Hellenic Complex Systems Laboratory

Uncertainty of Measurement and Diagnostic Accuracy Measures

Technical Report VII

Aristides T. Hatjimihail
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WOLFRAM Demonstrations Project

Uncertainty of Measurement and Diagnostic Accuracy Measures

Aristides T. Hatjimihail [a]

[a] Hellenic Complex Systems Laboratory

Search Terms: uncertainty of measurement, sensitivity, specificity, diagnostic test, clinical accuracy, diagnostic accuracy, permissible uncertainty, normal distribution, binormal distribution, positive predictive value, negative predictive value, likelihood ratio, odds ratio

Short Description of the Demonstration

This Demonstration compares various diagnostic accuracy measures of two diagnostic tests. The two tests measure the same measurand, for normally distributed nondiseased and diseased populations, for various values of the prevalence of the disease, of the mean and standard deviation of the populations, and of the uncertainty of measurement of the tests. A normal distribution of the uncertainty is assumed. The mean and the standard deviation of each population and the uncertainty of each test are measured in arbitrary units. The measures compared are the positive predictive value (PPV), the negative predictive value (NPV), the (diagnostic) odds ratio (OR), the likelihood ratio for a positive result (LR+), and the likelihood ratio for a negative result (LR-). The measures are calculated versus the sensitivity or the specificity of each test. That can be selected by clicking the respective button. The types of plot are: both measures (first test: blue plot, second test: orange plot), partial derivatives of both measures with respect to uncertainty (first test: blue plot, second test: orange plot), difference, and ratio of the two measures.

