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Modeling with R Shiny (Probability Distribution)

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1 Introduction to the Probability Distribution R Shiny Tool

概率分佈R Shiny 工具簡介

R is a powerful statistical programming language that allows us to perform data analysis, which is useful for mathematical modeling. Even better, we have set up a set of online tools using R Shiny so that you can perform various mathematical modelling tasks without any coding background.

R 是一種功能強大的統計程式語言，讓我們能夠進行數據分析，對數學建模十分有用。更理想的是，我們利用R Shiny 建立了一系列線上工具，讓使用者即使不具備程式設計背景，也能夠執行各種數學建模任務。

In particular, the Probability Distribution R Shiny tool provides an interactive way to explore different probability distributions and fit a Gaussian function to data. Users can adjust the parameters of different discrete and continuous probability distributions and observe the corresponding probability graphs. The tool also provides several methods for fitting a Gaussian function to a given dataset.

具體而言，概率分佈R Shiny 工具提供了一個互動式平台，讓使用者探索不同的概率分佈，並使用高斯函數對數據進行擬合。使用者可以調整不同離散及連續概率分佈的參數，並觀察相應的概率圖像。工具亦提供多種方法，讓使用者對給定的數據集進行高斯函數擬合。

Here is the guideline on how to use our Probability Distribution R Shiny Tool.
以下是有關如何使用我們的概率分佈R Shiny 工具的指引。

2 Using the Probability Distribution R Shiny tool

使用概率分佈R Shiny 工具

To use the tool, please visit our main website:
如要使用此工具，可前往我們的主網站：

<https://cuhkmathmodel.com>

for the list of tools, or simply go to
瀏覽工具列表，或直接前往

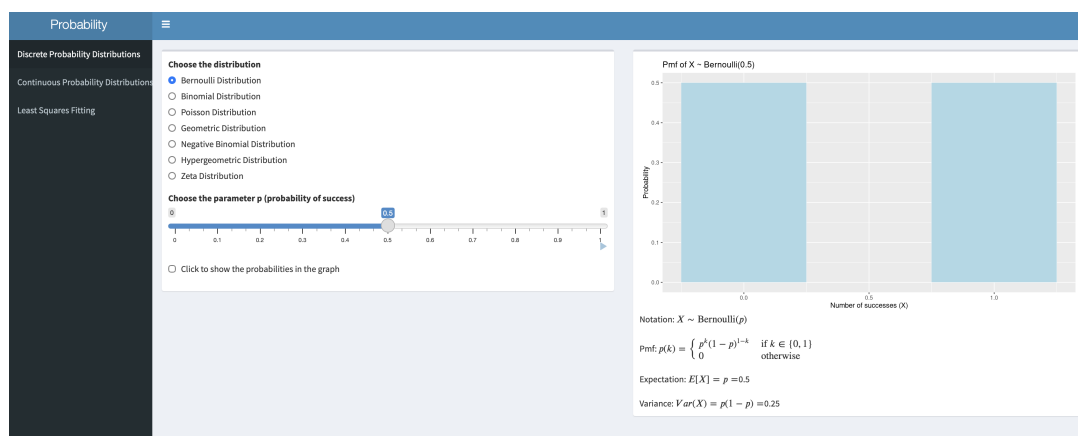
<https://mathmodelcuhk.shinyapps.io/probability-distribution/>

for the Probability Distribution R Shiny tool.

使用概率分佈R Shiny 工具。

After getting into the website, you can see the following:

進入網站後，你會看到以下畫面：



Don't worry if you think this is complicated! We will guide you step by step, and you can do multiple regression using our R Shiny tool.

如果你覺得這個界面有點複雜，不用擔心！我們會逐步引導你，讓你能夠順利使用我們的R Shiny 工具進行多元線性迴歸。

2.1 Interactive visualization of discrete probability distributions 離散概率分佈的互動式視覺化

The tool allows users to interactively explore several discrete probability distributions. Under “Discrete Probability Distributions”, the following distributions are available:

工具可以讓使用者互動式地探索多種離散概率分佈。在「Discrete Probability Distributions」中，可以選擇以下概率分佈：

- Bernoulli Distribution（伯努利分佈）
- Binomial Distribution（二項分佈）
- Poisson Distribution（泊松分佈）
- Geometric Distribution（幾何分佈）
- Negative Binomial Distribution（負二項分佈）
- Hypergeometric Distribution（超幾何分佈）
- Zeta Distribution（截塔分佈）

