Hellenic Complex Systems Laboratory

Analysis of Diagnostic Accuracy Measures for Two Combined Diagnostic Tests

Technical Report XI

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4-3-2018

WOLFRAM Demonstrations Project

Analysis of Diagnostic Accuracy Measures for Two Combined Diagnostic Tests

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Based on the Demonstration *Uncertainty of Measurement and Diagnostic Accuracy Measures* by: Aristides T. Hatjimihail

Search Terms: sensitivity, specificity, diagnostic test, clinical accuracy, diagnostic accuracy, normal distribution, bivariate normal distribution, positive predictive value, negative predictive value, likelihood ratio, odds ratio

Abstract

This Demonstration shows plots of various accuracy measures for two combined diagnostic tests applied at a single point in time on nondiseased and diseased populations. This is done for differing prevalence of the disease, taking into account the mean and standard deviations of the populations and the respective correlation coefficients. The mean and standard deviations are expressed in arbitrary units. You can select the following measures of the combined tests using the "plot" popup menu:

• "CSens": sensitivity

• "CSpec": specificity

• "PPV": positive predictive value

• "NPV": negative predictive value

• "OR": (diagnostic) odds ratio

• "LR+": likelihood ratio for a positive result

• "LR-": likelihood ratio for a negative result

These measures are plotted against the sensitivities or the specificities of each single test. You can select them by clicking the respective "versus" button.

