Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Analyze the factors influencing human-robot interaction using MCDM method

R.K.A. Bhalaji [a], S. Bathrinath [a,*], S.G. Ponnambalam [b], S. Saravanasankar [a]

[a] Department of Mechanical Engineering, Kalasalingam Academy of Research and Education, Krishnankovil 626126, India
[b] Universiti Malaysia, 26000 Pekan, Pahang, Malaysia

ARTICLE INFO

Article history:
Received 6 March 2020
Received in revised form 3 June 2020
Accepted 16 June 2020
Available online xxxx

Keywords:
HRI
Multi-criteria decision making
DEMATEL
Medical equipments
India

ABSTRACT

Robots play a key role in medical equipment manufacturing industry by safeguarding human workers from hazardous environment and risky jobs. Human robot interaction (HRI) is one of the robotic features that are enhanced in industrial robots. They mimic human behavior while arriving at a decision, contributing to the proficiency of the product. Tasks involving human cognitive skills and flexibility in the workers are combined with robots to obtain high-level accuracy, repeatability, and speed. Further, more challenges are to be met for achieving an effective human-robot interaction. In this paper, risk factors affecting the interaction between both robot and humans are discussed, and a contextual case is performed in a top south Indian medical equipment manufacturing industry. Industrial experts' inputs and relevant literature are considered to recognize the risk factors. Multi-Criteria decision-making method (MCDM) like DEMATEL (Decision Making Trial and Evaluation Laboratory) is used to analyze the risk factors influencing HRI in the assembly section. The paper's findings show that automation level and reliability of the robot are the most influential factor in the assembly section and need more attention to control and reduce the risk factor for the effective assembly.

1. Introduction

Recently, many industries are using robots because of their capability to do repeated work in all kinds of environments with good accuracy and precision. As per the international federation of robotics in 2019, over 2.6 million robots are used for the operational purposes in industries and also at an average of 13% of robots are being introduced newly by the industries every year. For the past few years, while considering the manufacturing industry's medical equipment, the robots are mainly used in the assembly section because of its handling, palletizing, cutting, finishing, and spraying skills. Nowadays, it is essential to manufacture the product with the interaction of both robot and human to complete the process faster with the desired precision [1]. The main aim of the HRI is to increase productivity by means of integrated automation. To effectively making the products, there is a need for excellent communication between robots and humans. In the case of the assembly section in the automotive industry, there are several risk factors engaged in between human-robot interaction. Due to these reasons, there is a lack of communication between them, and it affects the components assembly. The key objective of this research is to recognize the risk factors from the relevant literature collection, as well as input from experts, and then assess and analyze the risk factors using DEMATEL. The results of the research will be useful for the industrial managers for controlling the risks as well as implementing the human-robot interaction. Further risks involved in the HRI process are explored by many researchers [2,3]. This research considers the ensuing questions:

a) What are the major risks in a HRI?
b) What are the interactions between the risks in a HRI?
c) How will the major risks be sorted into cause and effect groups to give valuable implications for managers in industry?
d) How will the cause and effect group risks be useful to industrial managers for achieving a strong HRI?

* Corresponding author.
E-mail address: bathri@gmail.com (S. Bathrinath).

https://doi.org/10.1016/j.matpr.2020.06.316
2214-7853/

Please cite this article as: R. K. A. Bhalaji, S. Bathrinath, S. G. Ponnambalam et al., Analyze the factors influencing human-robot interaction using MCDM method, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.06.316

