Journal of Humanities Insights 5(1): 005-009, 2021
Research Paper

Assess The Ability to Estimate Human Capability Using Error Statistical Analysis Softwares

Mehmet Gromchuk*

Department of Statistics, Faculty of Science, University of Istanbul, Istanbul, Turkey

Received: 11 December 2020 Accepted: 23 January 2021 Published: 01 March 2021

Abstract

Production systems confront many accidents, malfunctions and quality defects due to human errors. Human reliability analysis (HRA) has been developed to identify and quantify the human error probability. Each HRA method has its advantages and disadvantages and has proposed for a specific environment or system and utilizes some unreal assumptions to make the problem easier to solve this assumption derive the HRA method from reality and the obtained results are unreliable. To overcome this issue. We propose an Artificial Intelligence System (AIS) in cooperation with Response Surface Method (RSM) to provide a new HRA method (ARHRA) and make HRA closer to reality. This method proposes a framework to calculate the effects of performance shaping factors on human error probability (HEP) with AIS and RSM. The proposed model has been applied to a real case and the provided results show that human reliability can be calculated more effectively using ARHRA method.

Keywords: Realiability; Human Resource; Error; Response Surface Method

How to cite the article:
Mehmet Gromchuk, Assess the ability to estimate human capability using error statistical analysis softwares, J. Hum. Ins. 2021; 5(1): 005-009, DOI: 10.22034/jhi.2021.122568.

Introduction

In recent year dynamic HRM has become an interesting issue for study since many parameters influence the human reliability and the effect of these parameters on human reliability cannot be calculated by exact algorithm. [1-3] proposed the Information Decision and Action in Crew (IDAC) context for HRA. The model was developed to predict the responses of the control room operating crew in nuclear power plants to use this method in probabilistic risk assessments (PRA). Trucco and Leva [4] developed a new probabilistic cognitive simulator (PROCOS) to obtain the errors of human in operational systems, they used the quantification susceptibilities of the first-generation HRA with a cognitive evaluation for an operator. Di Pasquale et al. [5] proposed the Simulator for Human Error Probability Analysis (SHERPA), and utilized the advantages of the simulation technique and the traditional HRA methods to model human behavior and obtain the error probability for a specific scenario in production systems. In these models the effect of PSFs have been simulated and the result used to predict the HEP. Simulation of the PSFs effect on HEP requires the occurrence probability of each PSFs and the manner of PSFs effect on HEP. In many real situations, these data are not available or accurate. Also, most of HRA methods have been developed in a specific context, such as nuclear power plants and less methods have been proposed for production systems.

In this paper, we combine the HRA and AIS with RSM and propose a new HRA Method as ARHRA.

* Corresponding Author Email: Mehmet.g@ui.ac.tr

This method uses the AIS to calculate the HEP based on several environmental, work (duration, type) and human (age, sex) factors, and RSM to investigate the effect of each PSF on human error.

Human error probability calculation

According to The THERP method, HRA aims to find the contribution of human reliability to the system reliability, that is to say, the aim is to predict human error probability and assess the total unreliability of human– machine systems likely to be caused by human in association with equipment, machines, procedures and other system and human characteristics which influence the production system [6].

The first step in the HRA is the error identification. In this step all probable errors should be identified with their consequences. The second step is calculating the occurrence probability for each identified error and the final step is the reduction of error probability.

It should be noted that data gathering to use this formula is not simple, some researchers presented that HEP is derived from four Contextual Control Modes (CoCoMs), scrambled, opportunistic, tactical and strategic in first generation an several PSFs such as stress and complexity, but dynamic HRA presented that HEP is a result of human performance factor relations and dependencies such as work type and work time [8].