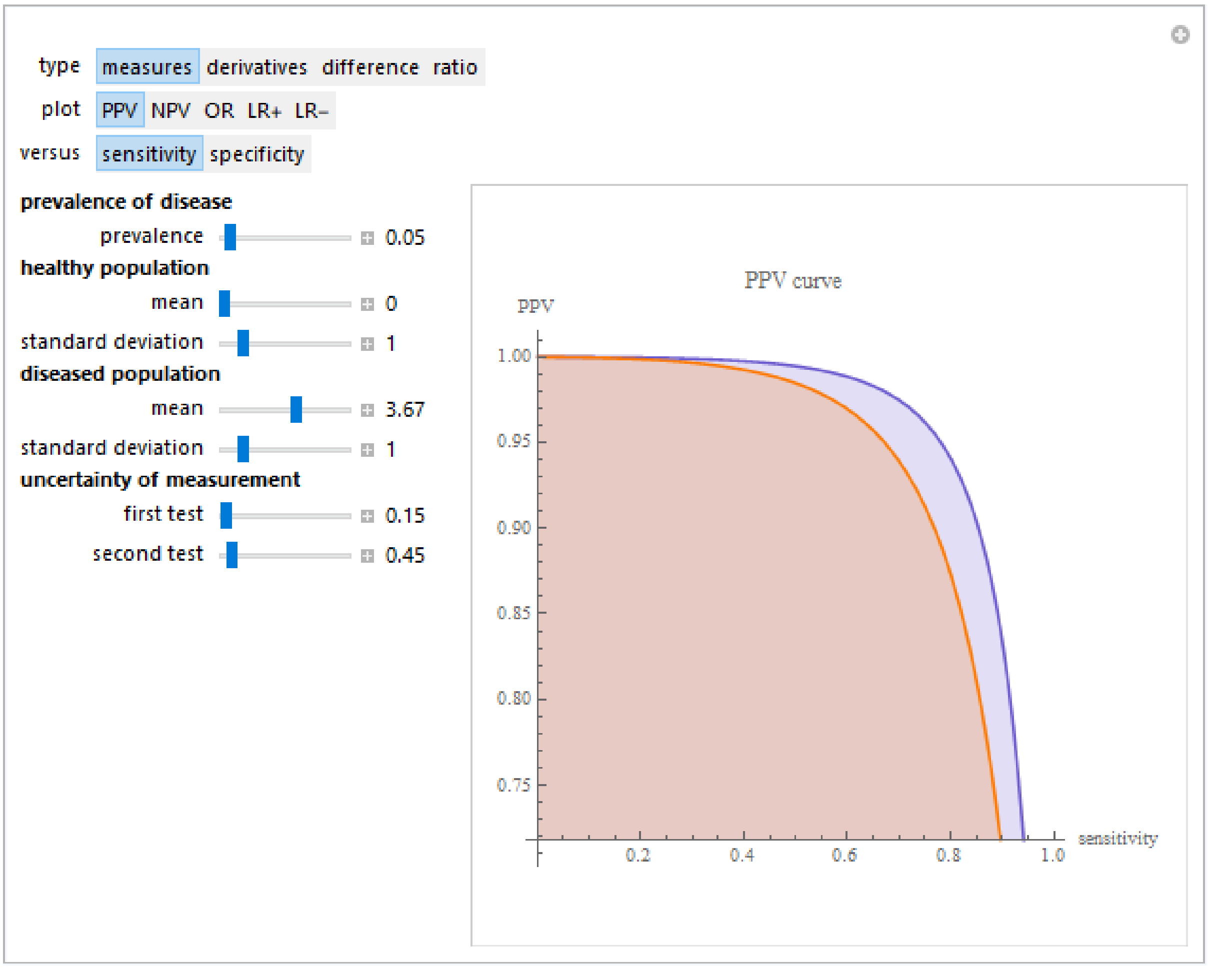

Figure 1: *Positive predictive value vs sensitivity curve plots of two diagnostic tests (first test: blue plot, second test: orange plot), with the settings shown at the left.*

