Bayesian Diagnostic Insights

A Software Tool for Applying Bayes' Theorem in Medical Diagnostics

Interface Documentation

v. 2.1.0

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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 diagnostics. The program allows for the calculation and plotting of four Bayesian diagnostic measures: positive predictive value $[P(D|T > t)]$, negative predictive value $[P(\overline{D}|T < t)]$, posterior probability for disease $[P(D|T = t)]$, and posterior probability for the absence of disease$[P(\overline{D}|T = t)]$. By utilizing the principles of uncertainty propagation, the program allows for the calculation and plotting of the sampling, measurement, and combined uncertainty of these measures, as well as the associated confidence intervals.

2. System Requirements

2.1. Processor

Intel Core i9® or equivalent CPU

2.2. System Memory (RAM)

32 GB+ recommended

2.3. Operating Systems

Microsoft Windows, Linux, Apple iOS

2.4. Software Requirements

Wolfram Player®, freely available at Wolfram Player or Wolfram Mathematica®.

3. Interface Overview

3.1. Tabbed Navigation

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

3.2. Numerical Settings: Sliders

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

Fine Manipulation

Press the 'alt' or 'opt' key while dragging the mouse for more precise control. For even finer adjustments, also press the '*shift*' or '*ctrl*' keys.

3.3. Non-Numerical Settings

Buttons control these settings. Each button is labeled clearly to indicate its function.

3.4. Additional Options

3.4.1. Plots

Users can select between an extended and limited plot range.

3.4.2. Tables

Users can define the number of decimal digits for results, ranging from 1 to 10.

3.5. Input Parameters

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

t: $maximum(0, minimum(m_{\bar{D}} - 5s_{\bar{D}}, m_D - 5s_{\bar{D}})) - maximum(m_{\bar{D}} + 5s_{\bar{D}}, m_D + 5s_{\bar{D}})$

n_D : 2 – 10,000

m_D: 0.1 – 10,000

s_D: 0.01 – 1,000

$n_{\bar{D}}$: 2 – 10,000

$m_{\bar{D}}$: 0.1 – 10,000

$s_{\bar{D}}$: 0.01 – 1,000

v : 0.001 – 0.999

n_U : 20 – 10,000

b_0 : 0 – $s_{\bar{D}}$

b_1: 0 – 0.1000

p: 0.900 – 0.999

$t, m_D, s_D, m_{\bar{D}}$, and $s_{\bar{D}}$ are defined in arbitrary units.

4. Modules and Submodules

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

5.1. Diagnostic Measures Plots:

Plots:

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

versus:

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

5.2. 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) $P(\overline{D}|T < t)$
d) $P(\overline{D}|T = t)$

The above modules allow the user to define:

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

5.3. 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) $P(\overline{D}|T < t)$ and $P(\overline{D}|T = t)$

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

5.4. 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) $P(\overline{D}|T < t)$
d) $P(\overline{D}|T = t)$

for a user-defined measurement value *t* and all the possible combinations of the distributions.

Each of the above modules allows users to define:

e) The size, mean, and standard deviation of the measurements of a diseased and a nondiseased population sample.

a) The univariate distribution of the measurements 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 (QC) measurements used to derive it.

b) The measurement value *t*.

c) The confidence level *p* of confidence intervals.

6. Source Code

6.1. Programming language

Wolfram Language

6.2. File format

Wolfram Notebook

6.3. Availability

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

6.4. License

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7. Notation and Abbreviations

7.1. Parameters

t : measurement value of a diagnostic test

μ_D: mean of the measurements of the diseased population

σ_D: standard deviation of the measurements of the diseased population

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

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

n_D : size of a diseased population sample

m_D: mean of the measurements of diseased population sample

s_D: standard deviation of the measurements of diseased population sample

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

$m_{\bar{D}}$: mean of the measurements of a nondiseased population sample

$s_{\bar{D}}$: standard deviation of the measurements of a nondiseased population sample

v : prior probability or prevalence of disease

n_U : number of quality control measurements

b_0 : constant contribution to measurement uncertainty

b_1: measurement uncertainty proportionality constant

p: confidence level

7.2. 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 the absence of disease

8. Conclusion

Bayesian Diagnostic Insights 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 useful medical statistics and diagnostics tool.

9. Citation

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10. License