

Sensitivity, Specificity, and Positive Predictive Value



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Examples from your paper readings (1/2)

Table 1. System Performance Validation Results of Snoring Detection

| GROUP | PATIENT | TOTAL SNORES | TP | FN | FP | SENSITIVITY | PPV |
|-----------------|----------|--------------|--------|-----|-----|-------------|-------|
| Regular snorers | Snorer A | 547 | 456 | 91 | 73 | 83.4% | 86.2% |
| | Snorer B | 1,281 | 778 | 118 | 24 | 86.8% | 97.0% |
| | Snorer C | 17 | 15 | 2 | 3 | 88.2% | 83.3% |
| | Snorer D | 2,546 | 2,522 | 124 | 46 | 95.3% | 98.2% |
| | Snorer E | 881 | 859 | 22 | 2 | 97.5% | 99.8% |
| OSAS patients | OSAS A | 1,849 | 1,545 | 304 | 284 | 83.6% | 84.5% |
| | OSAS B | 475 | 466 | 9 | 70 | 98.1% | 86.9% |
| | OSAS C | 731 | 725 | 6 | 47 | 99.2% | 93.9% |
| | OSAS D | 2,331 | 2,326 | 5 | 5 | 99.8% | 99.8% |
| | OSAS E | 1,965 | 1,904 | 61 | 184 | 96.9% | 91.2% |
| 10 patients | | 12,623 | 11,596 | 742 | 738 | 94.0% | 94.0% |

TP, true positive; FN, false negative; FP, false positive; PPV, positive predictive value; OSAS, obstructive sleep apnea syndrome.

Cheng, C. M., Hsu, Y. L., Young, C. M., Wu, C. H., "Development of a portable device for tele-monitoring of snoring and OSAS symptoms," *Telemedicine and e-Health*, Vol. 14, No. 1, pp. 55-68, February 2008.

Examples from your paper readings (2/2)

Table 1. Evaluation of Sensitivity and Specificity of the Algorithm in Identifying Still Postures and Dynamic Movements

| POSTURE/ACTIVITY | SENSITIVITY (%) | SPECIFICITY (%) |
|------------------|-----------------|-----------------|
| Sit-to-stand | 92.2 | 91.5 |
| Stand-to-sit | 95.6 | 88.5 |
| Sit-to-lie | 92.2 | 99.5 |
| Lie-to-sit | 95.6 | 88.0 |
| Walking | 98.9 | 99.5 |

- ✓ Table 1 shows the sensitivity and specificity obtained from 200 and 500 data samples, respectively.

Yang, C. C, Hsu, Y. L., “Development of a wearable motion detector for tele-monitoring and real-time identification of physical activity,” *Telemedicine and e-Health*, Vol. 15, No. 1, pp. 1035-1045, January/February 2009.

Binary Classification

- ✓ Binary classification is the task of classifying the members of a given set of objects into two groups on the basis of whether they have some property or not.
- ✓ For a test to identify “sick people” from a group of people
 - True positive (TP): Sick people correctly diagnosed as “sick”
 - False positive (FP): Healthy people incorrectly identified as “sick”
 - True negative (TN): Healthy people correctly identified as “not sick”
 - False negative (FN): Sick people incorrectly identified as “not sick”
- ✓ To evaluate the accuracy of the algorithm for snores and OSAS identification
 - TP: In all snores identified by the algorithm that are indeed snores
 - FP: In all snores identified by the algorithm that are not snores
 - TN: Not applicable in this case
 - FN: Snores that are not identified by the algorithm

Sensitivity

- ✓ Sensitivity and specificity are statistical measures of the performance of a binary classification test.
- ✓ Sensitivity measures the proportion of actual positives which are correctly identified as such.
- ✓ Sensitivity = $TP/(TP+FN)$
 - (TP+FN): total number of actual positive; total number of sick people; total number of true snores
- ✓ Sensitivity of 100% means that the test recognizes all actual positives; all sick people are correctly identified by the test; all snores are correctly identified by the algorithm.