2. Relevant literature

2.1. Risk factors involved in Human-Robot interaction

Robinette et al. [4] examined the factors that influence HRI in critical-time scenarios. Performance of the robot and emergency evacuation are the critical factors that influence HRI are shown in the results. Fossum et al. [5] addressed the challenges in project management and to design and develop the new technology that are not in the human factors. For this purpose, they have conducted a case study for human-robot interaction. The results shown that poor communications for operations and support, way to keeping and using procedures for operations and organization operations are the key factors affecting human-robot interaction. Hancock et al. [6] assessed the risk factors that are influencing interaction between human and robot and also 29 case studies are conducted and finally the data are collected. Reliability and behaviour of the robot, workload of the operator and also the type of task are the critical factors in the human-robot interaction that are depicted in the outcomes. Hoff and Bashir [7] studied the factors con-sequencing trust between robot and human in the automation. The consequences revealed that learned, situational and dispositional trust is the most influential trust and therefore more consideration should be given to this trust for the effective automation. Johannsmeier and Haddadin [8] created a model for task allocation and identified the factors affecting collaboration between human and robot in the assembly unit. The findings of the paper presented that collision handling, handover as well as pickup and assembling the spare parts are the vital factors in the assembly section and therefore, they need to implement some suitable systems for reducing the risk factors. Maurtua et al. [9] analysed the safety aspects, trust and interaction for robot and human in the application of industries. Safety monitoring, pointing gestures and manual guidance are needed for controlling the risk as well as improving the safety in the human-robot interaction is presented in the results. Tsarouchi et al. [10] reviewed the HRI (Human Robot Interaction) and addressed the challenges in programming and task planning. The outcomes shown that they introduced robot programming systems, tools and sensors for the effective coordination between both robot and human. Villani et al. [11] conducted the survey on collaboration between both robot and human in the industrial working scenario and they are more concentrated on the issues in cognitive and physical interaction. Moreover, they initiated collaborative solution for enhancing the system efficiency and controlling risks.

3. Research gap

Medical equipment manufacturing industry requires to be more efficient in the HRI process for achieving the trademark in their world market and business. Industry has poor skill about HRI in the rising nations like India. Interaction between both human and robot can add value to the industrial development for the future perspective, a place in which robots and humans can perform tasks and work together is known as Human-Robot interaction. Literature identified the risk factors intricate in the HRI in different industries. However, industry may manage dissimilar hurdles when undertaking the HRI process. As a result, the influence of specific risk factors may differ from industry to industry. Risk factors involved are not discussed adequately and risks ranking are also missing in the literature. To fulfil this gap, we have deliberated this study which will helpful in determining the critical risks as per the contextual case. For this purpose, this paper uses DEMATEL method for evaluating the inter-relationship among various risk factors and risks ranking in HRI. Some highlights of this paper are discussed below.

- Recognize the factors that influence HRI from relevant literature and also with the help of industrial experts as depicted in Table 1.
- Propose an outline to assess HRI risk factors in Indian environment with the help of MCDM method.
- Verify the suggested outline with a contextual case from the south Indian medical equipment manufacturing industry. The outcomes attained are then compared with present literature.

4. Outline of the paper

To achieve the objective of this paper, an outline is suggested in Fig. 1, to find the most influential risk factors in the HRI. The suggested outline consists of five phases. The risk factors are identified by using relevant literature in the similar field and from industrial experts as in the first phase. Industrial experts provided the rating for the risk factors as in second phase. In the third and fourth phase, select the method for solution like DEMATEL and analysis of data and assessment of outcome with the case study are carried out. Acquired outcomes are investigated and validated in fifth phase.

5. Method for solution

DEMATEL is a MCDM method used to analyse the interrelationship between each and every risk factor as well as it is used to solve problems with complicated. Recently, for analyzing the problem many investigators used DEMATEL method [12,13]. Linguistic scale was used for rating the risk factors as exhibited in Table 2. DEMATEL technique procedure is discussed in detail below [14–18]

Step 1: Compute the IRM-Initial relationship matrix (‘A’).

The first step of DEMATEL is to compute the initial relationship matrix ‘A’ dependent on the comments from industrial and domain specialists, on a scale fluctuating form 0 to 4 point linguistic scale and it is shown in Table 3.

$$A = \begin{bmatrix} 1 & A_{12} & A_{13} & \dots & A_{1(n-1)} & A_{1n} \\ A_{21} & 1 & A_{23} & \dots & A_{2(n-1)} & A_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \\ A_{(n-1)1} & A_{(n-1)2} & A_{(n-1)3} & \dots & 1 & A_{(n-1)1} \\ A_{n1} & A_{n2} & A_{n3} & \dots & A_{n(n-1)} & 1 \end{bmatrix} \quad (1)$$

Table 1
Factors influencing human-robot interaction in assembly section.