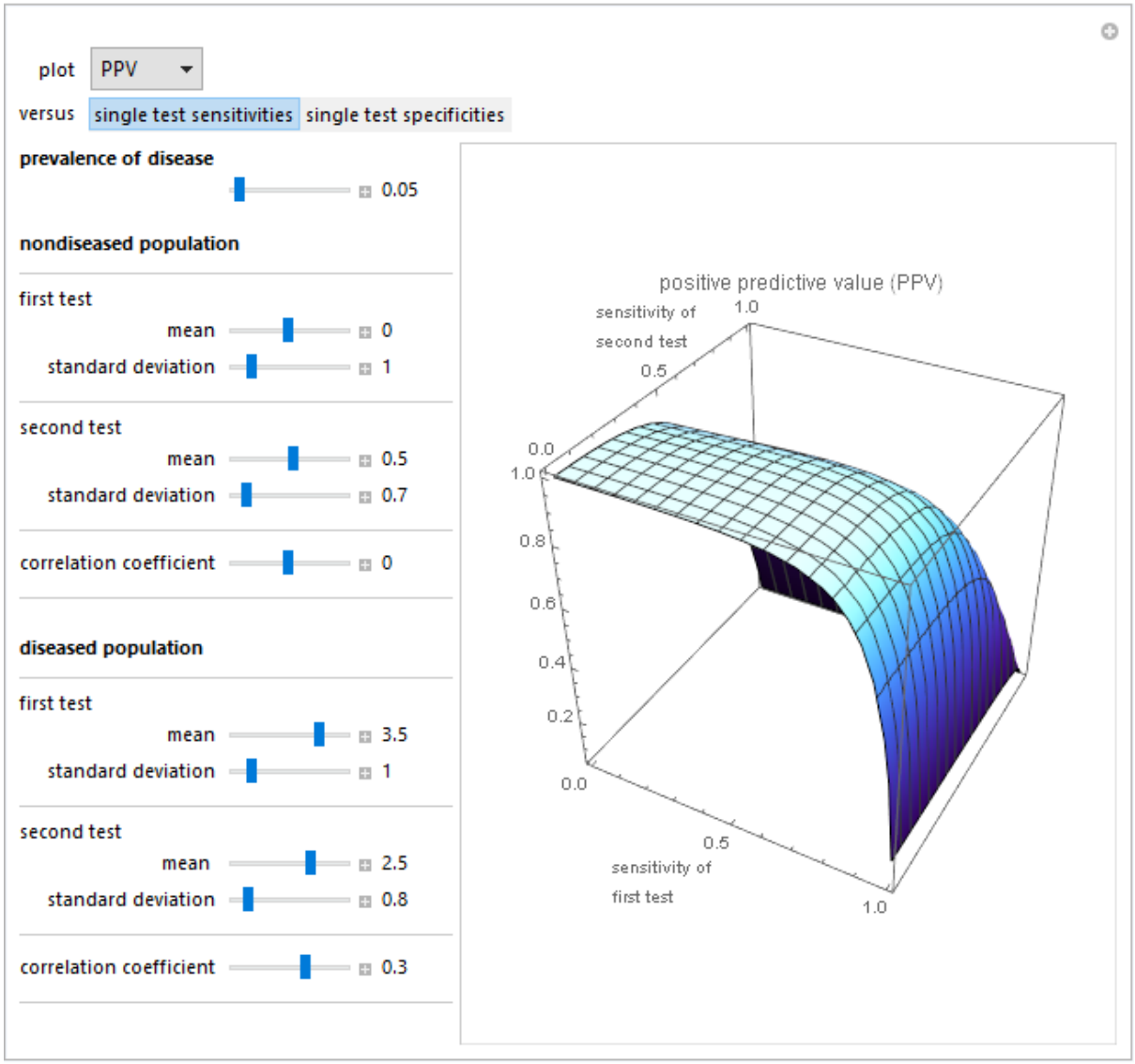

Figure 1: *Positive predictive value of two combined diagnostic tests vs sensitivity of each test plot. Prevalence of disease: 0.05, mean and standard deviation of the first test on the nondiseased population: 0.00 and 1.00 units respectively, mean and standard deviation of the second test on the nondiseased population: 0.50 and 0.70 units respectively, correlation coefficient of the two tests on the nondiseased population: 0.00, mean and standard deviation of the first test on the diseased population: 3.50 and 1.00 units respectively, mean and standard deviation of the second test on the diseased population: 2.50 and 0.80 units respectively, correlation coefficient of the two tests on the diseased population: 0.30.*

