Computer Life (CPL) ISSN: 1819-4818
DELIVERING QUALITY SCIENCE TO THE WORLD

Application of information fusion in reliability analysis

Hongbiao Shi

Shanghai University Of Engineering Science, China

Abstract: This paper mainly introduces the meaning of information fusion. The advantage of information fusion in reliability analysis. The development prospects are better than the traditional reliability analysis. It also introduces the algorithm of information fusion and Bayes formula. In this paper, bayesian formula is used to predict the probability of success of the next experiment by analyzing the experimental data. This is only a small part of information fusion in reliability analysis. Information fusion will become more and more intelligent.
Keywords: Information fusion, algorithm, the bayesian, prediction.

1. INTRODUCTION

Information fusion means collecting different information data through different channels.
Then some combination of rules or methods are used to process the data. Finally, the data is processed and consolidated into a set of data. This set of data is more accurate than previous single data to reflect the specific situation. Its advantage is that it integrates different data information, which can reflect the current state more comprehensively. At the same time, the reliability analysis based on information fusion has a solid theoretical foundation[1].
The famous scholar shannon first proposed the definition of entropy in information theory in the late 1950s. The development of information theory is greatly promoted. Now the biggest difference between science and traditional science lies in the difference in content, not in the center of material and energy research, but in the center of information, matter and energy. The theory of entropy based on information theory is the theoretical basis of reliability analysis[2].
Definition 1.1
The set of current states of the system to be tested use $\Theta=\{\theta_1,\theta_2,\cdots,\theta_n\}$ to represent. The current state of the system to be tested use $\theta\in\Theta$ to represent. $P_i=p\{\theta=\theta_i\}$ is the probability of that state. So its entropy is:

$$H(\theta)=-\sum_{i=1}^{N}P_i\bullet\log P_i \tag{1-1}$$

Therefore, the above equation is the uncertainty of the current state diagnosis of the system.
Definition 1.2: using x to represent the current state parameter measured. X is random[3]. $X\in\{x_1,x_2,\cdots,x_M\}$, when $X=x_j$, the conditional entropy of the current state of the system is as follows:

$$H(\theta \mid X = x_j) = --\sum_{i=1}^{M} P(\theta_i \mid x_j) \bullet \log P(\theta_i \mid x_j) \qquad (1\text{-}2)$$

Definition 1.2: When the current state parameter x is measured. The conditional entropy of the current state of the system is as follows.

$$H(\theta \mid X) = \sum_{j=1}^{M} P(x_j) \bullet H(\theta \mid X = x_j) \qquad (1\text{-}3)$$

The above theorem indicates that the accuracy of reliability analysis can be improved by adding some relevant conditions. Reducing the uncertainty of reliability analysis of the current state of the system.

2. LEVEL AND METHOD OF INFORMATION FUSION

The level of information fusion is divided into data hierarchy, feature level and decision level.

Data level fusion, the obtained data is directly integrated processing. The next step is to conduct reliability analysis based on the results of these data processing. This level of integration is called data level integration. It is the lowest fusion level[4].

The integration of the feature level, each set of data is extracted with feature extraction, and a series of characteristic quantities are obtained. And the data fusion of the feature level is the fusion of these feature vectors. The fusion of the feature level is the second level of data fusion, also known as the middle level data fusion.

Integration of decision levels, the integration of decision-making level is the fusion of these decision vectors, and the fusion of decision-making level is the highest level of fusion in data fusion.

Method of information fusion: By combining information fusion and reliability analysis, better analysis results can be obtained, and the uncertainty of reliability analysis can be greatly reduced. A combination of bayesian theory, evidence theory, fuzzy set theory, neural network and integrated information theory is combined to obtain the following fusion algorithms. The following figure shows:

