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Chapter 1

The Probably Approximately Correct Learning Model

1.1 A Rectangle Learning Game

The objective of this game is to learn an unknown *target* (axis-aligned) rectangle $\mathcal{R} = [a, b] \times [c, d] \subset \mathbb{R}^2$.

The player can gain information about \mathcal{R} only by choosing random points according to some distribution \mathcal{D} , and asking the game whether they are inside \mathcal{R} . By convention, points inside \mathcal{R} are considered positive.

Figure 1.1 shows an example of a possible target rectangle \mathcal{R} along with some points labeled using it.

The player's goal is to find a hypothesis rectangle \mathcal{R}' that “approximates” \mathcal{R} “as closely as possible”. To measure the quality of this approximation, we will consider the region $\mathcal{R} \Delta \mathcal{R}'$ of points that \mathcal{R} and \mathcal{R}' label differently. More precisely, we will consider the probability $\mathbb{P}(\mathcal{R} \Delta \mathcal{R}')$ of falling with this region according to \mathcal{D} and try to minimize this quantity.

Since \mathcal{R} is unknown in practice, \mathcal{R}' is evaluated by sampling a number of points from \mathcal{D} , labeling them using \mathcal{R}^{prime} and comparing to their true labels by asking the game. We then take the number of falsely labeled points divided by the total of chosen points as an estimation of $\mathbb{P}(\mathcal{R} \Delta \mathcal{R}')$. Note that this score is the same as $1 - \text{accuracy}$.

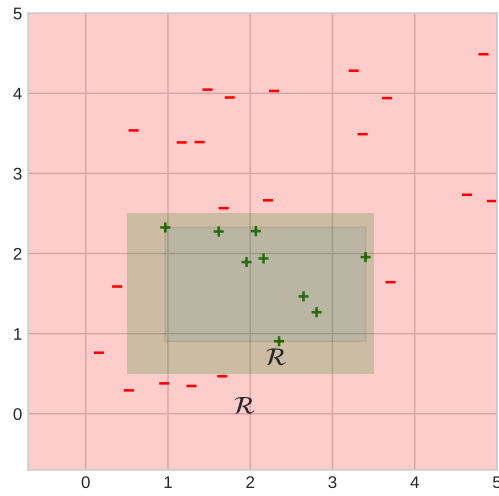


Figure 1.1: The target rectangle \mathcal{R} along with a labeled sample of points

A simple strategy for the player is to sample a sufficiently large number m of points from \mathcal{D} and request their labels, then chose as hypothesis \mathcal{R}' the smallest rectangle containing all positive examples and no negative ones¹. If all m points are negative, we chose $\mathcal{R}' = \emptyset$. Figure 1.2 illustrates this for one example.

¹Note that such at least one rectangle with this property is garenteed to exist, because \mathcal{R} is one such a rectangle

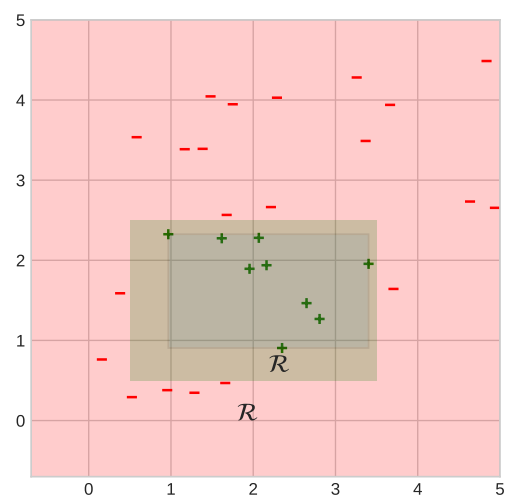


Figure 1.2: The tightest fit rectangle defined by the sample