Article

probTable: A Matlab calculator for lookuping probability tables

WenJun Zhang
School of Life Sciences, Sun Yat-sen University, Guangzhou 510275, China
E-mail: zhwj@mail.sysu.edu.cn, wjzhang@iaees.org

Received 19 June 2024; *Accepted 28 July 2024*; *Published online 31 December 2024*; *Published 1 December 2025*

Abstract
In present study, a calculator, probTable, was developed for lookuping probability tables. In the calculator, probability distributions as normal distribution, *t* distribution, *F* distribution, χ^2 distribution, Weibull distribution, lognormal distribution, binomial distribution, Poission distribution, negative binomial distribution, and uniform distribution, etc., were available for use. Probability density function, cumulative distribution function, and inverse cumulative distribution function of these probability distributions can be calculated. The calculator was developed as a standalone software using Matlab. Full codes and software were provided.

Keywords Matlab; calculator; probability table; probability distribution; probability density function; cumulative distribution function; inverse cumulative distribution function.

Selforganizology
ISSN 2410-0080
URL: http://www.iaees.org/publications/journals/selforganizology/online-version.asp
RSS: http://www.iaees.org/publications/journals/selforganizology /rss.xml
E-mail: selforganizology@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

In almost all studies involving in statistic tests, researchers need to lookup probability tables (Zhang, 2015, 2016, 2018, 2022a-c; Zhang and Li, 2015; Bagbag et al., 2024; Shobairi et al., 2024).

Therefore, in present study I developed a calculator, probTable, for lookuping probability tables. The calculator was developed as a standalone software using Matlab. Full codes and software were provided.

2 Probability Distributions

Suppose a random variable *X*, and *x* is a value of *X*. The probability density function of *X* is *f*(*x*) (Fig. 1). Some probability distributions are as follows:

(1) Normal distribution, $N(\mu, \sigma)$:

$$f(x)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where μ: mean, σ: standard deviation, $\sigma>0$. For the standard normal distribution $N(0, 1)$, $\mu=0$, $\sigma=1$.

(2) *t* distribution, $t(n)$:

$$f(x)=\frac{\Gamma(\frac{n+1}{2})}{\sqrt{n\pi}\Gamma(\frac{n}{2})}(1+\frac{x^2}{n})^{-\frac{n+1}{2}}$$

where n: a positive integer (degree of freedom).

(3) Exponential distribution, $e(\lambda)$:

$f(x)=\lambda e^{-\lambda x}$, $x\geq 0$

$f(x)=0$, $x<0$

where $\lambda>0$.

(4) F distribution, $F(m,n)$:

$$f(x)=\frac{\Gamma(\frac{m+n}{2})m^{\frac{m}{2}}n^{\frac{n}{2}}}{\Gamma(\frac{m}{2})\Gamma(\frac{n}{2})}\frac{x^{\frac{m}{2}-1}}{(mx+n)^{\frac{m+n}{2}}} \quad , x>0$$

$f(x)=0$, $x\leq 0$

where m, n: positive integers (degree of freedom).

(5) χ^2 distribution, $\chi^2(n)$:

$$f(x)=\frac{1}{2^{\frac{n}{2}}\Gamma(\frac{n}{2})}x^{\frac{n}{2}-1}e^{-\frac{x}{2}}$$

where n: a positive integer (degree of freedom).

(5) Γ distribution, $\Gamma(\alpha,\beta)$:

$$f(x)=\frac{1}{\beta^{\alpha+1}\Gamma(\alpha+1)}x^{\alpha}e^{-\frac{x}{\beta}} \quad , x\geq 0$$

$f(x)=0$, $x<0$

where $\beta>0$, $\alpha>-1$.

(6) Weibull distribution, $W(m,v,x_0)$:

$$f(x)=\frac{m}{x_0}(x-v)^{m-1}e^{-\frac{(x-v)^m}{x_0}} \quad , x\geq v$$

$f(x)=0$, $x<v$

where $m>0$, $x_0>0$, and v are constants.

Given x, we can find the value of the probability density function (pdf) $f(x)$.