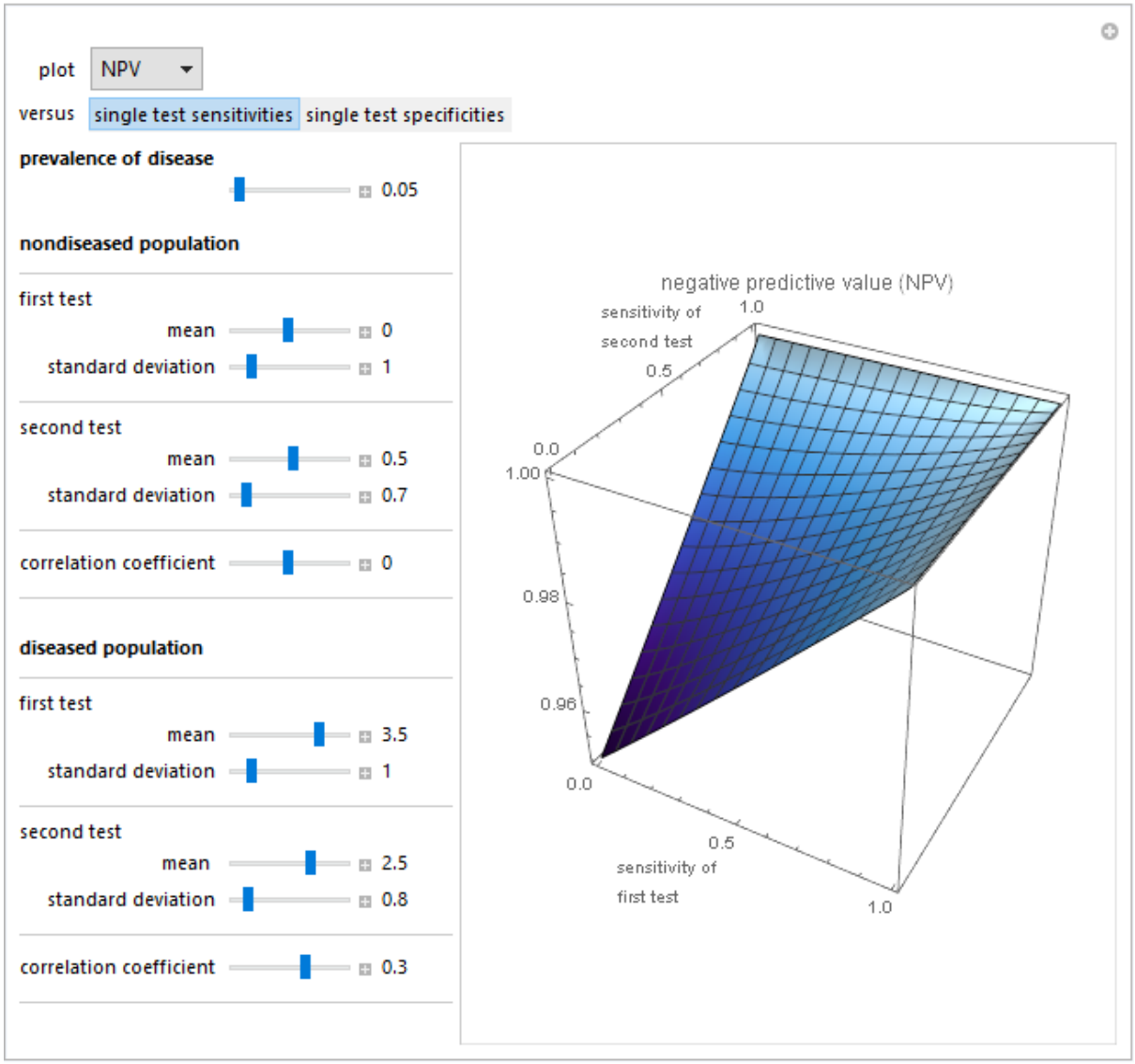

Figure 2: *Negative predictive value of two combined diagnostic tests vs sensitivity of each test plot. Prevalence of disease: 0.05, mean and standard deviation of the first test on the nondiseased population: 0.00 and 1.00 units respectively, mean and standard deviation of the second test on the nondiseased population: 0.50 and 0.70 units respectively, correlation coefficient of the two tests on the nondiseased population: 0.00, mean and standard deviation of the first test on the diseased population: 3.50 and 1.00 units respectively, mean and standard deviation of the second test on the diseased population: 2.50 and 0.80 units respectively, correlation coefficient of the two tests on the diseased population: 0.30.*