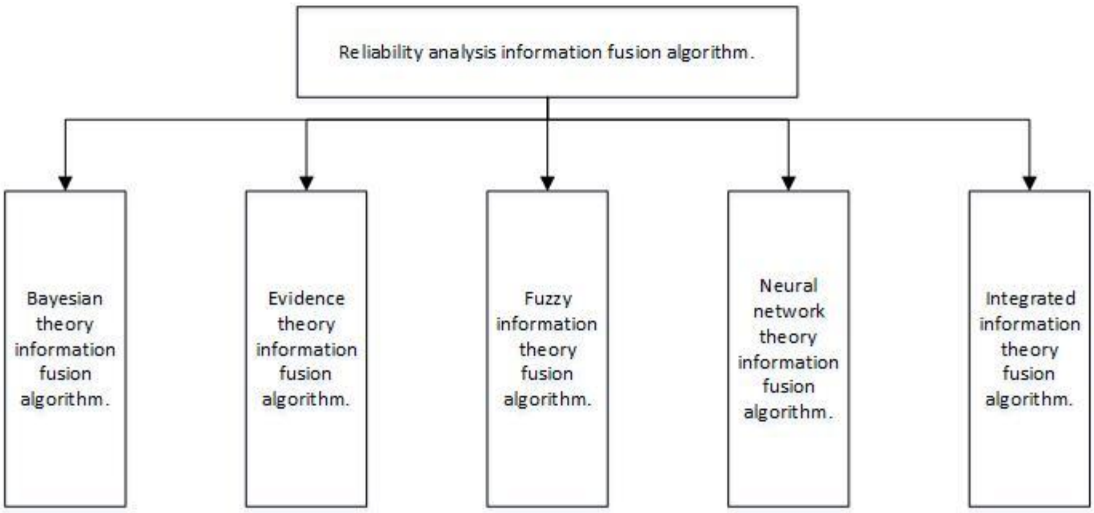

Figure 2.1 Information fusion algorithm

3. BAYES FORMULA

The core of bayesian reliability analysis is bayes' theorem. Bayes' theorem can update existing information by collecting data. In mathematics, bayes' theorem can be expressed as follows:

$$p(\theta|y) = \frac{f(y|\theta)p(\theta)}{m(y)} \tag{3.1}$$

Among them:

$$m(y) = \int f(y|\theta)\, p(\theta)\, d\theta \tag{3.2}$$

Function $p(\theta|y)$ called the posterior density function. Function $p(\theta)$ called the prior density function. $m(y)$ is the edge density function of the data. And the previous notation. $f(y|\theta)$ is the sampling density function of the data[5].

4. APPLICATION OF BAYESIAN THEORY IN RELIABILITY ANALYSIS

The following table shows the experimental data of a company launching a rocket.

These experimental data are used to analyze the success rate of the company. Through bayesian information fusion for reliability analysis. The bayesian formula is understood in the process of reliability analysis of bayesian theory. Reliability analysis is more accurate than traditional reliability analysis[6].

Table 4.1 experimental data.

name	result	name	result	name	result
S	successful	A	failure	C	failure
S	failure	A	failure	C	failure
S	failure	A	successful	C	successful
S	failure	A	failure		

For these experimental data, the main parameter π is the probability of success. Obviously π may be(0,1)any value. The first step of bayesian analysis is to determine the prior distribution of the estimated parameters.