Notation	Risk Factors	References
A1	Reliability of the Robot	Salem et al., 2015
A2	Automation level	Tsarouchi et al., 2017
A3	Amount of training	Mehrholz et al., 2015
A4	Operator workload	Landi et al., 2018
A5	False Alarms	Teo et al., 2018
A6	Situation awareness	Guzman et al., 2016
A7	Robot type	Dragan et al., 2015
A8	Prior experiences	Alterovitz et al., 2016
A9	Behavior of the robot	Mead and Mataric 2016
A10	Culture	Andrist et al., 2015
A11	Adaptability of robot	Clair et al., 2016
A12	Proximity	Gabler et al., 2017
A13	Surrounding environment	Zouoi et al., 2019
A14	Complexity of the task	Pardo et al., 2016
A15	Comfort and Attitudes towards robot	Backonja et al., 2018

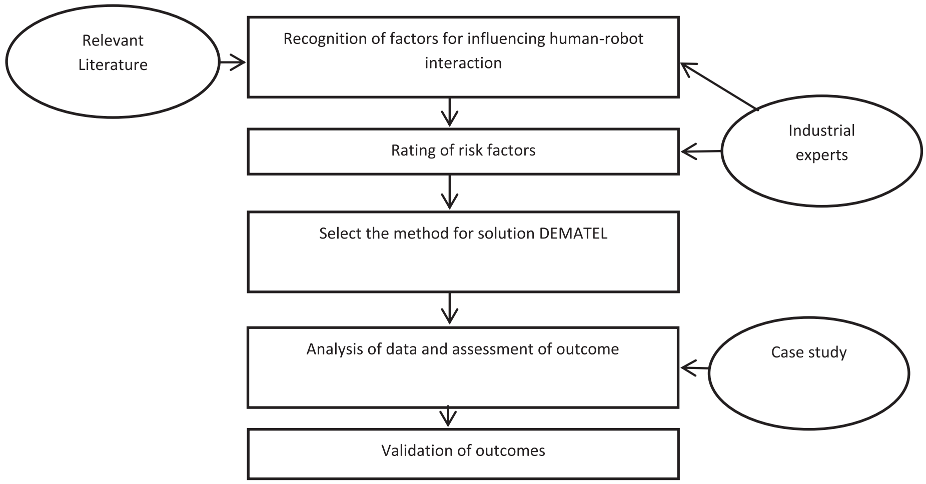

Fig. 1. Suggested outline for identifying most influential risk factor.

Table 2
Linguistic scales and their ratings.

Elements	Ratings
Very high influence	4
High influence	3
Low influence	2
Very low influence	1
No influence	0

Step 2: Normalize the matrix 'A' ('C').

The Initial relationship matrix (A) found in step 1 is normalized across the equations.

$$C = B \times A \tag{2}$$

$$B = \frac{1}{\max_{1 \leqslant i \leqslant n} \sum_{j-1}^{n} A_{ij}} \tag{3}$$

Where C indicates Normalization.

Step 3: Calculate the TORM-Total relation matrix ('D')

The next step identifies the total relation matrix. It is determined with the assist of (*C*) which is calculated in the earlier phase by using Eq. (4) where *I* signify the Identity matrix and it is shown in Table 4.

$$D = C(I - C)^{-1} \tag{4}$$

Step 4: Calculate the summation of rows and columns.

Summation of rows and columns are indicated by 'e_i' and 'f_i'and it is acquired through Eqs. (5) and (6) and it is exhibited in Table 3.

$$e_i = \left[\sum_{j-1}^{n} D_{ij}\right]_{n \times 1} \tag{5}$$

$$f_i = \left[\sum_{i=1}^{n} D_{ij}\right]_{1 \times n} \tag{6}$$

Step 5: Construct the Causal diagram.