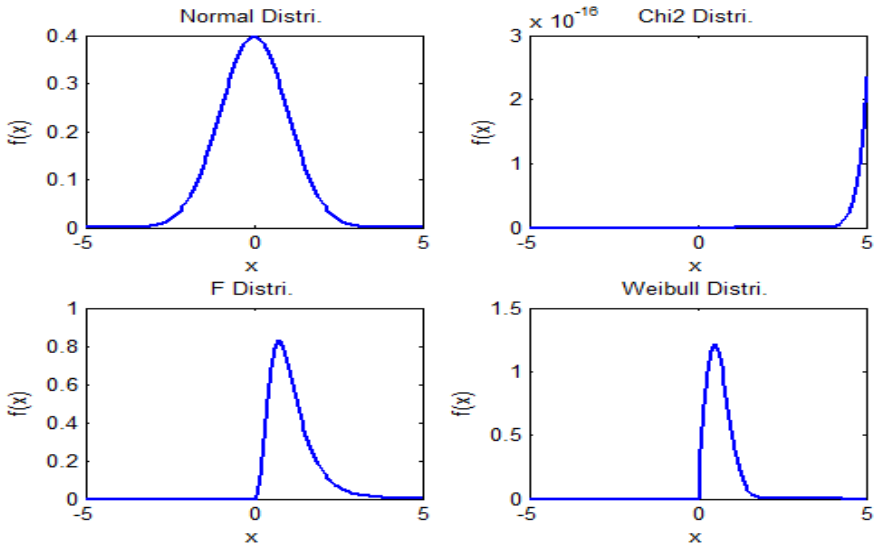

Fig. 1 Probability density functions of several random variables.

The probability that a random variable X takes a value less than x is:

$$p = F(x) = P(X<x) = \sum_{-\infty}^{x} f(x) \qquad (x \text{ is a discrete variable})$$

or

$$p = F(x) = P(X<x) = \int_{-\infty}^{x} f(x)\,dx \qquad (x \text{ is a continuous variable})$$

$F(x)$ is called the cumulative distribution function (cdf). Given x, we can find the value of the cumulative distribution function $F(x)$, or the probability p that the random variable X takes a value less than x (Fig. 2). Conversely, given the probability p that the random variable X takes a value less than x, or the cumulative distribution function value $F(x)$, we can find x, which is the value of the inverse cumulative distribution function (icdf).

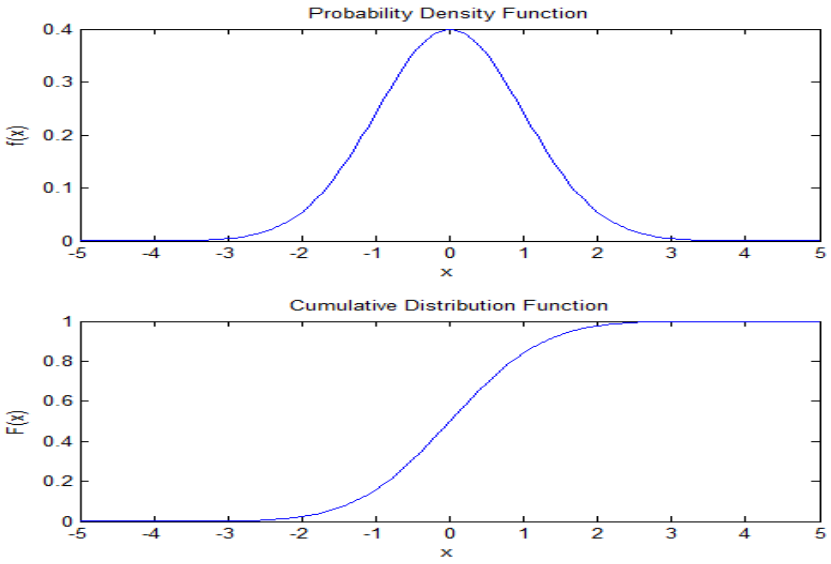

Fig. 2 Probability density function $f(x)$ and cumulative distribution function $F(x)$.

3 Matlab Functions For Probability Distributions

In Matlab, The commands for normal distribution, *t* distribution, *F* distribution, χ^2 distribution, lognormal distribution, binomial distribution, negative binomial distribution, Poission distribution, exponential distribution, Weibull distribution, and uniform distribution are norm, t, f, chi2, logn, bino, nbino, poiss, exp, weib, and unif respectively.

3.1 Matlab functions for calculating the probability density function ($\boldsymbol{f(x)}$)

(1) normpdf(x,mu,sigma)

The value of the normal distribution density function at *x* with parameters μ=mu, σ=sigma.

(2) tpdf(x, n)

The probability density function of the *t* distribution with *n* degrees of freedom.

(3) fpdf(x, m,n)

The probability density function of the *F* distribution with *m* as the first degree of freedom and *n* as the second degree of freedom.

(4) chi2pdf(x, n)

The probability density function of the χ^2 distribution with *n* degrees of freedom.

(5) weibpdf(x, a, b)

The probability density function of the Weibull distribution with parameters *a* and *b*.

(6) lognpdf(x, mu, sigma)

The probability density function of the lognormal distribution with parameters μ=mu, σ=sigma.

(7) binopdf (k, n, p)

The probability density function of the binomial distribution; p — the probability of event A occurring in each trial; k — event A occurring k times; n — the total number of trials.