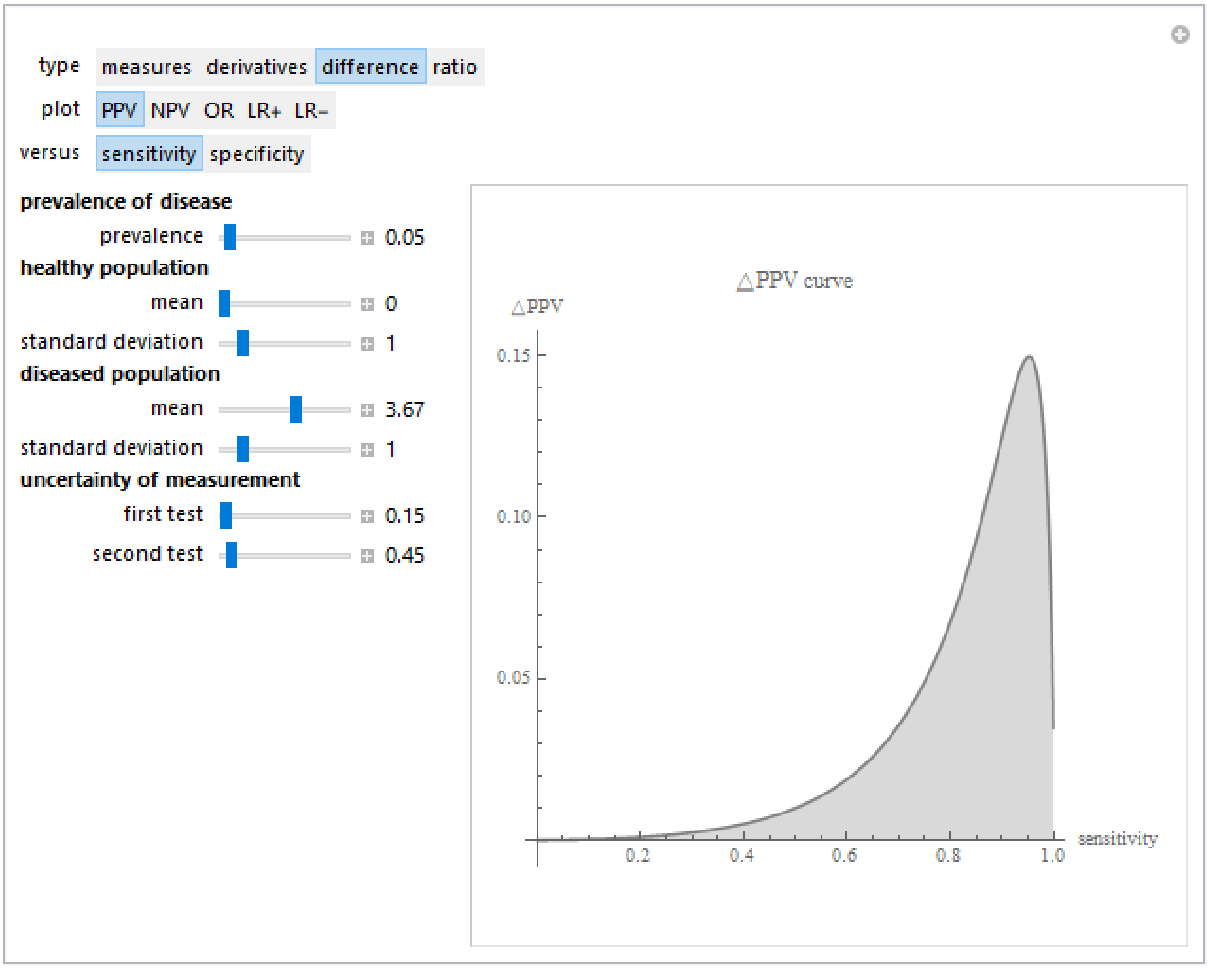

Figure 2: *Positive predictive value difference between two diagnostic tests vs sensitivity curve plot, with the settings shown at the left.*