By using the values of both $e_i$andf_i, draw the causal diagram and mapping the both vertical and horizontal axes of the graph. Most influential risk factor and their interrelationship with each other are defined in causal diagram.

6. Case study

For analyzing the risk factors, a contextual case is performed in a top medical equipment manufacturing industry in southern part of India, which has over 500 employees with a turnover of more than 50 crores. The name of the industry is not mentioned in the paper because of anonymization. In the assembly section of this industry, there is always problem arises because of the risks involved in HRI. It affects the interaction among both robot and human and hence it leads to delay and affecting the process which impacts the negative influences to the assembly section. To overcome this issue, identification and analysis of risk factors is required and DEMATEL technique is used to solve the problem. Decision makers like chief engineer, production manager and senior executive engineer are formed to provide the rating of iden-

Table 3
IRM (Initial relationship matrix).

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
A1	0	3	2	2	3	1	3	3	4	3	2	2	2	3	2
A2	3	0	3	3	4	2	2	1	3	2	2	3	2	4	1
A3	2	2	0	1	4	2	1	3	3	2	2	3	1	3	2
A4	**1**	1	2	0	4	2	1	3	3	2	1	2	1	3	1
A5	3	4	3	3	0	2	1	3	2	3	2	1	3	3	2
A6	1	1	2	2	2	0	1	1	1	1	1	1	1	2	1
A7	2	2	2	2	1	1	0	2	3	2	3	1	2	2	2
A8	1	1	2	2	3	2	1	0	2	3	1	2	2	3	2
A9	2	2	2	1	2	1	3	1	0	1	3	2	2	2	2
A10	1	1	1	1	1	1	1	2	3	0	1	2	1	3	1
A11	2	2	1	2	1	1	2	1	2	1	0	2	1	2	1
A12	1	1	2	2	1	1	1	3	1	1	1	0	2	3	1
A13	1	1	2	2	1	1	1	1	2	1	1	1	0	3	1
A14	2	2	3	2	1	1	1	2	1	1	2	2	2	0	1
A15	2	1	1	1	1	1	2	2	2	1	2	1	1	1	0

Table 4
TORM (Total relationship matrix).

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
A1	0.140	0.217	0.214	0.199	0.241	0.137	0.197	0.235	0.279	0.214	0.192	0.197	0.187	0.284	0.168
A2	0.217	0.145	0.241	0.226	0.268	0.163	0.172	0.191	0.255	0.190	0.192	0.223	0.188	0.310	0.143
A3	0.176	0.178	0.145	0.159	0.246	0.150	0.133	0.219	0.231	0.174	0.174	0.205	0.148	0.260	0.155
A4	0.135	0.137	0.179	0.115	0.230	0.138	0.118	0.202	0.211	0.160	0.134	0.164	0.133	0.238	0.118
A5	0.210	0.234	0.233	0.219	0.167	0.160	0.143	0.230	0.228	0.210	0.185	0.171	0.205	0.280	0.163
A6	0.100	0.101	0.138	0.130	0.141	0.059	0.088	0.113	0.121	0.100	0.099	0.104	0.097	0.162	0.088
A7	0.158	0.158	0.174	0.163	0.154	0.110	0.095	0.172	0.214	0.156	0.184	0.139	0.153	0.210	0.140
A8	0.131	0.132	0.174	0.162	0.199	0.135	0.115	0.122	0.184	0.179	0.130	0.160	0.153	0.233	0.138
A9	0.157	0.157	0.172	0.138	0.173	0.108	0.167	0.146	0.134	0.128	0.182	0.159	0.152	0.205	0.138
A10	0.105	0.105	0.119	0.110	0.119	0.088	0.095	0.142	0.175	0.077	0.106	0.135	0.104	0.193	0.092
A11	0.137	0.138	0.127	0.143	0.129	0.094	0.127	0.125	0.162	0.111	0.086	0.141	0.109	0.179	0.097
A12	0.108	0.109	0.150	0.140	0.127	0.094	0.096	0.173	0.132	0.109	0.108	0.088	0.132	0.201	0.096
A13	0.103	0.103	0.141	0.132	0.118	0.087	0.092	0.115	0.148	0.101	0.103	0.107	0.073	0.190	0.090
A14	0.144	0.145	0.185	0.151	0.141	0.101	0.106	0.160	0.147	0.119	0.143	0.151	0.141	0.142	0.104
A15	0.128	0.104	0.115	0.108	0.117	0.087	0.120	0.139	0.151	0.103	0.129	0.106	0.101	0.140	0.065