Choose the distribution

- ☒ Bernoulli Distribution
- ☐ Binomial Distribution
- ☐ Poisson Distribution
- ☐ Geometric Distribution
- ☐ Negative Binomial Distribution
- ☐ Hypergeometric Distribution
- ☐ Zeta Distribution

2.1.1 Choosing a distribution 選擇概率分佈

First, select a distribution from the list under “Choose the distribution”. The parameters corresponding to the selected distribution will then be displayed.

首先，在「Choose the distribution」下的列表中選擇所需的概率分佈。選擇分佈後，介面會顯示該分佈所需的相應參數。

For example, if “Bernoulli Distribution” is selected, the tool provides a slider for choosing the parameter p , which represents the probability of success. The graph on the right is updated according to the selected value of p .

例如，如果選擇「Bernoulli Distribution」，工具會提供參數 p 的滑桿，其中 p 表示成功的概率。右方的圖表會根據所選的 p 值自動更新。

2.1.2 Adjusting the parameters 調整參數

Different probability distributions require different parameters. For example, the Binomial Distribution requires parameters n and p , while the Poisson Distribution requires the parameter λ . The tool provides interactive controls for adjusting the corresponding parameters.

不同的概率分佈需要不同的參數。例如，二項分佈需要參數 n 和 p ，而泊松分佈則需要參數 λ 。工具會提供互動式控制項，讓使用者調整相應的參數。

Move the sliders to change the parameter values. The probability graph will be updated automatically when the parameters are changed.

移動滑桿以改變參數值。當參數發生變化時，概率圖像會自動更新。

2.1.3 Displaying probabilities 顯示概率

For discrete probability distributions, the tool also provides the option “Click to show the probabilities in the graph”. Select this option to display the probability values directly on the graph.

對於離散概率分佈，工具亦提供「Click to show the probabilities in the graph」選項。選擇此選項後，可以在圖表上直接顯示各數據點所對應的概率值。

This interactive visualization allows users to observe how changing the parameters affects the shape of the probability distribution.

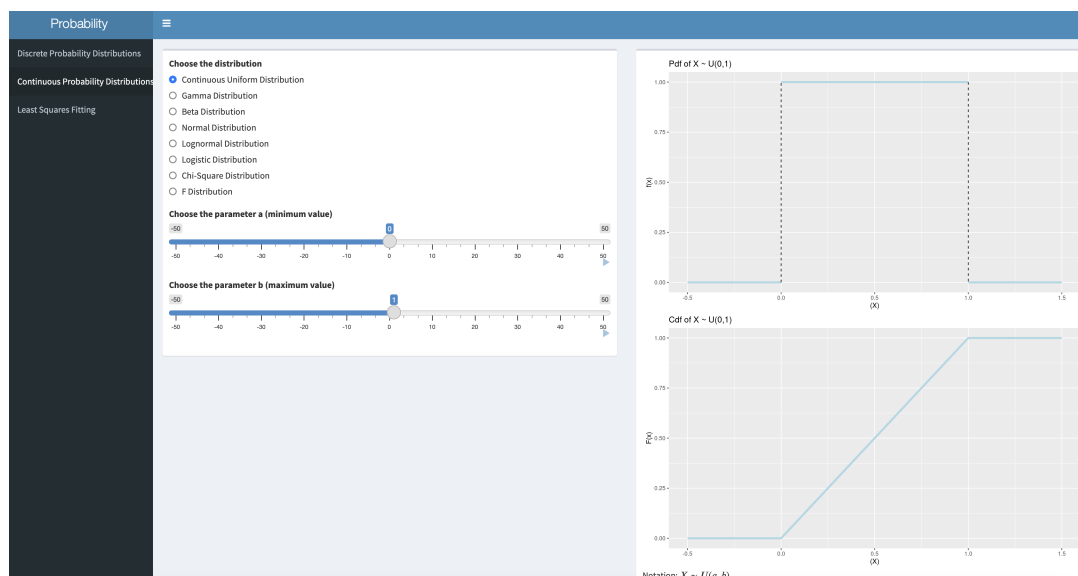
這種互動式視覺化可以讓使用者觀察參數的改變如何影響概率分佈的形狀。

2.2 Interactive visualization of continuous probability distributions 連續概率分佈的互動式視覺化

The tool also provides an interactive visualization of several continuous probability distributions. Under “Continuous Probability Distributions”, the following distributions are available:

工具亦提供多種連續概率分佈的互動式視覺化。在「Continuous Probability Distributions」中，可以選擇以下概率分佈：

- Continuous Uniform Distribution（連續均勻分佈）
- Gamma Distribution（伽馬分佈）
- Beta Distribution（貝塔分佈）
- Normal Distribution（常態分佈）
- Lognormal Distribution（對數常態分佈）
- Logistic Distribution（邏輯分佈）
- Chi-Square Distribution（卡方分佈）
- F Distribution（F 分佈）



2.2.1 Choosing and adjusting parameters 選擇及調整參數

Select a distribution from the list under “Choose the distribution”. The parameters required for the selected distribution will then be displayed. For example, for the Continuous Uniform Distribution, the parameters a and b represent the minimum and maximum values, respectively.

在「Choose the distribution」下的列表中選擇所需的概率分佈。選擇分佈後，介面會顯示該分佈所需的參數。例如，對於連續均勻分佈，參數 a 和 b 分別代表最小值和最大值。

Use the sliders to adjust the parameter values. The probability density function (pdf) and cumulative distribution function (cdf) are displayed on the right-hand side of the page and are updated when the parameters are changed.

使用滑桿調整參數值。頁面右方會顯示概率密度函數（pdf）及累積分佈函數（cdf），並會隨著參數的改變而更新。

2.2.2 Example: Continuous Uniform Distribution 例子：連續均勻分佈

For example, select “Continuous Uniform Distribution”. The parameters a and b can be adjusted using the corresponding sliders.

例如，選擇「Continuous Uniform Distribution」。可以使用相應的滑桿調整參數 a 和 b 。

If $a = 0$ and $b = 1$, the tool displays the probability density function and cumulative distribution function of $X \sim U(a, b) = U(0, 1)$.

當 $a = 0$ 及 $b = 1$ 時，工具會顯示 $X \sim U(a, b) = U(0, 1)$ 的概率密度函數及累積分佈函數。

Notation: $X \sim U(a, b)$

$$\text{Pdf: } f(x) = \begin{cases} \frac{1}{b-a} & \text{if } x \in [a, b] \\ 0 & \text{otherwise} \end{cases}$$

$$\text{cdf: } F(x) = \begin{cases} 0 & \text{if } x < a \\ \frac{x-a}{b-a} & \text{if } x \in [a, b] \\ 1 & \text{if } x > b \end{cases}$$

$$\text{Expectation: } E[X] = \frac{a+b}{2} = 0.5$$

$$\text{Variance: } Var(X) = \frac{(b-a)^2}{12} = 0.0833333333333333$$

The graphs allow users to observe how the probability distribution changes when its parameters are modified. For continuous distributions, the probability density function describes the distribution of probability density, while the cumulative distribution function shows the accumulated probability up to a given value.

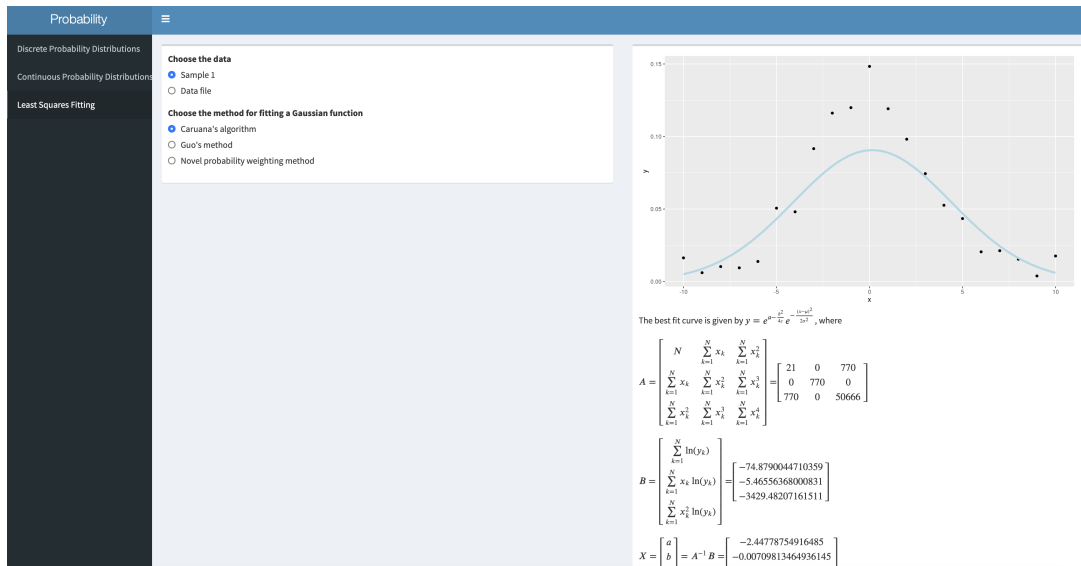
圖表可以讓使用者觀察概率分佈如何隨參數的改變而變化。對於連續概率分佈，概率密度函數描述概率密度的分佈，而累積分佈函數則顯示截至某一數值的累積概率。