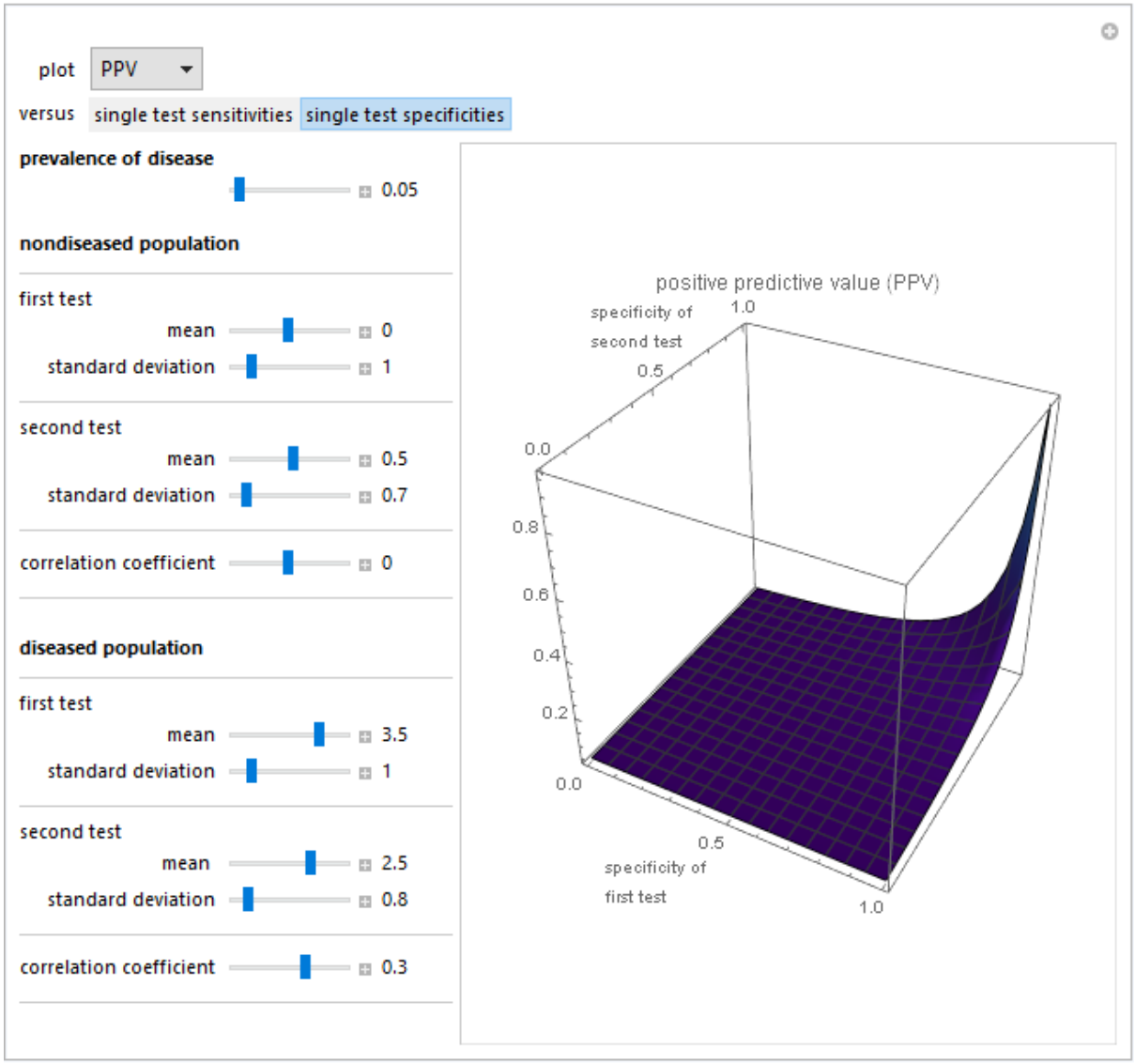

Figure 3: *Positive predictive value of two combined diagnostic tests vs specificity of each test plot. Prevalence of disease: 0.05, mean and standard deviation of the first test on the nondiseased population: 0.00 and 1.00 units respectively, mean and standard deviation of the second test on the nondiseased population: 0.50 and 0.70 units respectively, correlation coefficient of the two tests on the nondiseased population: 0.00, mean and standard deviation of the first test on the diseased population: 3.50 and 1.00 units respectively, mean and standard deviation of the second test on the diseased population: 2.50 and 0.80 units respectively, correlation coefficient of the two tests on the diseased population: 0.30.*

