

Bayesian Diagnostic Insights

A Software Tool for Bayesian Probabilistic Methods in Medical Diagnostics

Interface Documentation

v. 1.0.0

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1. Introduction

The *Bayesian Diagnostic Insights* software program is a specialized computational tool developed to assist medical professionals and researchers in the field of diagnostics. The program allows for the calculation, and plotting of four Bayesian diagnostic measures: positive predictive value [$P(D|T > t)$], negative predictive value [$P(\bar{D}|T < t)$], posterior probability for disease [$P(D|T = t)$], and posterior probability for the absence of disease [$P(\bar{D}|T = t)$]. Utilizing the principles of uncertainty propagation, the program allows for the calculation, and plotting of the sampling, measurement, and combined uncertainty of these measures and of the associated confidence intervals.

a) System Requirements

1.a.1. Processor

Intel Core i9® or equivalent CPU.

1.a.2. System Memory (RAM)

32 GB+ recommended.

1.a.3. Operating Systems

Microsoft Windows, Linux, Apple iOS.

1.a.4. Software Requirements

Wolfram Player®, freely available at [Wolfram Player](https://www.wolfram.com/player/) or Wolfram Mathematica®.

2. Interface Overview

a) Tabbed Navigation

The program features an intuitive tabbed user interface, designed to streamline users interaction, and facilitate effortless navigation across its multiple modules and sub-modules. Each tab is clearly labeled to correspond with its respective module, allowing for quick access to various functionalities.

b) Numerical Settings: Sliders

The program offers controls for numerical settings, which can be adjusted through sliders.

2.b.1. Fine Manipulation

For more precise control, hold down the '*alt*' or '*opt*' key while dragging the mouse. For even finer adjustments, also hold the '*shift*' and/or '*ctrl*' keys.

c) Non-Numerical Settings

These settings are controlled using buttons. Each button is labeled clearly to indicate its function.

d) Plot Range

All the plots can be plotted in extended and limited range.

3. Input Parameters

The program allows users to input a variety of parameters, each with a specific range:

$$t: \text{maximum}(0, \text{minimum}(\mu_{\bar{D}} - 6\sigma_{\bar{D}}, \mu_D - 6\sigma_D)) - \text{maximum}(\mu_{\bar{D}} + 6\sigma_{\bar{D}}, \mu_D + 6\sigma_D)$$

$$n_D: 2 - 10,000$$

$$\mu_D: 0.1 - 10,000$$

$$\sigma_D: 0.01 - 1,000$$

$$n_{\bar{D}}: 2 - 10,000$$

$$\mu_{\bar{D}}: 0.1 - 10,000$$

$$\sigma_{\bar{D}}: 0.01 - 1,000$$

$$v: 0.001 - 0.999$$

$$n_U: 20 - 10,000$$

$$b_0: 0 - \sigma_{\bar{D}}$$

$$b_1: 0 - 0.1000$$

$$p: 0.900 - 0.999$$

$t, \mu_D, \sigma_D, \mu_{\bar{D}},$ and $\sigma_{\bar{D}}$ are defined in arbitrary units.

4. Modules and Submodules

The program is organized into four primary modules, each with multiple submodules:

4.1. Diagnostic Measures Plots:

Plots:

- a) $P(D|T \geq t)$ and $P(D|T = t)$
- b) $P(\bar{D}|T < t)$ and $P(\bar{D}|T = t)$
- c) $P(D|T \geq t) / P(D|T = t)$
- d) $P(\bar{D}|T < t) / P(\bar{D}|T = t),$

versus:

- a) The measurement value t
- b) The prevalence or prior probability for disease v

4.2. Diagnostic Measures Tables:

For a measurement value t , the following measures are tabulated:

- a) $P(D|T \geq t)$,
- b) $P(D|T = t)$
- c) $P(\bar{D}|T < t)$
- d) $P(\bar{D}|T = t)$
- e) $P(D|T \geq t) / P(D|T = t)$
- f) $P(\bar{D}|T < t) / P(\bar{D}|T = t)$

The above modules allow the user to define:

- a) The prevalence or prior probability for disease v .
- b) The mean and standard deviation of a diseased and a nondiseased population.
- c) The univariate distribution of each population (normal, lognormal, gamma).
- d) The measurement value t .

4.3. Standard Uncertainty Plots:

Plots:

- a) The standard sampling, measurement, and combined uncertainty
- b) The relative standard sampling, measurement, and combined uncertainty
- c) The associated confidence intervals

of:

- a) $P(D|T \geq t)$ and $P(D|T = t)$
- b) $P(\bar{D}|T < t)$ and $P(\bar{D}|T = t)$

versus:

- a) The measurement value t
- b) The constant contribution b_0 to measurement uncertainty
- c) The measurement uncertainty proportionality constant b_1
- d) The total size of the population sample n
- e) The prior probability for disease v

4.4. Standard Uncertainty Tables:

The program tabulates the standard sampling, measurement, and combined uncertainty and relative uncertainty and the associated confidence intervals of:

- a) $P(D|T > t)$,
- b) $P(D|T = t)$
- c) $P(\bar{D}|T < t)$
- d) $P(\bar{D}|T = t)$

for a user defined value of the measurand t and all the possible combinations of the distributions.

Each of the above modules allows the user to define:

- a) The size, mean, and standard deviation of a sample from each of a diseased and nondiseased populations.
- b) The univariate distribution of each population (normal, lognormal, gamma).

A linear [$u_m(x) \cong b_0 + b_1 t$] or nonlinear [$u_m(x) = \sqrt{b_0^2 + b_1^2 t^2}$] equation of the measurement uncertainty versus the measurement value t , and the number of the quality control measurements used to derive it.

- c) The measurement value t .
- d) The confidence level p of confidence intervals.

5. Source Code

- a) Programming language

Wolfram Language

- b) Software source code file format

Wolfram Notebook

c) Availability

The updated source code is available at: <https://www.hcsl.com/Tools/BayesianDiagnosticInsights/BayesianDiagnosticInsights.nb>

d) License

The *Bayesian Diagnostic Insights* program is licensed under the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](#).

6. Notation and Abbreviations

a) Parameters

n_D : size of diseased population

μ_D : mean of diseased population

σ_D : standard deviation of diseased population

$n_{\bar{D}}$: size of nondiseased population

$\mu_{\bar{D}}$: mean of nondiseased population

$\sigma_{\bar{D}}$: standard deviation of nondiseased population

ν : prevalence or prior probability for disease

n_U : number of quality control measurements

b_0 : constant contribution to measurement uncertainty

b_1 : measurement uncertainty proportionality constant

p : confidence level

b) Bayesian Diagnostic Measures

$P(D|T \geq t)$: positive predictive value

$P(\bar{D}|T < t)$: negative predictive value

$P(D|T = t)$: posterior probability for disease

$P(\bar{D}|T = t)$: posterior probability for non-disease

7. Conclusion

The *Bayesian Diagnostic Insights* program offers a robust and user-friendly interface for medical professionals and researchers to estimate the uncertainty in Bayesian diagnosis. Its modular design and comprehensive output options make it a valuable tool in the field of medical statistics and diagnostics.

11. License

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