Specificity

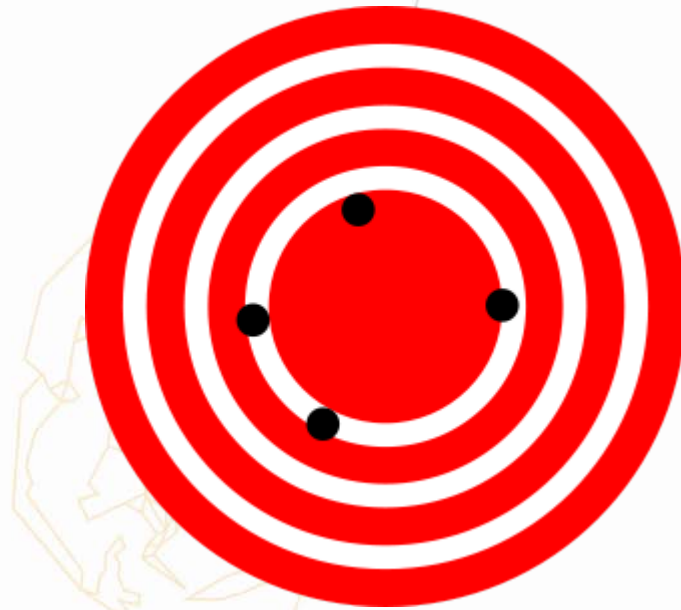
- ✓ Specificity measures the proportion of actual negatives which are correctly identified .
- ✓ Specificity = $TN/(TN+FP)$
 - (TN+FP): total number of actual negative; total number of “not sick” (healthy) people
 - Specificity: the rate of healthy people who are correctly identified as “not sick” out of the total number of healthy people
 - Specificity of “sit-to-stand” movements: the rate of movements data samples that are correctly identified as not “sit-to-stand” out of the total number of not “sit-to-stand” data sample
- ✓ Specificity of 100% means that the test recognizes all actual negatives; all healthy people are identified “not sick”, no false alarm (false positive is zero).

Positive Predictive Value (PPV)

- ✓ $PPV = TP / (TP + FP)$
 - (TP+FP): total number of positive; total number of people who are indentified “sick”; total number of snores identified by the algorithm
 - PPV is the proportion of people with positive test results who are correctly diagnosed (who are actually “sick”); the rate of true snores out of all snores identified by the algorithm
- ✓ PPV of 100% means that all positive recognized by the test are true positives; all people identified “sick” by the test are truly “sick”; all snores identified by the algorithm are true snores.
- ✓ PPV is the most important measure of a diagnostic method, as it reflects the probability that a positive test reflects the underlying condition being tested for.

Accuracy and Precision

- ✓ The accuracy of a measurement system is the degree of closeness of measurements of a quantity to its actual (true) value.
- ✓ The precision of a measurement system, also called reproducibility or repeatability, is the degree to which repeated measurements under unchanged conditions show the same results. [Wikipedia]



High accuracy, but low precision



High accuracy, but low precision

Accuracy and Precision in binary classification

- ✓ Accuracy: the proportion of true results (both true positives and true negatives) in the population.

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{FP} + \text{TN} + \text{FN})$$

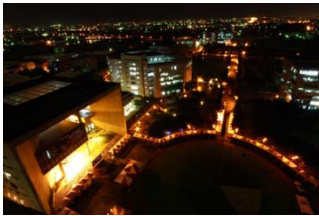
- ✓ Precision: the proportion of the true positives against all the positive results.

$$\text{Precision} = \text{TP} / (\text{TP} + \text{FP}) = \text{PPV}$$

- ✓ In binary classification, it is also possible to have high PPV (high precision) but low sensitivity (low accuracy), due to high FN.



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Thank You

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