Probability calibration : why it matters ?

Jaideep Ray · Follow

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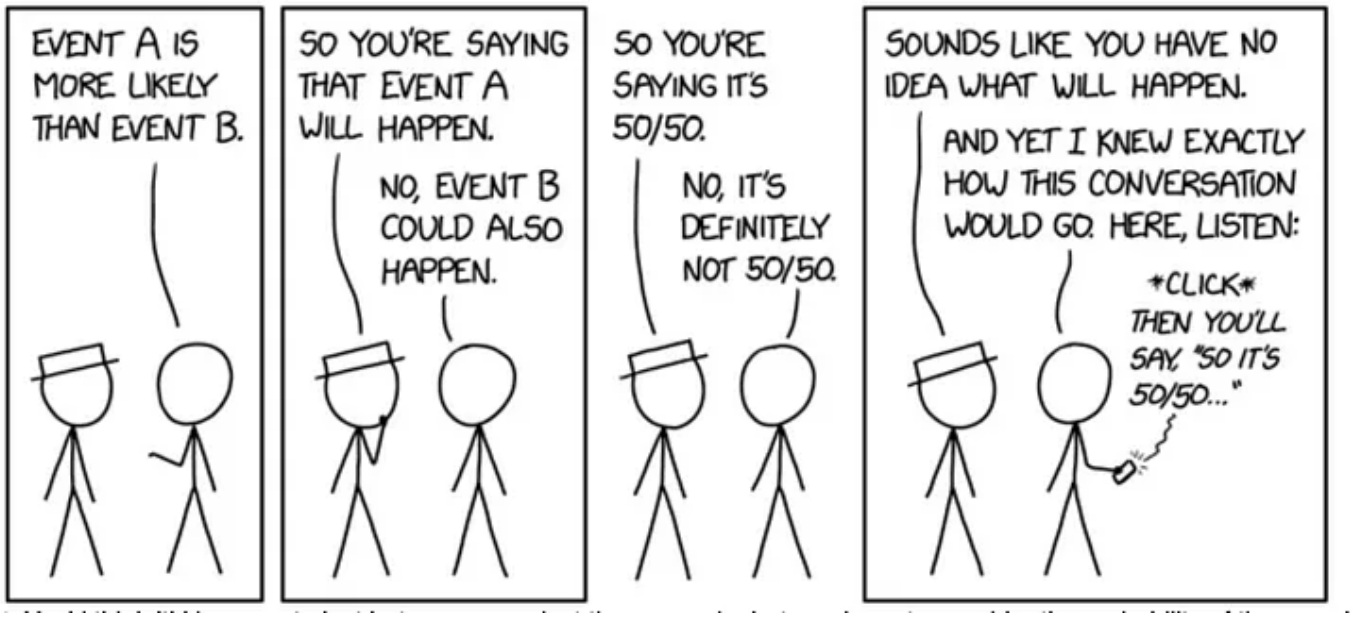
Why returning probability instead of prediction from your classification model is a good idea ?



https://www.explainxkcd.com/wiki/index.php/2370:_Prediction

1. **It is easier to reason around probabilities.**

A typical exercise in evaluating classifiers is going through a sample of false positives and false negatives and understanding classifier characteristics. Probabilities are easier to reason than values. As you keep on iterating on the classifier, this is a major win.

2. Picking thresholds

In typical binary classification scenario we often use classifier outputs with thresholds,
if pred > threshold, the predicted class is X else Y

If predictions are not probabilities, you have to reason through threshold values every time you update classifier.

3. Updating models in multi stage ranking.

In production we often see chain or cascade of classifiers (model outputs are used as input for other models) working together.

Even though this is not a great practice, this pattern finds its way into many important products. We discuss this multi-stage-ranking. It is important that each stage in multi stage ranking is emitting probabilities and not just predictions.

Let's say we have a 2 stage system, classifier A feeds to classifier B. Every iteration on classifier A changes its output distribution somewhat. If the outputs are not calibrated then it is hard to estimate the impact on classifier B and every iteration on A would require proper A/B experimentation with entire system retraining.

OTOH, with calibrated probabilities we can estimate the impact and retrain if the distributions change too much.

4. How to check if your classifier outputs are calibrated ?

Calibration plots

On the y axis plot fraction of positives (true label) and on the x axis plot bins that group examples by predicted score.