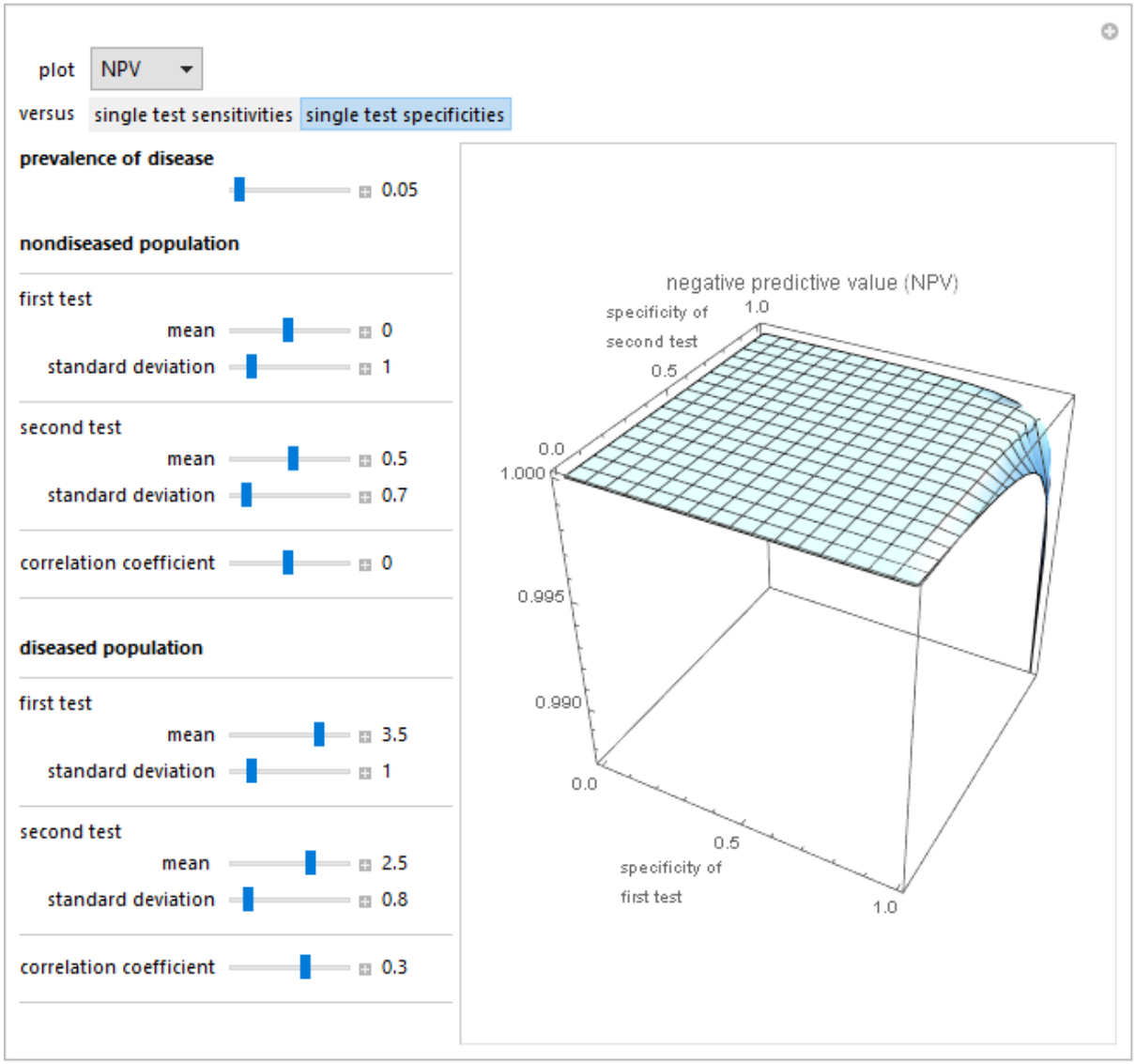

Figure 4: *Negative predictive value of two combined diagnostic tests vs specificity of each test plot. Prevalence of disease: 0.05, mean and standard deviation of the first test on the nondiseased population: 0.00 and 1.00 units respectively, mean and standard deviation of the second test on the nondiseased population: 0.50 and 0.70 units respectively, correlation coefficient of the two tests on the nondiseased population: 0.00, mean and standard deviation of the first test on the diseased population: 3.50 and 1.00 units respectively, mean and standard deviation of the second test on the diseased population: 2.50 and 0.80 units respectively, correlation coefficient of the two tests on the diseased population: 0.30.*

Details

Assume bivariate normal distributions for the paired measurements for each of the two tests on both nondiseased and diseased populations. The measures are used in evaluation of the clinical diagnostic accuracy of the combined diagnostic tests applied to a diseased or nondiseased population. They can be calculated as functions of the sensitivities or the specificities of each of the two tests.

Sensitivity of each single test is the fraction of the diseased population with a positive test result, while specificity is the fraction of the nondiseased population with a negative test result. Sensitivity of the two combined tests is the fraction of the diseased population with at least one positive test result, while specificity is the fraction of the nondiseased population with negative results for both tests. If we denote by *CSens* and *CSpec* the sensitivity and the specificity of the combined tests, and by *pr* the prevalence of the disease, we have:

$$PPV = \frac{Csens \times pr}{Cspec \times pr + (1 - Cspec)(1 - pr)}$$

$$NPV = \frac{Cspec\ (1 - pr)}{Cspec\ (1 - pr) + (1 - Csens)\ pr}$$

$$OR = \frac{\frac{Csens}{1 - Csens}}{\frac{1 - Cspec}{Cspec}}$$

$$LR+ = \frac{Csens}{1 - Cspec}$$

$$LR- = \frac{1 - Csens}{Cspec}$$

This Demonstration is an extension of [1] and is appropriate as an educational tool for medical students and junior doctors.

References

[1] Chatzimichail T. Analysis of Diagnostic Accuracy Measures. Wolfram Demonstrations Project, Champaign: Wolfram Research, Inc., 2015. Available at: http://demonstrations.wolfram.com/AnalysisOfDiagnosticAccuracyMeasures/

Source Code

The updated Wolfram Mathematica© source code is available at: https://www.hcsl.com/Tools/AnalysisOfDiagnosticAccuracyMeasures-author.nb

Permanent Citation:

Chatzimichail T, Hatjimihail AT. Analysis of Diagnostic Accuracy Measures for Two Combined Diagnostic Tests. Wolfram Demonstrations Project, Champaign: Wolfram Research, Inc., 2018. Available at: http://demonstrations.wolfram.com/AnalysisOfDiagnosticAccuracyMeasuresForTwoCombinedDiagnostic/

Published: April 3 2018