Table 5
Cause and effect group.

Rank	Cause group	$e_i - f_i$
1	A2	0.960
2	A1	0.953
3	A7	0.516
4	A5	0.468
5	A3	0.245
6	A4	0.119
Rank	Effect group	$e_i - f_i$
1	A6	−0.068
2	A15	−0.083
3	A8	−0.135
4	A11	−0.244
5	A10	−0.367
6	A13	−0.372
7	A12	−0.386
8	A9	−0.456
9	A14	−1.148

tified risk factors in the form of questionnaire with the help of linguistic scale and it is shown in Table 2. The managers from industries could use the outcome of this research for understanding about the type of risks involved in the section and in turn helps them to mitigate the risks and also to implement the interaction with both robot and human.

7. Analysis and discussion of results

The aim of the research is to recognize the most influential factor in the human-robot interaction in south Indian medical equipment manufacturing industry. By using the DEMATEL method, HRI risk factors were evaluated and the consequences as exhibited in Table 5. The causal diagram demonstrates the most influential factor in the HRI process as shown in Fig. 2 and it is sorted into two groups namely cause and effect group. The risk factors in the cause group are arranged as follows based on the order of sequence: A2 > A1 > A7 > A5 > A3 > A4. Automation level (A2) is top priority in the cause group with $e_i - f_i$ value of 0.960. In the HRI process, automation level in the robot is poor because of improper maintenance also not upgrading the software programs. Based on the application scenario, which is affected by many factors such as utilized robot, work task and available technologies, the automation level can vary from coexisting in the working environment to actually being physically attached to each other. Hence it is necessary to incorporate new technology to obtain proper communication between human and robots in assembling section. The second factor in the cause group is Reliability of the robot (A1) with $e_i - f_i$value of 0.953. Robot will perform work satisfactorily within the prescribed time interval as per the designed conditions. Poor reliability of the robot is source of cause for many issues such as inconvenience, condition with unsafe environment and high cost

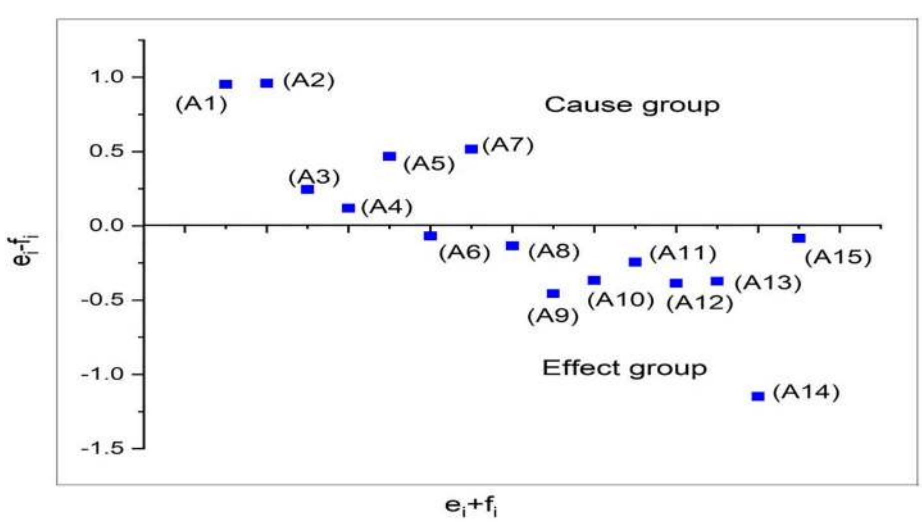

Fig. 2. Causal diagram.