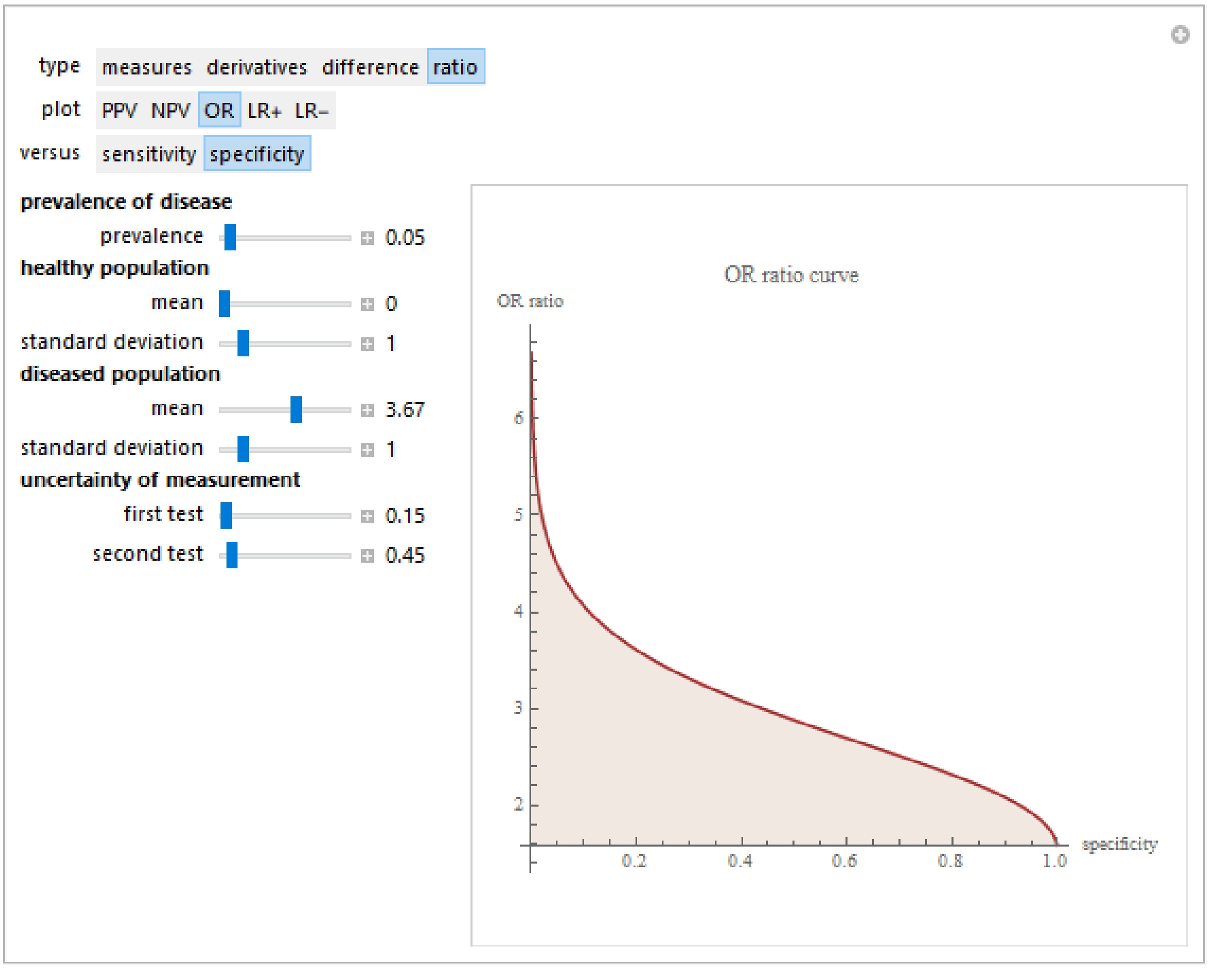

Figure 3: *Positive predictive value ratio of two diagnostic tests vs sensitivity curve plots, with the settings shown at the left.*

