The two tables below represent the output of a CCD at two instances in time. The top picture was acquired first.

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	2	0	0
0	0	0	9	1	0
0	0	1	1	0	0
0	0	0	0	0	5

0	1	0	0	0	0
1	10	1	0	0	0
0	1	0	0	0	0
0	0	0	5	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Perform a cross-correlation calculation (I recommend using Excel) on the two images to determine the most likely displacement using the relation:

$$C(r,s) = \sum_{i=0}^{D_I-1} \sum_{j=0}^{D_I-1} IA_1(i,j) IA_2(i+r, j+s),$$

$$r,s = -D_I/2, \ldots, D_I/2 - 1.$$

Assume the values in all other regions of the sensor are zero.

Test your calculation using contrived sensor output that you feel you know the answer for. Describe your test.

Based on what you learn:

- How do you interpret $C(r,s)$? In other words, does a positive value of r mean the particles are moving to the left or the right? Does a positive value of s mean up or down?
- What direction and how far do you estimate the displacement to be without subpixel estimation (i.e. to the nearest pixel)?
- If D_I is 6, as in this case, how big must IA_1 and IA_2 be?

Email me your "code." [40]