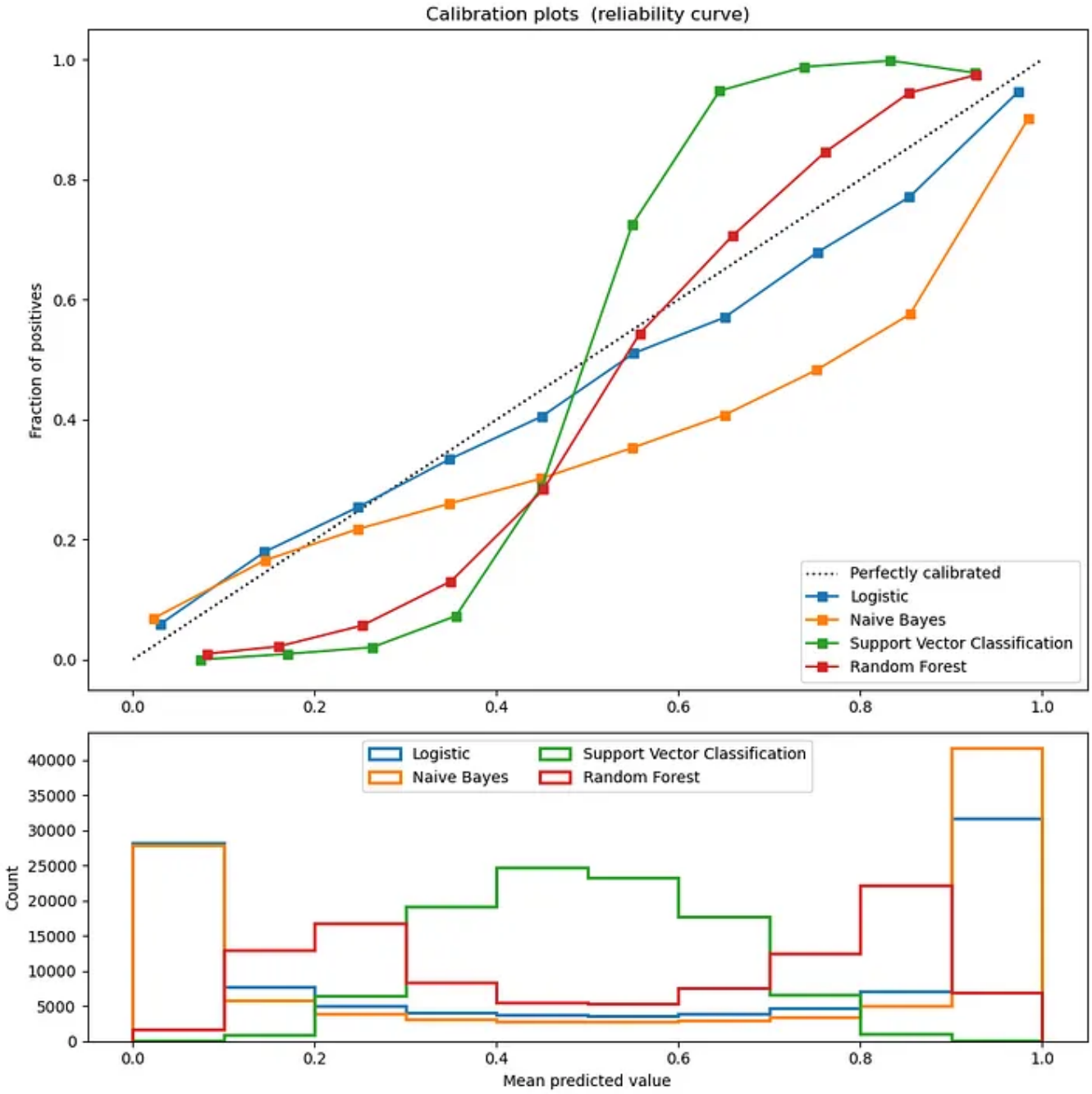
So, the y axis point for the interval [0.0–0.2] signifies :

n = number of examples for which prediction falls in [0.0–0.2] range.

n_p = number of examples for which true label is 1.

y_axis value = n_p / n

The diagonal represents perfectly calibrated scores. In this diagram, Logistic regression is better calibrated than other classifiers such as Random Forest.



Source : comparison of calibration curves

See point (6) for metrics for calibration.

5. How to calibrate your classifier ?

- **Collect calibration dataset.** This should be a held out dataset matching production traffic. Split this is calibration_train & calibration_test.
- Use platt scaling or isotonic regression to train a calibration your classifier score.
- Make sure inference stack can stitch the calibrated model appropriately.