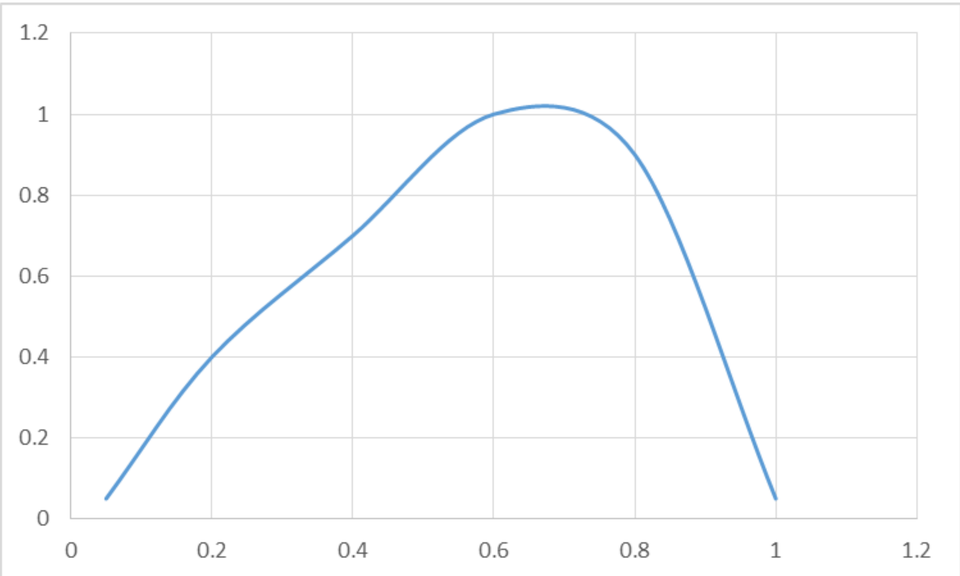

Figure 4.1Prior density function

For table 4.1 data, using previous data to determine the probability of a successful launch, the probability of a successful rocket launch is about 0.56. You can use one parameter $\alpha = 2.4, \beta = 2$ beta distribution as a prior distribution of successful rocket launch. figure 4.1. The probability density function of Beta distribution. Writing $\mathrm{Beta}(\alpha, \beta)$, Specific as follows:

$$\mathrm{p}(\pi|\alpha,\beta)=\frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)}\pi^{\alpha-1}(1-\pi)^{\beta-1}, 0\le\pi\le 1, \alpha,\beta>0 \quad (3.3)$$

Noticing that the main part of the prior distribution between 0.25 to 0.75, and the prior distribution of the value of alpha/(alpha + beta) = 0.55, the variance of ((alpha) 1)/((alpha + beta 2) = 0.53). The probability of this prior density is between 0.1 and 0.2 (0.0.2) and (0.75, 1). As can be seen from the figure, most of the prior distributions are concentrated around 0.5, the probability of falling in the interval (0.25, 0.75) is 0.6, and the probability of uniformly distributed falling in the same interval is 0.55.

The prior distribution $p(\theta)$ represents the initial estimation of the estimation parameters before the experiment. After get the test data, can take advantage of new information to update a priori information due to the updated be estimated parameters of probability reflects the understanding of parameters after getting the test data, so called the posterior distribution.

According to bayes's theorem, the posterior distribution is determined by multiplying the likelihood function and the prior distribution, which can be written in the following form:

Posterior distribution∝ likelihood function ×prior distribution

Because the $m(y)$ in equation 3.1 is independent of the model parameters, $m(y)$in the upper equation is regarded as one of the proportionality constant. Part of it doesn't happen directly[7]. Writing it as a probability density function, as follows:

$$\mathrm{p}(\theta|y)\propto f(y|\theta)p(\theta) \quad (3.4)$$

Bringing the data up here to the formula.

$$\mathrm{p}(\pi|y)\propto\pi^{3}(1-\pi)^{8}\pi^{1-1}(1-\pi)^{1-1} \quad (3.5)$$

Substituting that in:

$$\mathrm{p}(\pi|y)\propto\pi^{3}(1-\pi)^{8}\pi^{2.4-1}(1-\pi)^{2-1}\propto\pi^{5.4-1}(1-\pi)^{10-1} \quad (3.6)$$

