

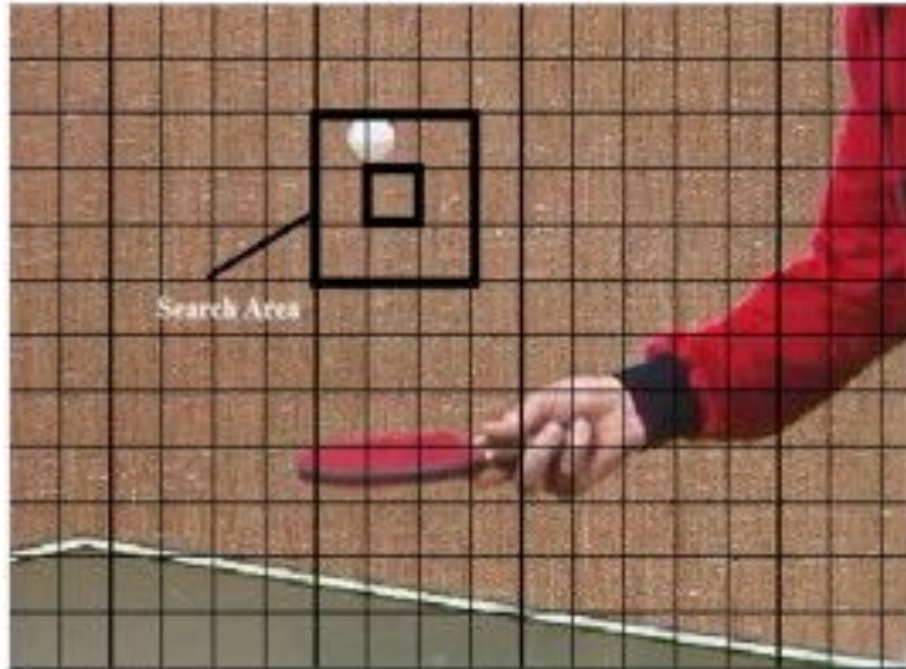
Block matching

For motion estimation in videos

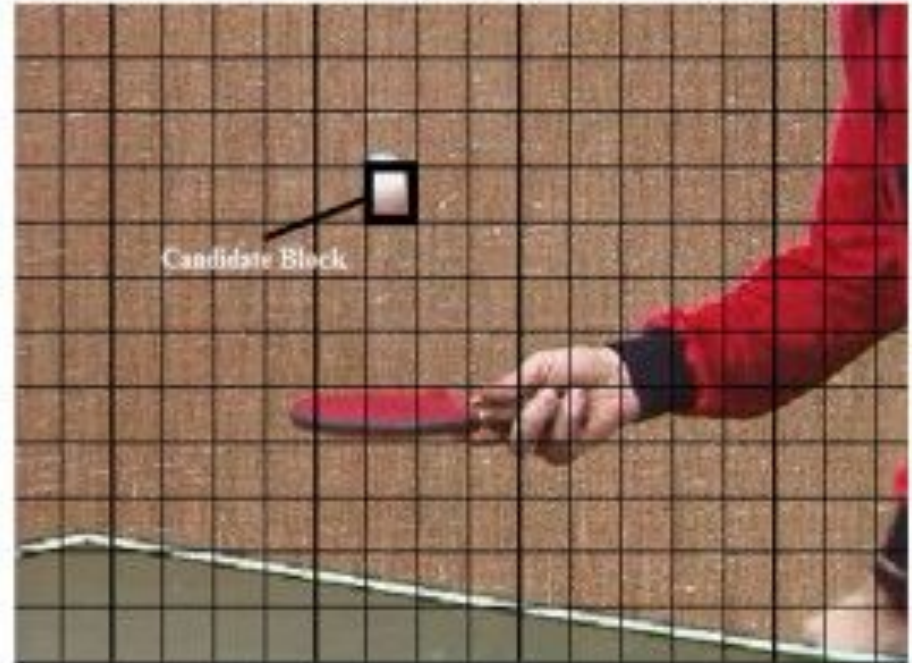
In a nutshell

- A set of heuristic algorithms
- Performs motion estimation, video compression
- Key idea - locate matching macro blocks in subsequent frames of video
- A vector to depict the motion of a macroblock from frame to frame