2.3 Data fitting using a Gaussian function

使用高斯函數進行數據擬合

The tool also provides a “Least Squares Fitting” section, where users can fit a Gaussian function to a given dataset. This function can be used to model data that approximately follows a bell-shaped curve.

工具亦提供「Least Squares Fitting」部分，讓使用者使用高斯函數對給定的數據集進行擬合。此函數適合用於描述大致呈鐘形曲線的數據。



2.3.1 Choosing the data

選擇數據

Under “Choose the data”, users can choose either “Sample 1” or “Data file”. “Sample 1” provides a built-in dataset for demonstrating the Gaussian fitting procedure.

在「Choose the data」下，使用者可以選擇「Sample 1」或「Data file」。「Sample

1」提供了一組內置數據，用於示範高斯函數擬合的過程。

To use your own data, select “Data file” and upload a CSV file. The file should contain two columns of numeric values representing x and y , respectively. No header row is required. 如要使用自己的數據，選擇「Data file」並上傳CSV 檔案。檔案應包含兩列數值，分別代表 x 和 y ，而且不需要標題行。

Choose the data

- ☐ Sample 1
☒ Data file

Choose the data file (CSV file with two columns of numeric values for x and y only; no header row needed)

Browse...	No file selected
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Choose the method for fitting a Gaussian function

- ☒ Caruana's algorithm
☐ Guo's method
☐ Novel probability weighting method

2.3.2 Choosing a fitting method 選擇擬合方法

Under “Choose the method for fitting a Gaussian function”, the tool provides three methods:

在「Choose the method for fitting a Gaussian function」下，工具提供三種方法：

- Caruana's algorithm（卡魯阿納演算法）
- Guo's method（郭氏法）
- Novel probability weighting method（新型機率加權方法）

After selecting the dataset and the fitting method, the tool displays the data points together with the fitted Gaussian curve. The fitted curve allows users to compare the Gaussian model with the observed data.

選擇數據集及擬合方法後，工具會將數據點及擬合所得的高斯曲線顯示在圖表中。使用者可以透過擬合曲線比較高斯模型與觀察數據之間的關係。

The tool also displays the fitted function and the calculations used in the fitting procedure. This provides additional information about how the Gaussian function is obtained from the given data.

工具亦會顯示擬合所得的函數及擬合過程中的相關計算，讓使用者進一步了解如何根據給定數據得到高斯函數。

2.4 Conclusion

總結

Probability distributions are an important tool in probability and mathematical modelling. By exploring different discrete and continuous probability distributions interactively, we can understand how different parameters affect the corresponding probability graphs. By fitting a Gaussian function to data, we can also use probability models to describe and analyse observed data. We hope that this R Shiny Probability Distribution tool may help you with your mathematical modelling journey. Good luck!

概率分佈是概率論及數學建模中的重要工具。透過互動式探索不同的離散及連續概率分佈，我們可以了解不同參數如何影響相應的概率圖像。透過使用高斯函數對數據進行擬合，我們亦可以利用概率模型描述及分析觀察數據。我們衷心希望這個R Shiny 概率分佈工具能夠在你的數學建模探索旅程中提供協助。祝你一切順利！