# **BNForSci - Bayesian Network Software** User Guide

## Introduction

Welcome to BNForSci, a web-based Bayesian Network tool. This user guide will help you navigate through the software's features and functionalities, providing step-by-step instructions.

### What are Bayesian Networks?

Bayesian Networks (BNs) are graphical models that represent variables and their conditional dependencies via a directed acyclic graph (DAG). They are powerful tools for reasoning under uncertainty and are widely used in scientific research, medical diagnosis, risk assessment, and many other fields.

### **Key Features of BNForSci**

- Intuitive web interface for creating and editing Bayesian Networks
- Network visualization
- Calculation of marginal probabilities
- Setting findings and calculating conditional probability distribution conditional on the findings
- Modern, responsive design that works on various devices

## **Getting Started**

### **System Requirements**

- A modern web browser (Google Chrome)
- Internet connection
- Screen resolution of at least 1280x720 for optimal experience

### **Accessing the Software**

- 1. Open your web browser
- 2. Navigate to the BNForSci URL provided by your administrator
- 3. You will be directed to the login page

BNForSci Login Register		LEVERHULM <u>TRUST</u>	E Leverhulme Research Centre for Forensis Science University of Dundee
	Login		
	Password		
	Login Don't have an account? Register he	ere .	
	<u></u>		
BNForSci Developed by LRCFS Funded by The Leverhulme Trust	LEVE TRUS	RHULME	Leverhulme Research Centre for Forensic Science University of Dundee

Figure 1: The Login Page

## **Creating an Account**

- 1. From the login page, click the "Register" link
- 2. Fill in the registration form with your:
  - <sup>o</sup> Username
  - <sup>o</sup> Email address
  - <sup>o</sup> Password (enter it twice for confirmation)
- 3. Click the "Register" button

	Register	
Username		
Email		
Password		
Confirm Password		
	Register	
	Already bays an account? Login bars	
	Already have an account: Cogin here	

Figure 2: The Registration Screen

## **Dashboard Overview**

After logging in, you will be taken to the dashboard. Here's what you'll find:

**Navigation Bar**: It is located at the top of the screen and contains links to Launch and Logout, and the username of the person currently logged in.

**Main Header**: It contains the title "Welcome to BNForSci" with a brief description below the title.

Action Buttons: It contains buttons Launch" and "Help" for quick access.

**Core Function**: It contains a description of the three main aspects of the software: Network Creation, Probability Analysis and Visualisation.



Figure 3: The dashboard

## **Creating a Bayesian Network**

### **Creating a New Network**

Click on "Launch" in the dashboard (Figure 3). You'll be directed to the Create Bayesian Network interface.

Id nodes, set CPTs, and optionally add findings to a	your network.
Add Node	CPTs
Node Name e.g., S for Smoking	Show All Nodes
Label	·
e.g., Smoking	Hold Ctrl/Cmd to select multiple nodes
Values (comma-separated)	Calculate Marginals Plot Marginals Plot Network
e.g., 0,1	
Usually 0,1 for binary variables	
Parent Nodes	
Hold Ctrl/Cmd to select multiple parents	Lactude Findings
	Include Finalings

Figure 4: The Bayesian Network Creation Interface

### **Adding Nodes**

We can add a node that has no parents following the steps below (Figure 5):

- 1. For each node, enter:
  - Node Name: A short name, with no spaces, that is used as a unique identifier, e.g. "P".
  - **Node Label**: A short text describing the node. A label is used when displaying the network, e.g. "Props"
  - Values: The possible values, or states, of the node, e.g. "Hp", "Hd".
  - Parent Nodes: None
- 2. Click "Add Node" to add the node to your network.

P abel Props	
P abel	
Props	
Props	
1005	
alues (comma-separated)	
Hp,Hd	
sually 0,1 for binary variables	
arent Nodes	
Select a parent node (optional)	l â
Props (P)	
Smoking (S)	
Unclear (U)	Ŧ

Figure 5: The Add Node Interface without Parent Node

We can add nodes with multiple parents by following the steps below (Figure 6):

- 1. For each node, enter:
  - Node Name: A short name, with no spaces, that is used as a unique identifier, e.g. "C"
  - **Node Label**: A short text describing the node. The label is used when displaying the network, e.g. "Cancer"
  - Values: The possible values, or states, of the node, e.g., "a", "no\_a"
  - **Parent Nodes**: Hold the ctrl button and click on the parent nodes which in this instance are Props(P), Smoking(S) and Unclear(U).
- 2. Click "Add Node" to add the node to your network

Add Node
Node Name
c
Label
Cancer
Values (comma-separated)
a, no_a
Usually 0,1 for binary variables
Parent Nodes
Select a parent node (optional) Props (P)
s (s) U (U)
Hold Ctrl/Cmd to select multiple parents
Add Node

Figure 6: The Add Note Interface with Parent Node Addition

### **Setting Conditional Probability Tables (CPTs)**

- 1. In the Bayesian network creation interface (Figure 4), select a node
- 2. Click "Edit CPT"
- 3. You will see a table with rows for each combination of parent states (Figure 7).
- 4. Enter probabilities for each state of the selected node. Probabilities across each row must sum to 1.
- 5. Click "Save CPT"

alues: Hp, Hd		
arents: None		
Probability Tab	le	
Р	Probability	
Нр	0.5	

Figure 7: Conditional Probability Tables (CPT) Interface

## **Editing** a Node

A node can be edited by clicking on the "Edit" button of the node in the CPTs table. It includes various fields and options for editing the node properties.

