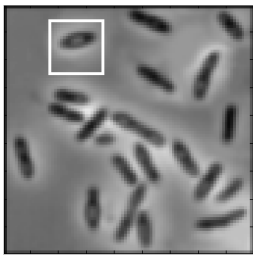
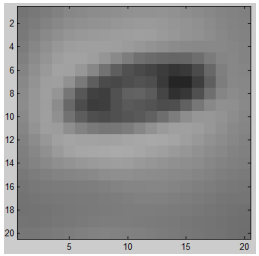
Sample – Question 5 2024 - 2025

Part A [15 Marks]

You have been tasked with writing a program to analyze images of bacteria taken by a microscope. A sample image shown on the right, along with a small blown up portion from the top left of the original image:





is

The actual gray-level values in the small 20x20 portion of the image are given below:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	117	121	125	130	136	139	141	142	144	146	147	147	148	146	143	140	137	133	131	129
2	120	125	131	137	142	145	147	148	151	153	155	155	153	150	148	145	140	135	132	130
3	122	130	138	144	150	153	155	156	158	159	160	159	155	152	148	146	142	137	133	131
4	125	135	144	152	158	160	160	160	159	156	152	148	144	140	138	137	137	137	135	132
5	129	140	149	158	164	163	159	150	139	126	114	108	104	102	103	111	124	134	136	132
6	133	144	154	163	162	152	136	115	95	82	75	69	61	54	58	76	105	128	136	134
7	137	148	159	160	146	122	95	76	73	79	83	79	59	38	39	62	96	126	137	136
8	140	151	160	150	119	89	66	64	82	98	100	92	70	49	56	81	112	134	140	137
9	141	152	159	141	105	77	61	63	81	91	88	84	78	80	98	120	137	145	144	138
10	139	152	160	145	115	94	80	76	81	86	90	98	111	126	142	151	152	148	140	135
11	135	148	159	157	143	131	123	119	120	125	135	146	155	160	161	158	152	145	139	134
12	131	141	152	161	165	164	163	162	164	166	168	169	168	165	159	153	146	141	136	131
13	128	136	145	155	163	167	168	169	171	170	167	163	160	155	151	146	141	137	132	129
14	126	132	138	144	148	152	155	157	159	158	154	151	148	145	143	141	136	132	129	127
15	121	125	129	132	134	136	139	142	144	144	142	141	140	139	137	134	131	127	125	123
16	118	121	123	124	125	126	127	129	132	134	134	135	135	133	131	128	126	123	121	120
17	116	118	120	121	122	123	123	125	126	128	130	130	130	128	126	124	122	119	118	118
18	115	116	117	119	121	122	123	124	125	126	126	126	125	124	123	121	119	117	115	114
19	117	116	118	120	121	123	125	126	126	126	125	124	123	122	120	118	117	115	113	112
20	120	120	122	124	126	129	131	132	131	130	129	127	125	123	121	119	117	116	113	111

Parallel to vertical axis

Parallel to horizontal axis

In the questions below, you may assume that the simple finite derivative masks discussed in class (i.e. of type [-1 1]) are used to compute the gradient direction, and the convention of the axes is the same as that preferred in class.

a. [5 Marks] On the grid of numbers shown above, mark a location where the gradient direction is exactly parallel to the horizontal axis, and another location where the gradient direction is exactly parallel to the vertical axis.

b. [5 Marks] Using the convention of axes used in class, compute gradient magnitude and direction at pixel location (8, 16) and (18, 9). [*If you do not have a calculator, you can just plug the values in the appropriate formula*].

At (8,16), $f_x = 81 - 62 = 19$ $f_y = 81 - 56 = 25$

$\text{magnitude} = (19^2 + 25^2)^{0.5} = 31.4$

$\text{direction} = \text{atan}(25/19) = 52.76°$

At (18,9), $f_x = 125 - 126 = -1$ $f_y = 125 - 124 = +1$

$\text{magnitude} = (-1^2 + 1^2)^{0.5} = 1.41$

$\text{direction} = \text{atan}(1/-1) = -45°$

c. [5 Marks] Your friend argues that the gradient direction value computed at one of the pixels above is more 'reliable' than the other. Do you agree or disagree? Explain your position.

At (8,16), the difference between neighboring pixels is large, so the direction is reliably established. However, at (18,9), the difference between neighboring pixels is only 1 and likely a result of noise. The gradient direction will not be reliable here.

Part B [10 Marks]Write the Algorithm for HOG Feature/Descriptor Detection. (See the Lecture Slides)