Before calibration :

y = model(input)

6. Metrics for calibration:

Brier score loss : The Brier score measures the mean squared difference between the predicted probability and the actual outcome. The Brier score always takes on a value between zero and one, since this is the largest possible difference between a predicted probability (which must be between zero and one) and the actual outcome (which can take on values of only 0 and 1). The lower, the better.

Recap :

- Output well calibrated probabilities from classifier wherever possible.

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Written by Jaideep Ray

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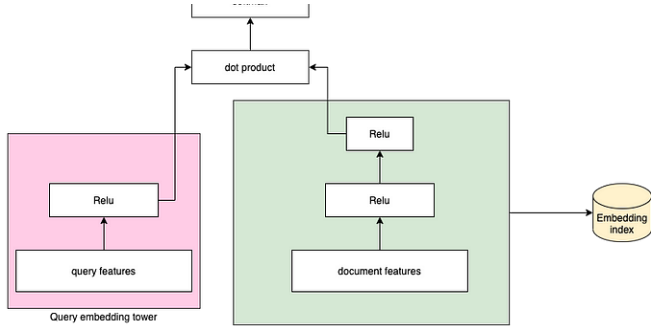

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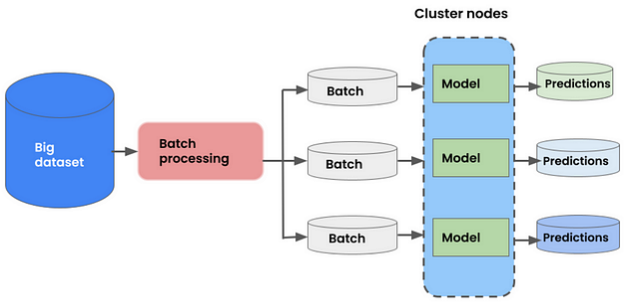

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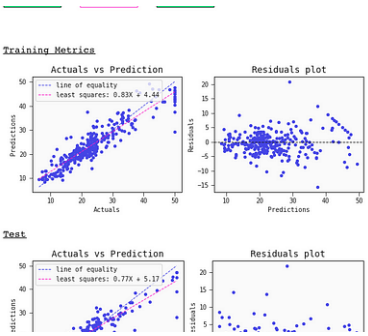

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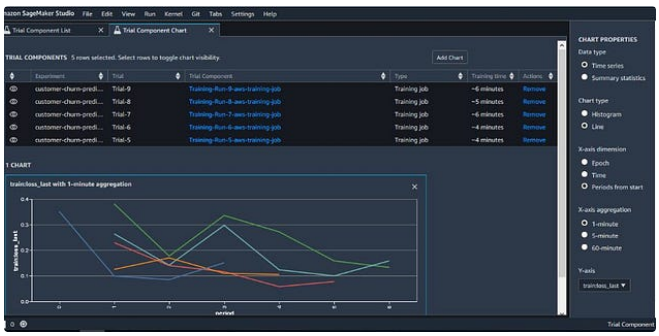

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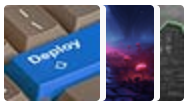

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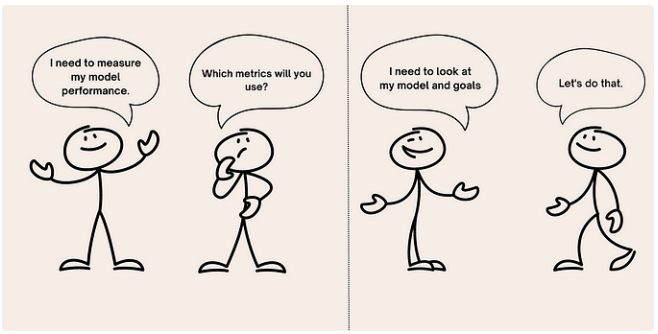

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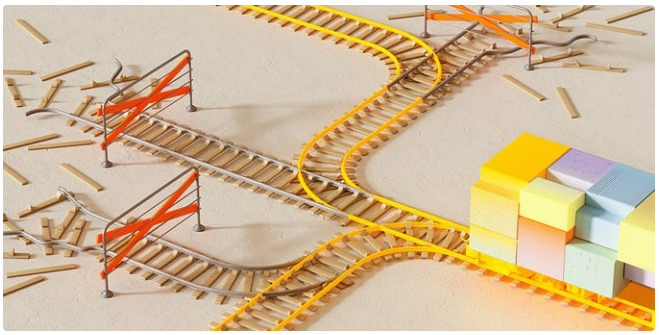

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