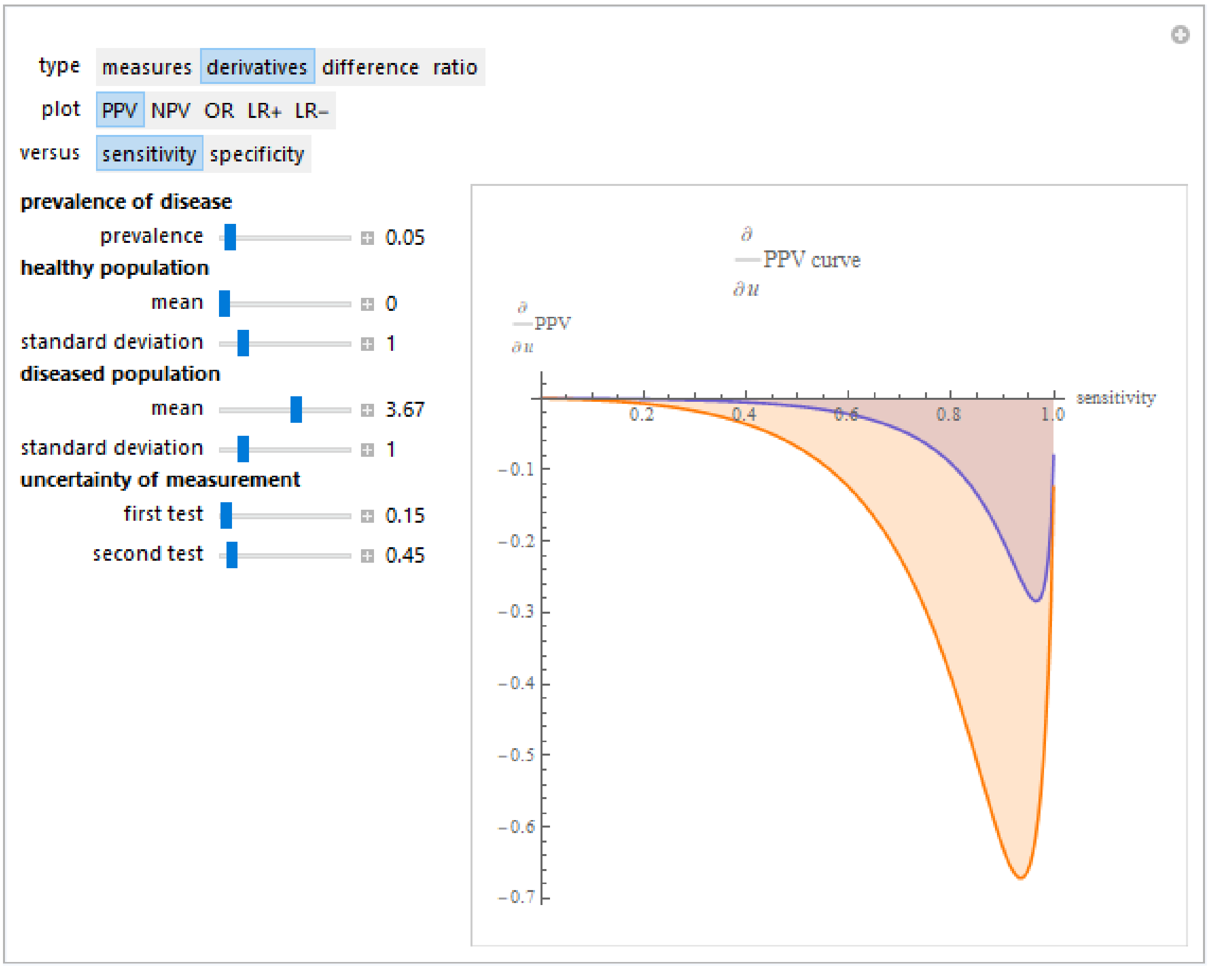

Figure 4: *Partial derivative of the positive predictive value with respect of the uncertainty of two diagnostic tests vs sensitivity curve plots tests (first test: blue plot, second test: orange plot) , with the settings shown at the left.*

Details

In addition to the receiver operating characteristic (ROC) curves, various measures are used in the evaluation of the clinical accuracy of a diagnostic test applied to a diseased or a nondiseased population. They can be calculated versus the sensitivity or the specificity of the test. Sensitivity is the fraction of the diseased population with a positive test, while specificity is the fraction of the nondiseased population with a negative test. In addition, if we denote by *sens* and *spec* the sensitivity and the specificity of the combined tests, and by *pr* the prevalence of the disease, we have:

$$PPV = \frac{sens \times pr}{spec \times pr + (1 - spec)(1 - pr)}$$

$$NPV = \frac{spec\ (1 - pr)}{spec\ (1 - pr) + (1 - sens)\ pr}$$

$$OR = \frac{\frac{sens}{1 - sens}}{\frac{1 - spec}{spec}}$$

$$LR+ = \frac{sens}{1 - spec}$$

$$LR- = \frac{1 - sens}{spec}$$

This Demonstration could be useful in evaluating the maximum medically permissible uncertainty of measurement of a diagnostic test. For example, in the thumbnail and the snapshots the populations data describes a bimodal distribution of serum glucose measurements with a nondiabetic and a diabetic population [1]. The first test has a state-of-the-art performance, while the second test has a greater uncertainty.

Reference

[1] T. O. Lim, R. Bakri, Z. Morad, and M. A. Hamid. Bimodality in Blood Glucose Distribution: Is It Universal? *Diabetes Care,* **25**(12), 2002 pp. 2212–2217.

Source Code

Programming language: Wolfram Language

Availability: The updated source code is available at:
https://www,hcsl.com/Tools/Demonstrations/UncertaintyOfMeasurementAndDiagnosticAccuracyMeasures.nb

Software Requirements

Operating systems: Microsoft Windows, Linux, Apple iOS

Other software requirements: Wolfram Player®, freely available at: https://www.wolfram.com/player/ or Wolfram Mathematica®.

System Requirements

Processor: x86-64 compatible CPU.

System memory (RAM): 4GB+ recommended.

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