Reference Frame



Current Frame



Typical macroblock size = 16 pixels

Cost functions

$$\text{Mean Absolute Difference (MAD)} = \frac{1}{N^2} \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} |C_{ij} - R_{ij}|$$

$$\text{Mean Squared Error (MSE)} = \frac{1}{N^2} \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (C_{ij} - R_{ij})^2$$

Algo 1: Exhaustive Search

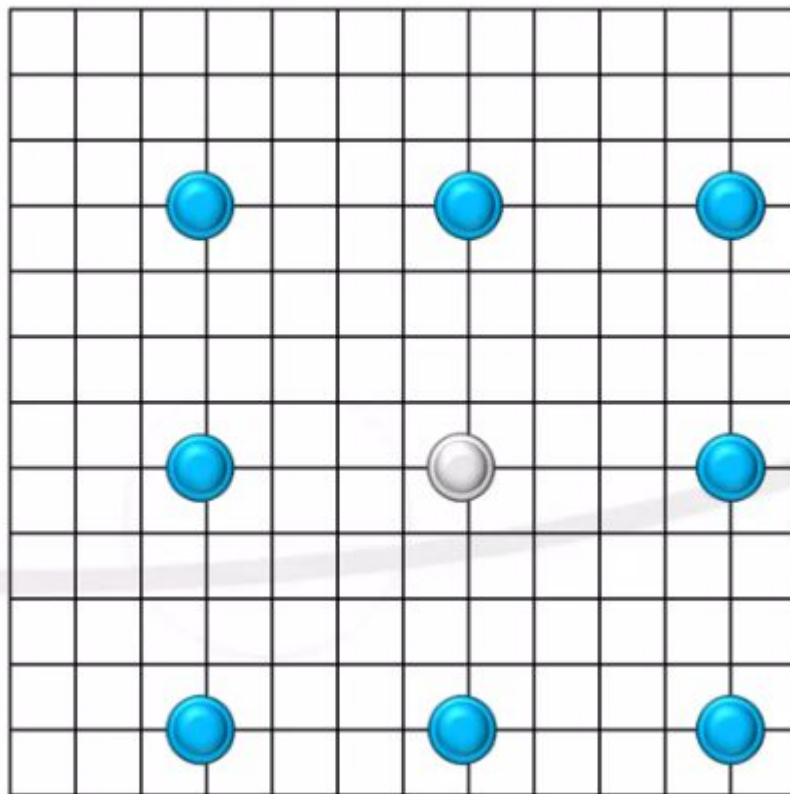
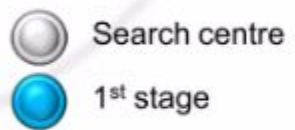
1. Set a search window e.g: 7 pixels on all sides of the candidate block
2. Calculate cost function for each possible location in search window
3. The position with the optimal cost value is the best match
4. Draw a vector between the centers of the candidate macro block in the current frame and the matching block in reference frame