(8) poisspdf(x,Lamda)

The probability density function of the Poisson distribution with parameter λ=Lamda.

(9) unifpdf (x, a, b)

The probability density function of the uniform distribution (continuous variable) on [a,b] at *X*=*x*.

(10) unidpdf(x,n)

The probability density function of the uniform distribution (discrete variable). n — the total number of trials.

(11) nbinpdf(x, R, P)

The probability density function of the negative binomial distribution with parameters R and P.

3.2 Matlab functions for calculating the cumulative distribution function (probability distribution function, $\boldsymbol{p = F(x)}$)

(1) normcdf(x, mu, sigma)

The cumulative distribution function of the normal distribution with parameters μ=mu, σ=sigma.

(2) tcdf(x, n)

The cumulative distribution function of the *t* distribution with *n* degrees of freedom.

(3) fcdf(x, m, n)

The cumulative distribution function of the *F* distribution with the first degree of freedom being m and the second degree of freedom being n.

(4) chi2cdf(x, n)

The cumulative distribution function of the chi-square distribution with *n* degrees of freedom.

(5) weibcdf(x, a, b)

The cumulative distribution function of the Weibull distribution with parameters a and b.

(6) logncdf(x, mu, sigma)

The cumulative distribution function of the lognormal distribution with parameters μ=mu, σ=sigma.

(7) binocdf (k, n, p)

The cumulative distribution function of binomial distribution; k is the number of times event A occurs in n trials, n is the total number of trials, p is the probability of event A occurring in each trial, and this command returns the probability that event A occurs exactly k times in n trials.

(8) poisscdf(x,Lamda)

The cumulative distribution function of Poisson distribution with parameter λ=Lamda.

(9) unifcdf (x, a, b)

The cumulative distribution function of uniform distribution (continuous variable) on [a,b].

(10) unidcdf(x,n)

The cumulative distribution function of uniform distribution (discrete variable).

(11) nbincdf(x, R, P)

The cumulative distribution function of negative binomial distribution with parameters R, P.

3.3 Matlab functions for calculating the inverse cumulative distribution function ($\boldsymbol{x = F^{-1}(p)}$)

(1) x=norminv(p,mu,sigma)

p is the cumulative probability value, μ=mu, σ=sigma, and x is the critical value, satisfying: $p=P\{X<x\}$.

(2) x=tinv (p, n)

t distribution inverse cumulative distribution function.

(3) x=finv (p, n1, n2)

F distribution inverse cumulative distribution function.

(4) x=chi2inv (p, n)

χ^2 distribution inverse cumulative distribution function.

(5) x=weibinv (p, a, b)

Weibull distribution inverse cumulative distribution function.

(6) x=unifinv (p, a, b)

Uniform distribution (continuous variable) inverse cumulative distribution function ($p=P\{X<x\}$, find x).

(7) x=unidinv (p,n)

Uniform distribution (discrete variable) inverse cumulative distribution function, *x* is the critical value.

(8) x=binoinv (k,n,p)

Inverse cumulative distribution function of binomial distribution.

(9) x=poissinv (p,Lamda)

Inverse cumulative distribution function of Poisson distribution.

(10) x=logninv (p, mu, sigma)

Inverse cumulative distribution function of lognormal distribution.

(11) x=nbininv (p, R, P)

Inverse cumulative distribution function of negative binomial distribution.

