

03. Problem Visualization

Neural Networks - From Brain to Business

Learning Goal

Visualize why complex market data cannot be separated by simple linear rules.

Key Concept (1/2)

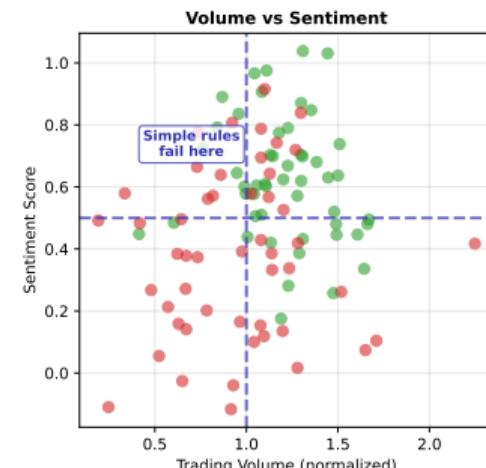
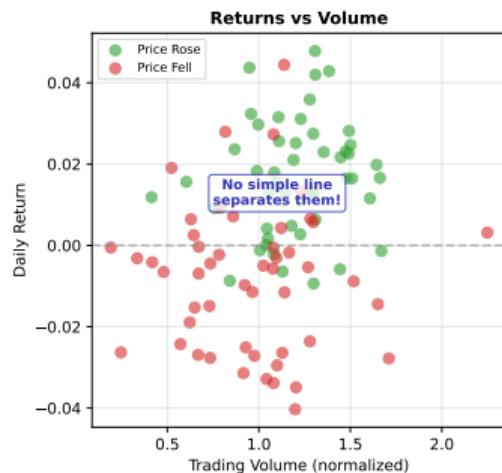
When we plot market features against each other (returns vs volume, sentiment vs volatility), we often see **overlapping clusters** rather than clean separations. Days when the market went up (one class) are scattered throughout the same regions as days when it went down (other class).

Key Concept (2/2)

This overlap explains why simple rules fail. "Buy when volume is high" doesn't work because high volume days include both winners and losers. The relationship between features and outcomes is **non-linear** - success depends on complex combinations of factors, not single thresholds.

Neural networks excel at finding these complex, non-linear patterns. They can learn decision boundaries that curve through the data, separating classes that no straight line could divide.

Visualization



Linear decision boundary attempt:

$$w_1 \cdot \text{returns} + w_2 \cdot \text{volume} + b = 0$$

This defines a straight line in feature space, but for overlapping data, no such line achieves good separation.

Classification error:

$$\text{Error} = \frac{\text{Misclassified Points}}{\text{Total Points}}$$

Imagine sorting marbles by color when red and blue marbles are thoroughly mixed together in a pile. You can't draw a single straight line through the pile to separate them - wherever you draw the line, some marbles of each color end up on the wrong side.

Market data is similar: "up" days and "down" days are interspersed throughout feature space. Simple rules (like "buy when sentiment is positive") misclassify many examples because the relationship is more complex.

Practice Problem 1

Problem 1

You plot 100 trading days: 50 "up" days and 50 "down" days. When Volume ≥ 0.6 , you find 30 up days and 25 down days. Is "Volume ≥ 0.6 predicts up" a good rule?

Solution

Above threshold (Volume ≥ 0.6): - Up days: 30 - Down days: 25 - Total: 55

Accuracy of "predict UP when Volume ≥ 0.6 ":

$$\text{Accuracy} = \frac{30}{55} = 54.5\%$$

Below threshold (Volume < 0.6): - Up days: 50 - 30 = 20 - Down days: 50 - 25 = 25 - Total: 45

If we predict DOWN below threshold:

$$\text{Accuracy} = \frac{25}{45} = 55.6\%$$

Overall accuracy: $(30 + 25) / 100 = 55\%$

This is only slightly better than chance (50%). The rule captures some signal but leaves much unexplained. **Not a good rule** - the overlap is too significant.

Practice Problem 2

Problem 2

Why might the combination of volume AND sentiment predict better than either alone?

Solution

Interaction effects between features can be more predictive than individual features:

1. **High volume + positive sentiment:** Strong buying pressure, likely UP
2. **High volume + negative sentiment:** Strong selling pressure, likely DOWN
3. **Low volume + positive sentiment:** Weak signal, uncertain
4. **Low volume + negative sentiment:** Weak signal, uncertain

Neither feature alone captures this pattern: - High volume alone? Could be buying OR selling - Positive sentiment alone? Could be acted upon OR ignored

The **combination** reveals the true signal. This is exactly what neural networks learn - complex interactions between features that simple rules miss.

Key Takeaways

- Market data often shows overlapping classes in feature space
- Simple linear rules fail when data is non-linearly separable
- Plotting features reveals the complexity of the classification problem
- Neural networks can learn non-linear boundaries through overlapping regions
- Complete overlap = unpredictable; partial overlap = opportunity for learning