Best possible match but **computationally expensive**

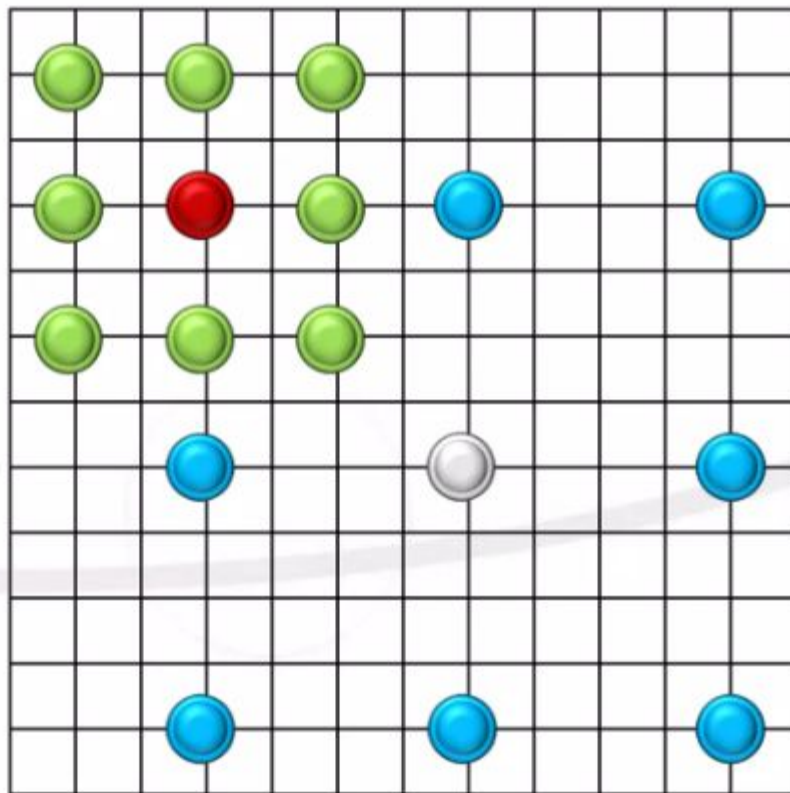
Algo 2: Three step search

1. Start with search location as centre
2. Set step size **$S = 4$** and search window = 7 pixels
3. Search 8 locations $\pm S$ pixels around location (0,0) and the location (0,0)
4. Pick among the 9 locations searched, the one with minimum cost function
5. Set the new search origin to the above picked location
6. Set the new step size as **$S = S/2$**
7. Repeat the search procedure until $S = 1$

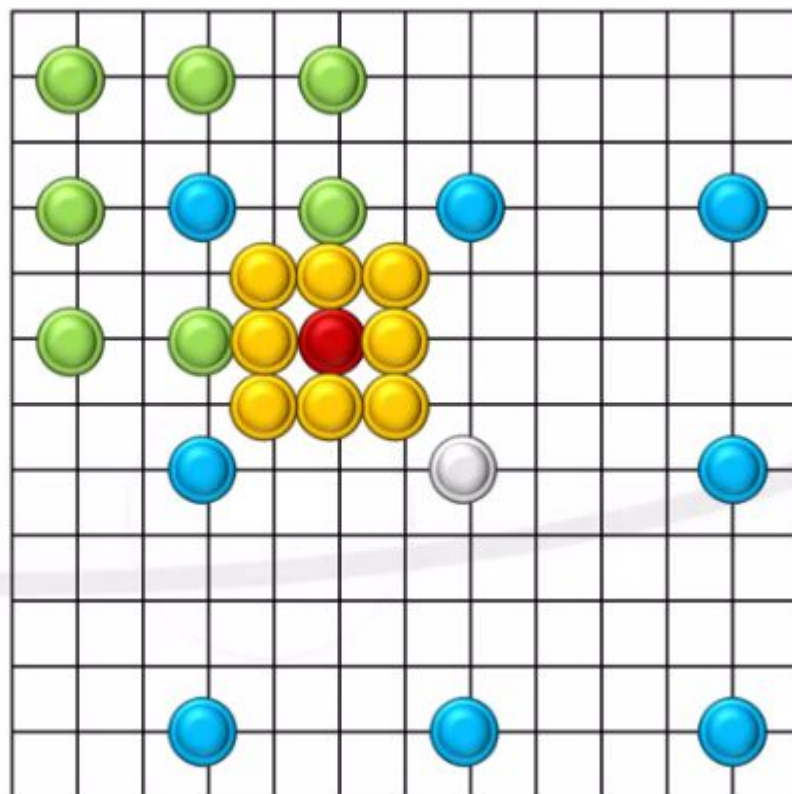
The resulting location for $S=1$ is the one with minimum cost function and the macro block at this location is the best match.