Performance shaping factors

PSF was advocated by Swain [9] first time and usually treated as ‘‘the regulation item for the introduction of the error rate’’ or ‘‘the providing items for the prediction of human error’’. In fact PSFs are the aspects of human behavior and the context that can impact on human resource performance, these factors were viewed in terms of the effects, they might exert on human performance such as work efficiency and system reliability. Many PSFs and categories have been proposed by researchers for different systems such as nuclear or power plant, [12, 11].

In practice, the number of PSFs that are included in HRA methods lies between these 1 to 62 PSFs. For example, the SPAR-H method [6], which is widely used in the US nuclear industry, includes eight PSFs. The internationally widely used Cognitive Reliability and Error Analysis Method (CREAM) [10] uses nine PSFs. Boring studied the important PSFs and proposed 8 PSFs that are considered in common HRA methods [13]. These PSFs are as follows:

- Available Time
- Stress
- Complexity
- Experience and Training
- Procedures
- Ergonomics
- Fitness For Duty
- Work Process

PSFs may have a negative impact or a positive impact on human error. When the influencing factor represents a positive impact, it corresponds to a value less than one; which is used to decrease the HEP value. Also the PSF represents a negative impact, it corresponds to a value greater than one and leads to decreases the HEP. The total impact of PSFs is calculated using below equation

$$Total\ PSFs\ Impact = IPSF_1 * IPSF_0 * \ldots * IPSF_8$$

Equation (1) shows that the total impact of PSFs is the multiplication of each PSF impact (IPSF). The HEP formulation has been shown by:

$$HEP_{composite} = \frac{HEP_{nominal} \cdot PSF_{total}}{HEP_{nominal} \cdot (PSF_{total} - 1) + 1}$$

Although Equation (3) is used to obtain the human error probability considering the PSFs in some mentioned methods. In this paper, we investigate the impact of PSFs on HEP separately, the PSFs impact on HEP are evaluated by AIS. That is to say, in the proposed method the value of $HEP_{composite}$ are predicted by AIS and historical data and there is no need to calculate the $HEP_{nominal}$ in the first step.

Artificial Immune System

A simplified view of the human immune system is that it is made up of two types of cells, B cells and T cells. Upon encountering an antigen B cells are stimulated by a number of sources and with the help of T cells undergo cloning and somatic hyper-mutation. The antigens are then attacked by killer T cells and removed from the system. The immune system maintains a memory of the infection so that if ever exposed to the same antigen a quicker response can be elicited against the infection. Several theories as to how immune memory works have been proposed. The Immune Network Theory, first proposed by Jerne[14], proposes that a network dynamically maintains the immune memory using feedback mechanism. Thus if something has been learnt, it can be forgotten unless it is reinforced by other parts of the network. With the B cell clones undergoing mutation the immune system can defend itself not only against previously known antigens, but also slight variations of such antigens. It is this behavior on which the AIS capitalize.

RSM

Response surface method has been proposed by Box and his collaborators [15]. This method was derived from the multidimensional graph to assess the fitness of the mathematical model.

RSM consists of a group techniques that aim to fit an empirical model based on the experimental data, to achieve this goal, linear or square polynomial functions are employed to describe the system studied and, to optimize the experimental conditions in order to propose the optimal configuration of input parameters [16].

ARHRA Framework

The proposed framework to assess the human reliability is shown in Figure 1. As could be seen the framework has two subsystems, the first is AIS that evaluate the effect of PSFs on human error and the second is RSM which identify the most effective PSFs in different systems. This framework proposed the HEP value and provide the most effective PSFs in different systems that leads to reduce time and cost in data gathering and increase the accuracy of HEP value.