Please cite this article as: R. K. A. Bhalaji, S. Bathrinath, S. G. Ponnambalam et al., Analyze the factors influencing human-robot interaction using MCDM method, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.06.316

of maintenance. Therefore they need to improve a standard for robot reliability and preventive maintenance for the robot since it diminishes the cost of unexpected failures and repairs and hence it enhances the safety of human.

The final factor in the cause group is operator workload (A4) with $e_i - f_i$ value of 0.119. It is mainly due to person who maintain, operate, design, test and manufacture a robot. As per the reports, 30 to 60% of all failures in HRI were due to these risks. They need to implement some techniques for reducing the risks such as fault tress, man–machine systems analysis and error-cause removal program.

Based on the sequential order the risk factor in the effect group is arranged as follows: A6 > A15 > A8 > A11 > A10 > A13 > A12 > A9 > A14. Situation awareness (A6) is the first factor ranked in the effect group with $e_i - f_i$ value of −0.068. In case of fire emergency or others, the ability of the robot to comprehend and to surpass from the blocked environments without human intervention. Therefore we suggest an RSAW (Robot situation awareness) system, improved in order to assist a robot to surpass the difficult situation in the working environment and achieving the objectives while reducing the human interventions as well as it increases robot autonomy. Comfort and attitudes towards robot (A15) with $e_i - f_i$ value of −0.083 is second one in the effect group. Most of the employees have negative attitudes towards robot in some situations and discomfort with respect to social impact. Therefore the industry needs to buy PARO robot for the good attitudes and comfort with human. Surrounding environment (A13) has $e_i - f_i$value of −0.372. Robot used the sensor for obtains data from surrounding environment to provide required input signals to the controller and it carry out activities for achieving the preferred tasks. Some robots have poor sensors because they are dependent on the human organ functions. Therefore, industry need to buy autonomous robot because it has skill to understand information related to surrounding environments without the intervention of human and it works for a long period of time. Complexity of task (A14) has $e_i - f_i$ value of −1.148. Based on the required decision and the amount of sensing, there are four different levels for task complexity for robots. So they need to use level 1 for achieving the better accuracy in assembly section.

8. Conclusion

Medical equipment manufacturing industry contains several risk factors in the HRI in the assembly section. This paper not only deliberates the process of HRI but also comprehend the significance of HRI in the Indian scenario. The industrial managers are facing a lot of challenges to control the risk factors. Because of restriction of time, they are using some traditional techniques for examining the risk factors but it is a difficult activity to manage it. For solving this issue, the most influential risk factors are identified by using DEMATEL, a multi-criteria decision making method. Automation level (A2) and reliability of the robot (A1) is the vital one of human-robot interaction in the assembly section based on the causal diagram in Fig. 2. Robot with advanced programmes and technologies, good reliability, behavior and also the Robot Situation Awareness (RSAW) system is much needed for controlling the risks as well as improving the interaction with human-robot. Finally, Selective Compliance Assembly Robot Arm (SCARA) robot is required for the industry because it has good performance in the assembly section.

The results reported in this paper are based on only subjective decisions and the expert's team. It has several limitations that can be investigated in the future. DEMATEL method is used in this paper for analysing the risk factors but other ranking methods like VIKOR, AHP and ANP could also be tested. Finally, the case study conducted is in an industry located in southern part of India. Future researchers may explore a similar study in different regions in India to find the influence of factors on the HRI process.

CRediT authorship contribution statement

R.K.A. Bhalaji: Writing - original draft, Methodology. **S. Bathrinath:** Validation. **S.G. Ponnambalam:** Formal analysis. **S. Saravanasankar:** Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thanks to the management of medical equipment manufacturing industry and Kalasalingam Academy of Research and Education for carried out the research work.

