Confusion matrix

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In the field of machine learning, a **confusion matrix**, also known as a contingency table or an error matrix [1] , is a specific table layout that allows visualization of the performance of an algorithm, typically a supervised learning one (in unsupervised learning it is usually called a **matching matrix**). Each column of the matrix represents the instances in a predicted class, while each row represents the instances in an actual class. The name stems from the fact that it makes it easy to see if the system is confusing two classes (i.e. commonly mislabeling one as another).

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Example

If a classification system has been trained to distinguish between cats, dogs and rabbits, a confusion matrix will summarize the results of testing the algorithm for further inspection. Assuming a sample of 27 animals — 8 cats, 6 dogs, and 13 rabbits, the resulting confusion matrix could look like the table below:

		Predicted class		
		Cat	**Dog**	**Rabbit**
Actual class	**Cat**	5	3	0
	Dog	2	3	1
	Rabbit	0	2	11

In this confusion matrix, of the 8 actual cats, the system predicted that three were dogs, and of the six dogs, it predicted that one was a rabbit and two were cats. We can see from the matrix that the system in question has trouble distinguishing between cats and dogs, but can make the distinction between rabbits and other types of animals pretty well. All correct guesses are located in the diagonal of the table, so it's easy to visually inspect the table for errors, as they will be represented by any non-zero values outside the diagonal.

Table of confusion

In predictive analytics, a **table of confusion** (sometimes also called a **confusion matrix**), is a table with two rows and two columns that reports the number of *false positives*, *false negatives*, *true positives*, and *true negatives*. This allows more detailed analysis than mere proportion of correct guesses (accuracy). Accuracy is not a reliable metric for the real performance of a classifier, because it will yield misleading results if the data set is unbalanced (that is, when the number of samples in different classes vary greatly). For example, if there were 95 cats and only 5 dogs in the data set, the classifier could easily be biased into classifying all the samples as cats. The overall accuracy would be 95%, but in practice the classifier would have a 100% recognition rate for the cat class but a 0% recognition rate for the dog class.

Assuming the confusion matrix above, its corresponding table of confusion, for the cat class, would be:

5 true positives (actual cats that were correctly classified as cats)	3 false negatives (cats that were incorrectly marked as dogs)
2 false positives (dogs that were incorrectly labeled as cats)	17 true negatives (all the remaining animals, correctly classified as non-cats)

The final table of confusion would contain the average values for all classes combined.

The following Python code will convert a confusion matrix into a confusion table of true/false positives/negatives.

```
def confusion_table(cfm, label):
    """Returns a confusion table in the following format:
    [[true positives, false negatives],
     [false positives, true negatives]]
    for the given label index in the confusion matrix.
    """
    predicted = cfm[label]
    actual    = [cfm[i][label] for i in range(len(cfm))]
    true_pos  = predicted[label]
    false_pos = sum(actual) - true_pos
    false_neg = sum(predicted) - true_pos
    total     = sum([sum(i) for i in cfm])
    true_neg  = total - true_pos - false_pos - false_neg

    return [[true_pos, false_neg],
            [false_pos, true_neg]]

>>> cfm = [[5, 3, 0], [2, 3, 1], [0, 2, 11]]
>>> confusion_table(cfm, 0) # Cat class
[[5, 3], [2, 17]]
```

See also

- Binary classification
- Sensitivity and specificity
- Signal detection theory
- Type I and type II errors

References

1. ^ Stehman, Stephen V. (1997). "Selecting and interpreting measures of thematic classification accuracy". *Remote Sensing of Environment* **62** (1): 77–89. doi:10.1016/S0034-4257(97)00083-7 (http://dx.doi.org/10.1016%2FS0034-4257%2897%2900083-7).

External links

- Theory about the confusion matrix (http://www2.cs.uregina.ca/~dbd/cs831/notes/confusion_matrix/confusion_matrix.html)
- GM-RKB Confusion Matrix concept page (http://www.gabormelli.com/RKB/Confusion_Matrix)