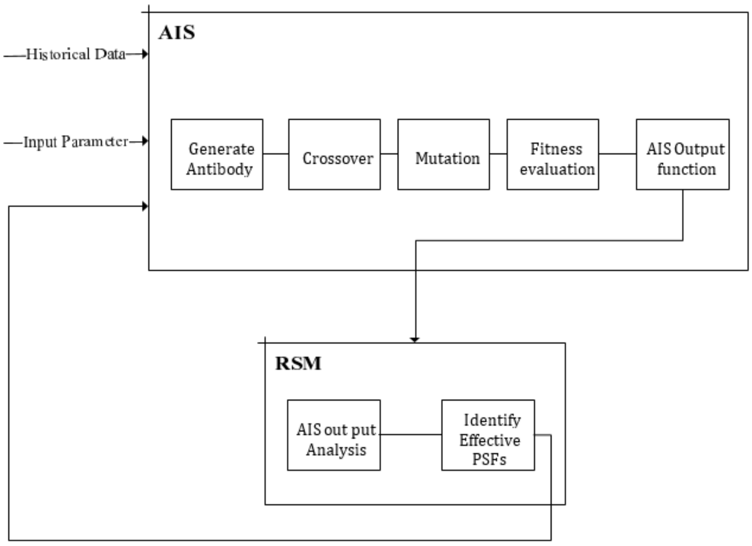

Figure 1. ARHRA framework

Numerical example

We use the proposed framework to assess the human reliability in a real production system. In this case a melting workshop with one human resources and 8 PSFs has been considered. In some day the error rate of the human resources has been measured by sampling the PSFs to produce some historical data. The obtained data are shown in Table 0. As could be seen we have values for each PSFs and human reliability. The PSFs multipliers can be found in [17] and [18].

Table 1. The PSFs level for each instances

	Available Time	*Stress*	*Complexity*	*Experience And Training*	*Procedures*	*Ergonomics*	*Fitness For Duty*	*Work Process*	*HEP*
Ins 1	2021	2	0	2	1	12	2	5	20155
Ins0	2021	1	5	205	5	12	5	2	2003
Ins 3	12	1	2	1	02	1	5	1	2017
Ins 4	201	5	5	205	5	2	2	205	2019
Ins 5	201	1	1	2	1	2	2	1	2029
Ins 6	1	0	5	2	02	2	2	5	2005

Using AIS, we try to determine the effect of each PSF on HEP based on a first degree equation. Table 0 shows the results proposed by AIS for historical data.

As could be seen the difference between HEP and Estimated HEP is large in some instances, such as instance 1, 3 and 6. To eliminate this tolerance we use the RSM method to identify the most effective

PSFs and remove the ineffective PSFs to increase the accuracy of AIS.

According to above equation the sixth PSF has not an important effect on human error and can be eliminated from AIS parameters, therefore this PSF have been eliminated and the AIS run again to increase the accuracy of HEP estimation. The results are shown in Table 3.

Table 2. The estimated HEP by AIS

	HEP	Estimated HEP	SE
Ins 1	20155	20134	4041E-24
Ins2	2003	2019	1062E-23
Ins 3	2017	20160	6042E-25
Ins 4	2019	2004	0052E-23
Ins 5	2029	2011	4022E-24
Ins 6	2005	2000	9022E-24
Ins 7	2013	2015	4022E-24

Table 3. The results proposed by AIS after RSM

	HEP	Estimated HEPBefore RSM	Estimated HEPAfter RSM	SE-Before RSM	SE-After RSM
Ins 1	20155	20134	20140	4041E-24	1069E-24
Ins2	2003	2019	20013	1062E-23	0089E-24
Ins 3	2017	20160	20163	6042E-25	4092E-25
Ins 4	2019	2004	20003	0052E-23	1029E-23
Ins 5	2029	2011	20125	4022E-24	0005E-24
Ins 6	2005	2000	20006	9022E-24	5076E-24
Ins 7	2013	2015	20140	4022E-24	1044E-24

Conclusion

In recent years, many efforts have been done to assess the human reliability and human error probability. In this regard, Human reliability analysis (HRA) methods have been proposed to measure the human error probability and reliability. Each method has its advantages and suffers from some disadvantages, also most of these methods have been proposed for specific systems such as nuclear or power plants. On the other hand human reliability also is an important issue in production systems and some methods should be proposed to evaluate the reliability of human in these systems. In this paper, we proposed an Artificial Immune System based Response Surface Method HRA (ARHRA). This method proposed a framework to calculate the effects of performance shaping factors (PSFs) on human error probability (HEP) with AIS and RSM. Using RSM helps to find the most effective PSFs and eliminate the ineffective PSFs based on the conditions of production systems.