- Node Name: A text field to input the name of the node.
- Label: A field for specifying the label of the node.
- Values: A field for entering comma-separated values (e.g., "Hp, Hd").
- **Parent Nodes**: A section where users can select multiple parent nodes, such as "Smoking (S)," "Unclear (U)," and "Cancer (C)." Users can hold "Ctrl/Cmd" to select multiple options.

The Visual Properties section allows users to adjust the appearance of the node:

- X Position and Y Position: Fields to set the node's position on the canvas.
- Width and Height: Fields to define the size of the node.
- **Edge Color**: A color picker for the border of the node (e.g., purple in the image).
- Fill Color: A color picker for the node's background (e.g., light blue in the image).
- Line Width: A field to set the thickness of the border.
- Font Size: A field to adjust the text size within the node.
- **Text Color**: A color picker for the text color (e.g., black in the image).

At the bottom, there are two buttons: **Cancel** and **Save Changes**, allowing users to discard or apply their edits

Edit Node	×
Node Name	
Р	
Label	
Props	
Values (comma-separated)	
Hp,Hd	
Parent Nodes	
Smoking (S) Unclear (U) Cancer (C)	•
Hold Ctrl/Cmd to select multiple par	rents
Visual Properties	^
X Position	Y Position
1.2	1
Width	Height
0.9	0.4
Edge Color	Fill Color
Line Width	Font Size
1	12
Text Color	
	Cancel Save Changes

Figure 8: Edit Node Interface

## Visualisation

 To visualise your network, In the Bayesian network creation interface (Figure 4), click "Plot Network". Lines between nodes represent dependencies (arrows point from parent to child). The text inside the nodes is the node name.



Figure 9: Network Structure

### **Saving Your Network**

- 1. Once you've added all nodes, relationships, and CPTs, In the Bayesian network creation interface (Figure 4), click "Save Network"
- 2. A box pops out showing you to give a name to your network.
- 3. Your network will be saved in a json file format to your account.

Save Network	×
Network Name	
ба	
	Cancel Save

Figure 10: Save Network Interface

## **Calculating Marginal Probabilities**

- 1. In the Bayesian network creation interface (Figure 4), click "Calculate Marginals" button.
- 2. The system will compute the probability distribution for each node.
- 3. Results will be displayed next to each node or in a separate panel (Figure 11).



Figure 11: The Plot Marginal Interface

## **Setting Findings**

Findings are known values for specific nodes.

- 1. In the Conditional Probability Table, scroll down and turn on the "Include Findings" button
- 2. Choose the node that you want to set as findings and choose the nodes values you want to set findings on.
- 3. The network will be updated with your findings and how this finding affects other nodes by clicking on "Plot Marginals" button.

Set Findings	
Props (P)	
No finding	~
S (S)	
No finding	~
U (U)	
No finding	~
C (C)	
No finding	~

Figure 12: Set Findings Interface

### **Interpreting Results**

- Nodes with findings will be highlighted in red (Figure 13)
- The probabilities of other nodes will update based on the findings.
- These updated probabilities represent the conditional probabilities given the findings
- The probability of the findings is displayed at the top of the screen, e.g. "P(P=Hp)=0.5000".



Figure 13: Plot Marginals with Findings

## **Loading Networks**

- 1. From the dashboard, click "Load Network"
- 2. Click "Browse" and select the network file
- 3. Click "Upload"
- 4. If the file is valid, the network will be imported to your account

## **Troubleshooting**

### **Common Issues and Solutions**

### **Login Problems**

- Ensure your username and password are correct
- Check if Caps Lock is on

### **Network Not Saving**

- Check your internet connection
- Ensure all required fields are filled
- Try refreshing the page and attempting again

### **Calculation Errors**

- Ensure all CPTs are correctly defined (sum to 1.0 for each row)
- Check for cycles in your network (not allowed in Bayesian Networks)
- For complex networks, calculations may take time; please be patient

## **Glossary of Terms**

#### **Bayesian Network**

A probabilistic graphical model representing variables and their conditional dependencies.

#### Node

A variable in the network.

#### State

A possible value that a node can take.

#### Edge

A directed link from a parent node to a child node.

#### **CPT (Conditional Probability Table)**

A table defining the probability of each state of a node given all combinations of its parents' states.

#### **Finding/Evidence**

A known value (state) for a specific node.

#### **Marginal Probability**

The probability distribution of a node without any findings.

#### **Conditional Marginal Probability**

The probability distribution of a node after incorporating findings.

#### **Posterior Probability**

The updated probability after incorporating evidence.

#### D3.js

The JavaScript library used for visualization.