

## Problem 5: SVM (18 Points)

### Part A (2 Points)

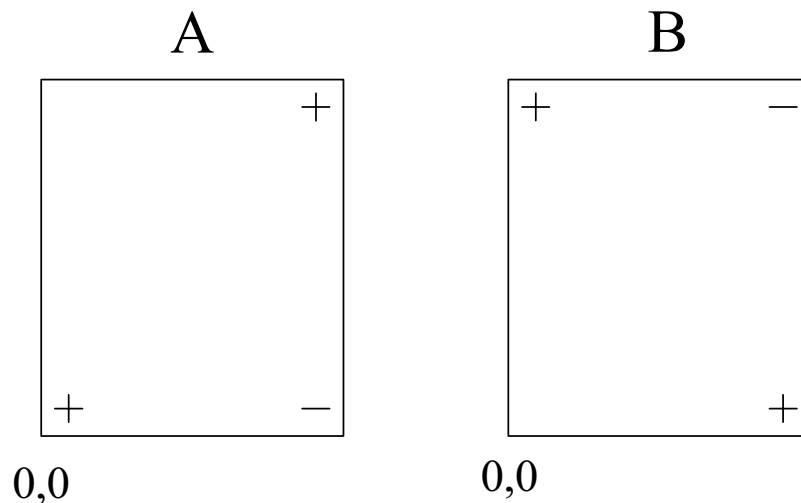
Consider the two arrangements of + and - points in drawings A and B, in which the arrangement in B is produced by rotating the arrangement in A around the center. Then select true or false for the following assertions:

Given a radial-basis kernel,  $\kappa(v_1, v_2) = e^{-\frac{\|v_1 - v_2\|^2}{0.5}}$ , the boundary separating the + and - points in B can be aligned with the boundary in A by a combination of translation and rotation.

- **True** Vectors do not reference origin, so situations same under rotation and translation.
- **False**

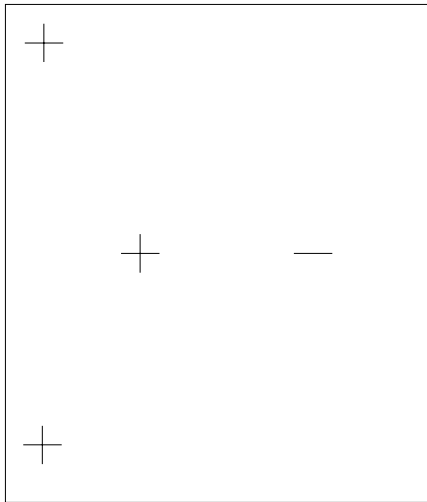
Given a polynomial kernel,  $\kappa(v_1, v_2) = (v_1 \cdot v_2)^2$ , where the vectors are drawn from the origin, the boundary separating the + and - points in B can be aligned with the boundary in A by a combination of translation and rotation..

- **True**
- **False** Vectors are from origin, so situations are not rotationally symmetric.

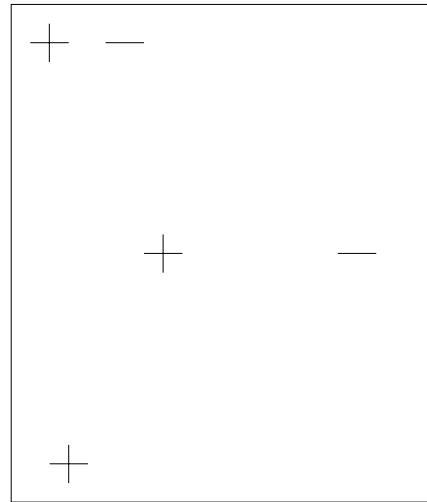


**Part B (4 Points)**

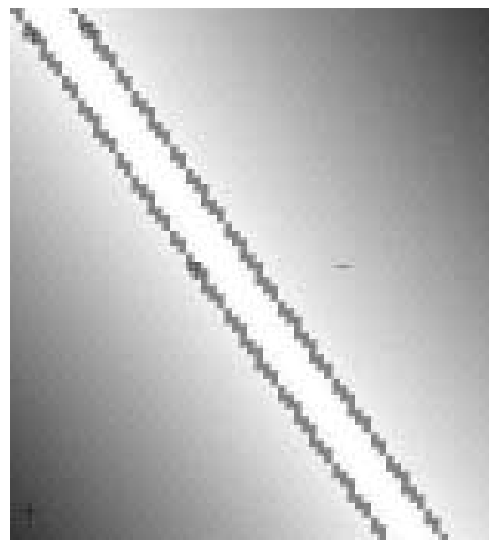
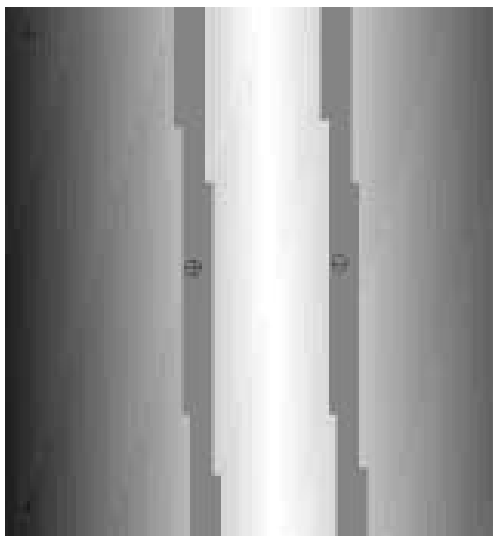
Assume that a support vector machine is to learn to separate the + and - points in the following diagrams. Sketch the -1 or +1 lines (gutters of the widest street) and circle the points corresponding to support vectors assuming a polynomial kernel,  $\kappa(v_1, v_2) = (v_1 \cdot v_2)^1$