References

1) Chang, Y.H.J., Mosleh A. Cognitive modeling and dynamic probabilistic simulation of operating crew response to complex system accidents. Part 0: IDAC performance influencing factors model. *Reliability Engineering & System Safety,* 0227. 90(8): 1214-1242.
2) Chang, Y.H.J. Mosleh A. Cognitive modeling and dynamic probabilistic simulation of operating crew response to complex system accidents: Part 3: IDAC operator response model. *Reliability Engineering & System Safety,* 0227. 90(8): 1241-1262.
3) Chang, Y.H.J., Mosleh A. Cognitive modeling and dynamic probabilistic simulation of operating crew response to complex system accidents. Part 4: IDAC causal model of operator problem-solving response. *Reliability Engineering & System Safety*, 0227. 90(8): 1261-1275.
4) Trucco, P., Leva M.C. A probabilistic cognitive simulator for HRA studies (PROCOS). *Reliability Engineering & System Safety*, 0227. 90(8): 1117-1132.
5) Di Pasquale, V., et al. A Simulator for Human Error Probability Analysis (SHERPA). Reliability Engineering & System Safety, 0215. 139: 17-30.
6) Cacciabue, P.C. 1998. Modelling and simulation of human behaviour for safety analysis and control of complex systems. *Safety Science*, 08(0): 97112.
7) Kirwan, B. 1996. The validation of three human reliability quantification techniques — THERP, HEART and JHEDI: Part 1 — technique descriptions and validation issues. *Applied Ergonomics*, 07(6): 359-373.
8) Hollnagel, E. 1994. Simplification of Complexity: The Use of Simulation to Analysis the Cognition of Reliability. in: Reliability and Safety Assessment of Dynamic Process Systems. Springer, Berlin, Heidelberg, NY, USA.
9) Swain, A.D. 1967. Field calibrated simulation, Proceeding of the symposium on human performance quantification in system effectiveness. *National academy command and the national academy of engineering*, IV-1–IV-A-01.
10) Miller, D.P., Swain A.D. 1987. Human error & human reliability. In: G. Solvandy (Ed.), Handbook

of Human Factor, Prude University, WileyInterscience, New York.
11) Williams, J.C. 1986. HEART-A proposed method for assessing and reducing human error. in Procedure of the 9th Advances in Reliability Technology Symposium. University of Bradford.
12) Leva, M.C., et al. Quantitative analysis of ATM safety issues using retrospective accident data: The dynamic risk modelling project. *Safety Science*, 0229. 47(0): 052-064.
13) Boring, R.L. How many performance shaping factors are necessary for human reliability analysis. in the 12th International Probabilistic Safety Assessment & Management Conference (PSAM12). 0212. Seattle, US.
14) Jerne, N. 1974. Towards a network theory of the immune system. *Annals of Immunology* 105: 373-389.
15) Bruns, R.E., I.S. Scarminio, and B.B. Neto, *Statistical Design – Chemometrics*. 0226, Amsterdam: Elsevier.
16) Teofilo, R.F., Ferreira M.M.C. Chemometrics II: spreadsheets for experimental design calculations, a tutorial. Quím. Nova [online], 0226. 09(1): 338-352.
17) Boring R.L., Blackman H.S. The origins of the SPAR-H method's performance shaping factor multipliers, in Human Factors and Power Plants and HPRCT, 13th Annual Meeting. 0227, Sage Publications. pp. 177-184.
18) Gertman, D., et al. The SPAR-H human reliability analysis method, n.R. Commission, Editor. 0225: Washington.