References

[1] L. Probst, L. Frideres, B. Pedersen, C. Caputi, Service innovation for smart industry: human–robot collaboration, European Commission, Luxembourg (2015).
[2] M.S. Erden, J.A. Jonkman, Physical human-robot interaction by observing actuator currents, Int. J. Rob. Autom. 27 (3) (2012) 233.
[3] M. Zheng, P.X. Liu, Q.H.M. Max, Interpretation of human and robot emblematic gestures: How do they differ?, Int J. Rob. Autom. 34 (1) (2019) 55–70.
[4] P. Robinette, A.M. Howard, A.R. Wagner, Effect of robot performance on human–robot trust in time-critical situations, IEEE Trans. Hum.-Mach. Syst. 47 (4) (2017) 425–436.
[5] K.R. Fossum, B.E. Danielsen, W. Aarseth, S.O. Johnsen, A project management issue of new technology developments: A case study on lack of human factors' attention in human–robot interaction, Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability 232(2) (2018) 164-173.
[6] P.A. Hancock, D.R. Billings, K.E. Schaefer, J.Y. Chen, E.J. De Visser, R. Parasuraman, A meta-analysis of factors affecting trust in human-robot interaction, Hum. Factors 53 (5) (2011) 517–527.
[7] K.A. Hoff, M. Bashir, Trust in automation: Integrating empirical evidence on factors that influence trust, Hum. Factors 57 (3) (2015) 407–434.
[8] L. Johannsmeier, S. Haddadin, A hierarchical human-robot interaction-planning framework for task allocation in collaborative industrial assembly processes, IEEE Rob. Autom. Lett. 2 (1) (2016) 41–48.
[9] I. Maurtua, A. Ibarguren, J. Kildal, L. Susperregi, B. Sierra, Human–robot collaboration in industrial applications: Safety, interaction and trust. International Journal of Advanced Robotic Systems 14(4) (2017) 1729881417716010.
[10] P. Tsarouchi, S. Makris, G. Chryssolouris, Human–robot interaction review and challenges on task planning and programming, Int. J. Comput. Integr. Manuf. 29 (8) (2016) 916–931.
[11] V. Villani, F. Pini, F. Leali, C. Secchi, Survey on human–robot collaboration in industrial settings: Safety, intuitive interfaces and applications, Mechatronics 55 (2018) 248–266.
[12] S. Bathrinath, V.S. Charan, S.G. Ponnambalam, S. Saravanasankar, Identification and evaluation of criteria of agile manufacturing using dematel: a case from an indian metal fabrication industry, J. Modern Manuf. Syst. Technol. 2 (1) (2019) 61–74.
[13] R.K.A. Bhalaji, S. Bathrinath, S.G. Ponnambalam, S. Saravanasankar, A fuzzy decision-making trial and evaluation laboratory approach to analyse risk factors related to environmental health and safety aspects in the healthcare industry, Sādhanā 44 (3) (2019) 55.
[14] A. Alkan, K. Canbay, G. Akman, Z. Aladağ, Researching usage of globe culture dimensions in organizational management by using dematel method, Sakarya Univ. J. Sci. 23 (2) (2019) 282–290.
[15] H. Xu, Y. Deng, Dependent evidence combination based on decision-making trial and evaluation laboratory method, Int. J. Intell. Syst. 34 (7) (2019) 1555–1571.
[16] S.S. Qarnain, S. Muthuvel, S. Bathrinath, Analyzing factors necessitating conservation of energy in residential buildings of Indian subcontinent: A DEMATEL approach, Mater. Today: Proc. (2020).
[17] R.K.A. Bhalaji, S. Bathrinath, S.G. Ponnambalam, S. Saravanasankar, A soft computing methodology to analyze sustainable risks in surgical cotton manufacturing companies, Sādhanā 45 (1) (2020) 1–22.
[18] K. Karuppiah, B. Sankaranarayanan, S.M. Ali, P. Chowdhury, S.K. Paul, An integrated approach to modeling the barriers in implementing green manufacturing practices in SMEs, J. Cleaner Prod. 121737 (2020), https://doi.org/10.1016/j.jclepro.2020.121737.