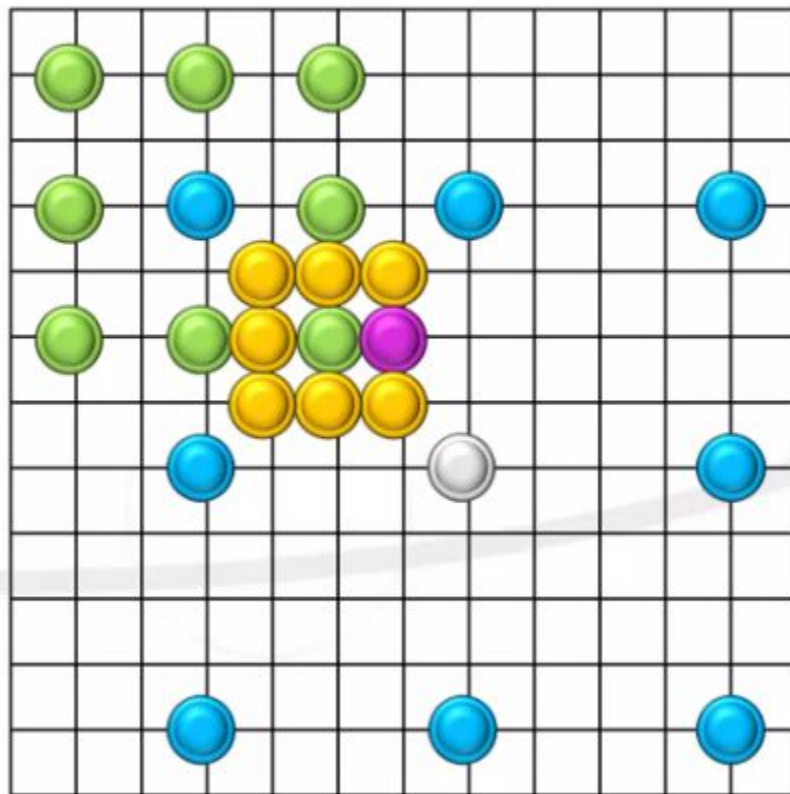
-  Search centre
-  1st stage
-  2nd stage
-  Best candidate



-  Search centre
-  1st stage
-  2nd stage
-  3rd stage
-  Best candidate



- ❑ The number of stages depends on the initial distance to which the first 9 neighbors are selected




Algo 3: Diamond Search

- Uses Manhattan distance criteria to search in a diamond pattern inside of rectangle(square)
- Two different types of fixed patterns are used for search:
 - Large Diamond Search Pattern (LDSP)
 - Small Diamond Search Pattern (SDSP)

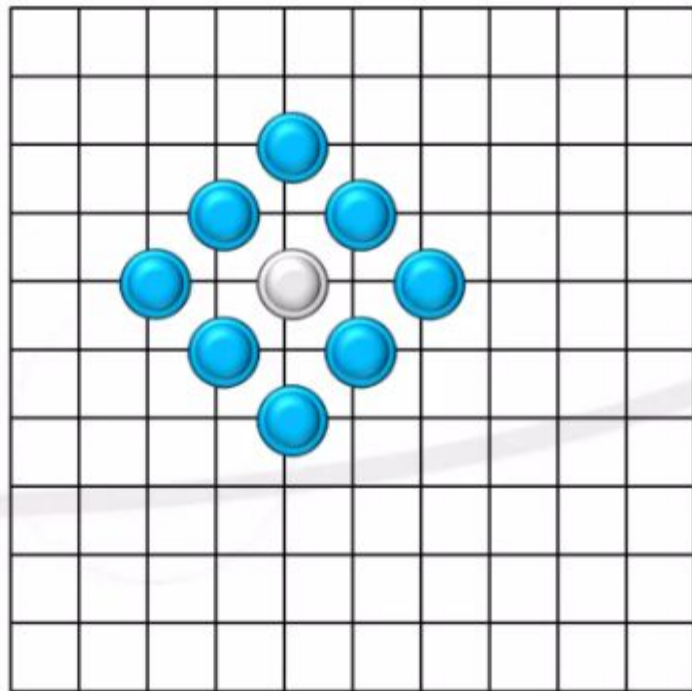
Diamond Search algorithm has a peak signal-to-noise ratio close to that of Exhaustive Search with significantly less computational expense.

For details see:

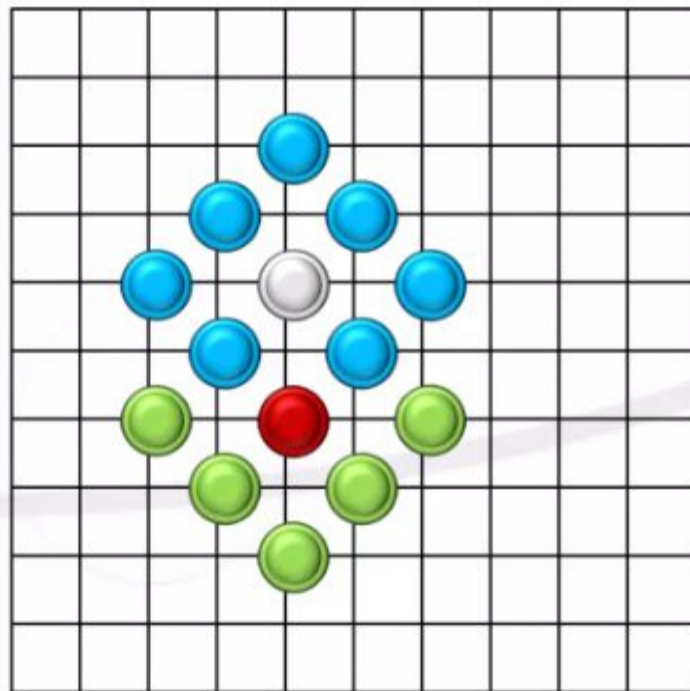
https://en.wikipedia.org/wiki/Block-matching_algorithm#Diamond_Search