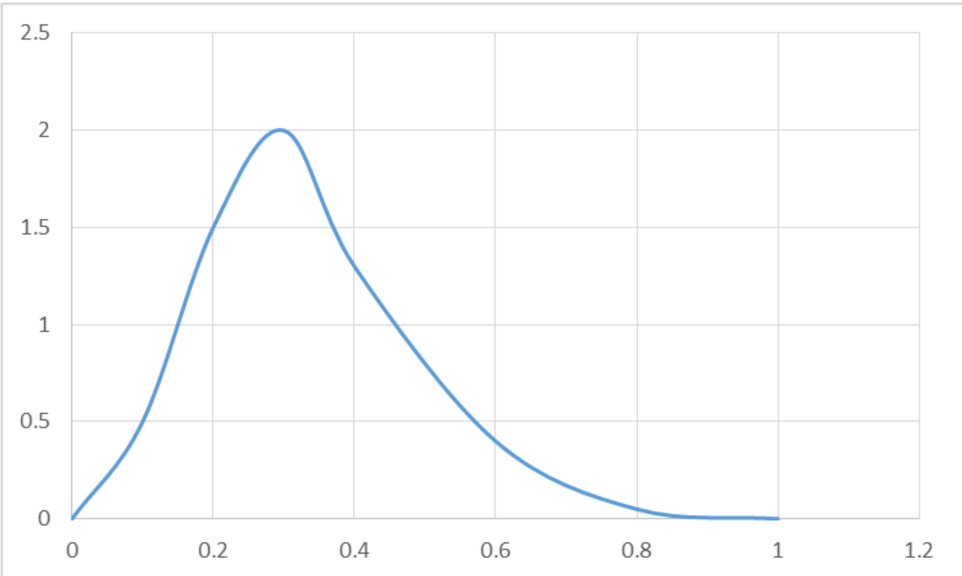

Figure 4.2Posterior density function.

The posterior distribution is proportional to the beta distribution, so the normalized constant is obtained in a similar way. In this case, The normalized constant is$\Gamma(15.3)/[\Gamma(5.5)\Gamma(11)]$. See below figure.

The posterior distribution shown in the figure contains all available information about the estimated parameters, after comprehensive consideration of prior and experimental data. All statistical inference from the bayesian school to the estimation parameters is derived from the posterior distribution. In the above example assumes that the prior distribution of uniform prior distribution, will be estimated parameters on interval (0.2, 0.2) beta can through the posterior distribution of probability density function (4, 9) in this range of integral, the final result is 0.73. The probability of the next successful launch is 0.73.

5. CONCLUSION

Due to the continuous development of artificial intelligence, the reliability analysis will become more and more intelligent. The above example simply illustrates the application of bayesian formula in reliability analysis. The fusion of the other methods such as neural network information fusion algorithm, itself is a kind of artificial intelligence algorithms, later of reliability analysis is more and more simple, the accuracy will be more and more high, only need sensor, data input, equipment can through the algorithm to calculate the reliability has been input, the service life of equipment, failure rate and so on.

REFERENCES

[1] Qi-hua WANG. Reliability Information Fusion Method Based on Evidence Theory[A]. ADVANCED SCIENCE AND INDUSTRY RESEARCH CENTER.Proceedings of 2017 2nd International Conference on Information Technology and Management Engineering(ITME 2017)[C].ADVANCED SCIENCE AND INDUSTRY RESEARCH CENTER:,2017:5.

[2]Qi LIU. Exponential System Reliability Test Design Based on Information Fusion[J].Journal of Donghua University(English Edition),2016,33(02):323-326.

[3]Hao CHEN. Bayesian Assessment for Reliability of Binomial Components Based on Information Fusion of Similar Products[J].Journal of Donghua University(English Edition), 2015, 32(06):940-945.

[4]Yongnan Wang. The Application of Information Fusion in Reliability Evaluation of Complex Electromechanical System[A].2015:4.

[5]Xu Shuyu. Study on Prior Information Fusion Method in Reliability Assessment for Low-voltage Switchgear[A]. China Electrotechnical Society(CES).Proceedings of the 26th International Conference on Electrical contacts and the 4th International Conference on Reliability of Electrical Products & Electrical Contacts[C].China Electrotechnical Society (CES):, 2012:4.

[6]J.Feng. Reliability Information Fusion Based on Bayesian Generalized Mean Operator[A]. Intelligent Information Technology Application Association.Future Communication, Computing, Control and Management(ICF4C 2011 LNEE 142)[C].Intelligent Information Technology Application Association:,2011:7.

[7]Jun-bo WAN~a,Tong-min JIANG~b,Xiao-yang LI~c,Yu FAN~d School of Reliability and System Engineering,Beihang University,Beijing 100191,P.R.China. An Information fusion Method for Reliability Based on D-S Evidential Theory[A]. 2010:4.