0,0



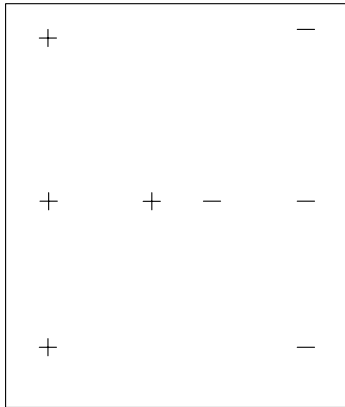
0,0



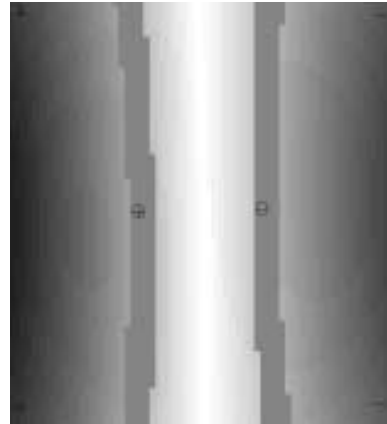
**Part C.1(2 Points)**

Assume that a support vector machine is to learn to separate the + and - points in the following diagram. Sketch the decision boundary (the 0 line, not the -1 or +1 lines) and circle the points corresponding to support vectors assuming a radial basis kernel,

$\kappa(v_1, v_2) = e^{-\frac{\|v_1 - v_2\|^2}{2\sigma^2}}$ , and a very large sigma.



0,0

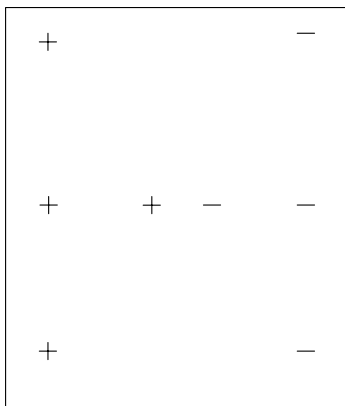


Two are support vectors

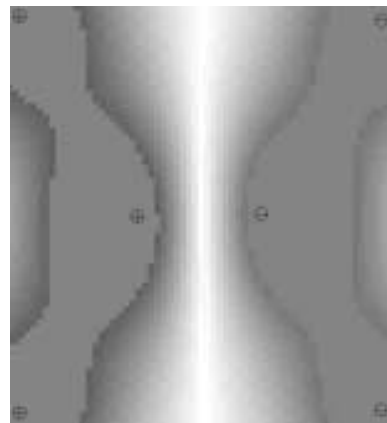
**Part C.2(2 Points)**

Assume that a support vector machine is to learn to separate the + and - points in the following diagram. Sketch the decision boundary (the 0 line, not the -1 or +1 lines) and circle the points corresponding to support vectors assuming a radial basis kernel,

$\kappa(v_1, v_2) = e^{-\frac{\|v_1 - v_2\|^2}{2\sigma^2}}$ , and a very small sigma.



0,0



All are support vectors

### Part D (8 Points)

On the separate sheet, there are nine colored diagrams, labeled A through I, representing graphs of SVMs trained to separate pluses (+) from minuses (-). Indicate which diagram results from using which kernel function by writing the letter of the diagram next to the corresponding kernel.

**Note that the points are the same in diagrams A, B, C, and D. They are also the same in E, F, and G.**

$\kappa(v_1, v_2) = (v_1 \cdot v_2)^1$	A, E, H	$\kappa(v_1, v_2) = e^{\frac{-\ v_1 - v_2\ ^2}{0.5}}$	C, G
$\kappa(v_1, v_2) = (v_1 \cdot v_2)^2$	B	$\kappa(v_1, v_2) = e^{\frac{-\ v_1 - v_2\ ^2}{0.22}}$	D, F
$\kappa(v_1, v_2) = (v_1 \cdot v_1)^2$	Nonsense	$\kappa(v_1, v_2) = e^{\frac{-\ v_1 - v_2\ ^2}{0.08}}$	I