4 Matlab Calculator

Full Matlab codes of the calculator are as follows:

```
function probTable
distri=input('Choose a probability distribution (1: Normal distri.; 2: t distri.; 3: F distri.; 4: Chi-square distri.; 5: Weibull distri.; 6: Lognormal distri.; 7: Poission distri.; 8: Binomial distri.; 9: Negative binomial distri.; 10: Uniform distri. (continuous var.)): ');
sel=input('Choose a function to be calculated (1: Probability density function (f(x)); 2: Cumulative distribution function (p=F(x)); 3: Inverse cumulative distribution function (x=F-1(p))): ');
```

```
switch distri
    case 1
        mu=input('Mean (mu) =: ');
        sigma=input('Standard deviation (sigma) =: ');
    case 2
        n=input('Degree of freedom (n) =: ');
    case 3
        m=input('1st degree of freedom (m) =: ');
        n=input('2nd degree of freedom (n) =: ');
    case 4
        n=input('Degree of freedom (n) =: ');
    case 5
        a=input('a =: ');
        b=input('b =: ');
    case 6
        mu=input('Mean (mu) =: ');
        sigma=input('Standard deviation (sigma) =: ');
    case 7
        mu=input('Mean (Lamda) =: ');
    case 8
        n=input('Total number of trials (n) =: ');
        sigma=input('Probability of event A (p) =: ');
    case 9
        mu=input('R =: ');
        sigma=input('P =: ');
    case 10
        a=input('a =: ');
        b=input('b =: ');
end
if (sel==1)
    x=input('Random variable x =: ');
switch distri
    case 1
        pdf=normpdf(x,mu,sigma);
    case 2
        pdf=tpdf(x,n);
    case 3
        pdf=fpdf(x,m,n);
    case 4
        pdf=chi2pdf(x,n);
    case 5
        pdf=weibpdf(x,a,b);
    case 6
        pdf=lognpdf(x,mu,sigma);
    case 7
```

```
            pdf=poisspdf(x,lamda);
        case 8
            pdf=binopdf(x,n,p);
        case 9
            pdf=nbinpdf(x,R,P);
        case 10
            pdf=unifpdf(x,a,b);
end
fprintf('The value of probability density function, f(x) :\n');
fprintf(num2str(pdf));
end
if (sel==2)
    x=input('Random variable (x) =: ');
switch distri
    case 1
        cdf=normcdf(x,mu,sigma);
    case 2
        cdf=tcdf(x,n);
    case 3
        cdf=fcdf(x,m,n);
    case 4
        cdf=chi2cdf(x,n);
    case 5
        cdf=weibcdf(x,a,b);
    case 6
        cdf=logncdf(x,mu,sigma);
    case 7
        cdf=poisscdf(x,lamda);
    case 8
        cdf=binocdf(x,n,p);
    case 9
        cdf=nbincdf(x,R,P);
    case 10
        cdf=unifcdf(x,a,b);
end
fprintf('The value of cumulative distribution function, p=F(x) :\n');
fprintf(num2str(cdf));
end
if (sel==3)
    x=input('Probability (0<p<1) =: ');
switch distri
    case 1
        invs=norminv(x,mu,sigma);
    case 2
        invs=tinv(x,n);
```

```
    case 3
        invs=finv(x,m,n);
    case 4
        invs=chi2inv(x,n);
    case 5
        invs=weibinv(x,a,b);
    case 6
        invs=logninv(x,mu,sigma);
    case 7
        invs=poissinv(x,lamda);
    case 8
        invs=binoinv(x,n,p);
    case 9
        invs=nbininv(x,R,P);
    case 10
        invs=unifinv(x,a,b);
end
fprintf('The value of inverse cumulative distribution function, x=F-1(p) :\n');
fprintf(num2str(invs));
end
fprintf('\n');
pause
```

To use the calculator, first, you should have installed the MATLAB software in your computer. Second, double-click probTable.exe to run it (Fig. 3).

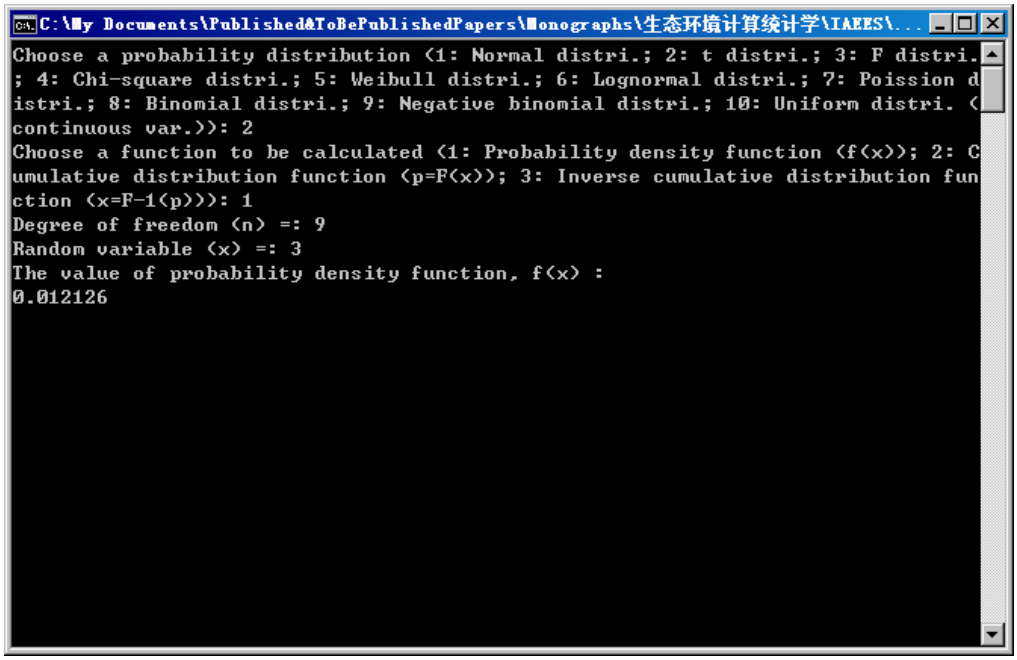

Fig. 3 Command lines of the calculator, probTable.

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