 Search centre

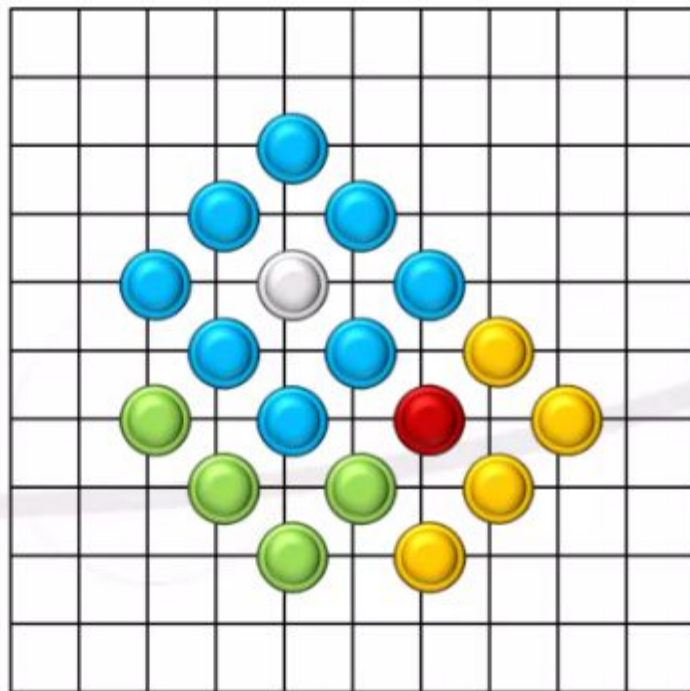
 1st stage



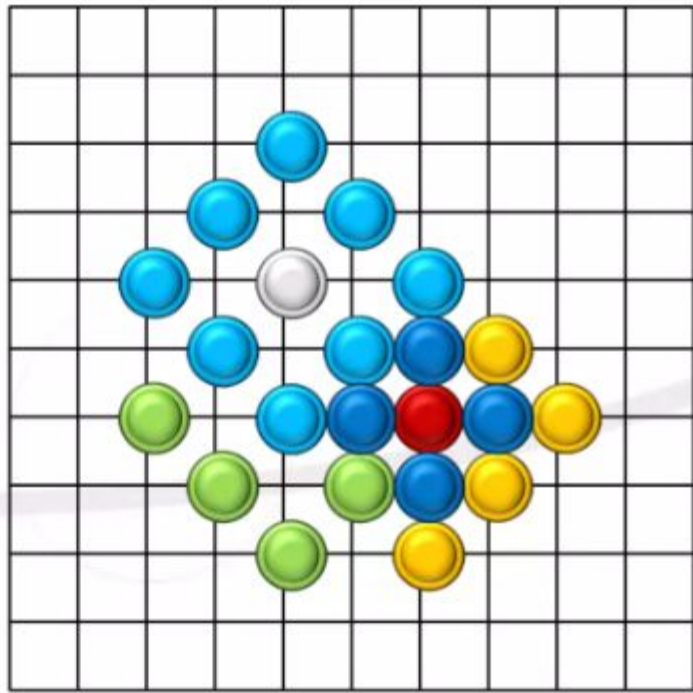
-  Search centre
-  1st stage
-  2nd stage
-  Best candidate



-  Search centre
-  1st stage
-  2nd stage
-  3rd stage
-  Best candidate



-  Search centre
-  1st stage
-  2nd stage
-  3rd stage
-  4th stage
-  Best candidate



- ❑ Each new stage (except the reduced step stage) evaluates four or five blocks
- ❑ The neighbors are selected at a mixed distance

