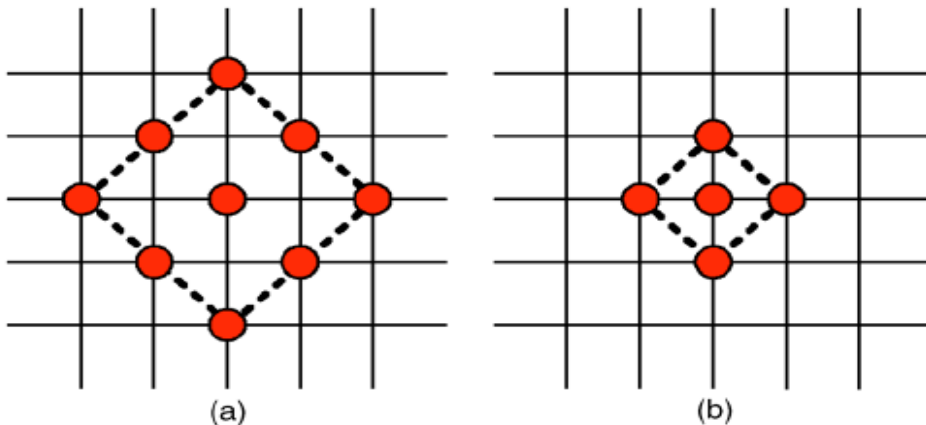
- The motion vector distribution probabilities within certain distances from the search window center.
  - About **52.76% to 98.70%** of the motion vectors are enclosed in a **circular support with a radius of 2 pixels** and centered on the position of zero motion.
  - The block displacement mainly in horizontal and vertical directions.

Radium (pel)	Tennis	Football	Caltrain	Susie	Salesman	Claire
0	0.2622	0.6196	0.0416	0.0938	0.6562	0.9076
1	0.3751	0.7297	0.5373	0.3592	0.9452	0.9702
2	0.5276	0.7983	0.8523	0.5950	0.9609	0.9870
3	0.7178	0.8641	0.9168	0.7622	0.9741	0.9932
4	0.8402	0.9042	0.9380	0.8225	0.9795	0.9950
5	0.8930	0.9329	0.9561	0.8779	0.9853	0.9957
6	0.9200	0.9483	0.9720	0.9038	0.9957	0.9964
7	0.9599	0.9658	0.9894	0.9365	0.9975	0.9973

# Diamond Search Algorithm: DS

- Large Diamond Search Pattern (LDSP) and Small Diamond Search Pattern (SDSP)
  - LDSP is repeatedly used until the step in which the minimum block distortion (MBD) occurs at *the center point*.
  - switched from LDSP to SDSP

Search path example which leads to the motion vector  $(-4, -2)$  in five search steps.





# References

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*Thank You!*

*Dr. Xigun Lu*

**xqlu@zju.edu.cn**