3. Decision Boundaries

In this problem, we will investigate the decision boundary of different classifiers.

3. (a)

2/2 points (graded)

Consider the function defined over three binary variables: $f(x_1, x_2, x_3) = (\neg x_1 \wedge \neg x_2 \wedge \neg x_3)$.

We aim to find a θ such that, for any $x = [x_1, x_2, x_3]$, where $x_i \in \{0, 1\}$:

$$\theta \cdot x + \theta_0 > 0 \text{ when } f(x_1, x_2, x_3) = 1, \text{ and}$$

$$\theta \cdot x + \theta_0 < 0 \text{ when } f(x_1, x_2, x_3) = 0.$$

If $\theta_0 = 0$ (no offset), would it be possible to learn such a θ?

- Yes
- No ✔

Would it be possible to learn the pair θ and θ_0?

- Yes ✔
- No

Solution:

- Since $\theta \cdot 0 = 0$, it is impossible to obtain $\theta \cdot x + \theta_0 > 0$ for $f(0,0,0) = 1$.
- $\theta_1 = \theta_2 = \theta_3 = -1$ and $\theta_0 = 0.5$ is a valid solution.

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Answers are displayed within the problem

3. (b-1)

1/1 point (graded)

You are given the following labeled data points:

- Positive examples: $[-1, 1]$ and $[1, -1]$,
- Negative examples: $[1, 1]$ and $[2, 2]$.

For each of the following parameterized families of classifiers, identify which parameterized family has a family member that can correctly classify the above data and find the corresponding parameters of a family member that can correctly classify the above data.

Note: If there is no family member inside the parameterized family that can correctly classify the above data, just enter 0 for all the parameters.

Inside (positive) or outside (negative) of an origin-centered circle with radius r. Enter a scalar for r. If there is no such r, just enter 0.

0 ✔ **Answer:** 0

Solution:

- Any circle that correctly classifies $[-1,1]$ and $[1,-1]$ would incorrectly classify $[1,1]$

Submit You have used 1 of 3 attempts

ℹ Answers are displayed within the problem

3. (b-2)

2/2 points (graded)
Inside (positive) or outside (negative) of an $[x,y]$-centered circle with radius r.

$[x,y]$: [-1,-1] ✔ **Answer:** See solution

r: 2.1 ✔ **Answer:** See solution

Solution:

- A valid solution is $[x,y]=[-1,-1]$, $r=2.1$

Submit You have used 1 of 3 attempts

ℹ Answers are displayed within the problem

3. (b-3)

1.0/1 point (graded)
Strictly above (positive) or below (negative) a line through the origin with normal θ. Here we define "above" as $\theta \cdot x > 0$, and define "below" similarly. **Note:** Please enter a list for θ as $[\theta_1, \theta_2]$. If there is no solution, enter $[0,0]$

[0,0] ✔ **Answer:** [0, 0]

Solution:

- There is no line through the origin that can simultaneously be strictly below $[1,-1]$ and $[-1,1]$

Submit You have used 1 of 3 attempts

ℹ Answers are displayed within the problem

3. (b-4)

2/2 points (graded)
Strictly above (positive) or below (negative) a line with normal θ and offset θ_0. Here we define "above" as $\theta \cdot x + \theta_0 > 0$, and define "below" similarly. **Note:** If there is no solution, enter $\theta = [0,0]$ and $\theta_0 = 0$.

$[\theta_1, \theta_2]$: [-1,-1] ✔ **Answer:** See solution

θ_0: 0.1 ✔ **Answer:** See solution

Solution:

- A valid solution is $[\theta_1, \theta_2, \theta_0] = [-1, -1, 0.5]$

Submit You have used 2 of 3 attempts

Answers are displayed within the problem

3. (b-5)

1/1 point (graded)
Which of the below are families of linear classifiers?

(Choose all that apply.)

- [ ] Inside or outside of an origin-centered circle with radius r.
- [ ] Inside or outside of an $[x, y]$-centered circle with radius r.
- [x] Strictly above or below a line through the origin with normal θ. ✔
- [x] Strictly above or below a line with normal θ and offset θ_0. ✔

✔

Solution:

- The first two families are nonlinear (circles), and the last two families are linear classifiers (lines).

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Answers are displayed within the problem

Discussion

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Topic: Unit 1 Linear Classifiers and Generalizations (2 weeks):Homework 1 / 3. Decision Boundaries