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Nano-medicine effectiveness in pediatric patients: An artificial intelligence investigation

Shaona Wang and Fan Yang*

Department of Pediatrics, Shengjing Hospital of China Medical University, Shenyang 110022, Liaoning, China

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Abstract. Emerge of nanotechnology has affected many aspects of our life and also triggers research studies in many fields. Nano-medicine are proven to be effective in encountering diseases. In the present study, aspects of the applications and effectiveness of nano-medicine in pediatrics patients are studied. In this regard, using experimental data of previous published researches, combination and dose of nano-medicines are optimized using response surface method and neural-fuzzy inference network. The input parameters of the selected multiple nano-medicines are dose and type and the output is the effectiveness of the combinations using IC50 parameter. A detailed parameter study is presented to observe effects of each inputs on the IC50. The results indicate that personalized scaling of nano-medicine is required in therapy of pediatric diseases such as cancers.
Keywords: artificial intelligence; cancer; nano-medicine; nanoparticles; pediatric patients

1. Introduction

Diseases in children are different in many aspects from their equivalent disease in adults and different treatment procedure should be adopted. For an account, there are three main differences in pediatrics and adults cancers (Zou *et al*. 2019, Liu *et al*. 2021c, Hou *et al*. 2022, Xue *et al*. 2022). First, cancer in children is not caused by life style. Second, for the same cancer therapy, a different response is seen in children, and third, type of mutation is different (Dai and Safarpour 2021, Forsat *et al*. 2021, Ghamkhar *et al*. 2021, Khadimallah *et al*. 2021a, Khadimallah *et al*. 2021b, Kumar *et al*. 2021, Madenci 2021, Tlidji *et al*. 2021). Therefore, specific treatments must be sought in the case of pediatric patients.

Using nanomaterials in the medical treatment have found several applications (Fan *et al*. 2022, Luo *et al*. 2022b, Wang *et al*. 2022a, Xia *et al*. 2022). In the ligament injury repair, graphene nanocomposites (Habibi *et al*. 2019a, d, e, Al-Furjan *et al*. 2020d, f, i, j) are utilized in scaffold shape instead of conventional screws (Silva *et al*. 2020). Recent developments in nanotechnology in different fields make drug delivery more efficient and simpler. Using iron oxide nanoparticles (NPs) as carriers of medicine, it is possible to direct the nano-medicine to a specific location in the body. On the other hand, the amount of the chemical medicine is considerably reduced using nano-carriers (Jin and Wang 2019, Gao *et al*. 2020, Li and Wang 2021, Jin *et al*. 2022). Using in vitro experiments, Sunoqrot and Abujamous (2019) demonstrated that effects of drug delivery using NPs was significantly higher than conventional drug administration. They used a polymeric NP of the drug with mean diameter 66.8nm. The results showed that the parameter IC_{50} in nano-medicine was extremely lower than conventional drug which indicates its effectiveness. Kim *et al*. (Kim *et al*. 2010) reviewed the application of nano-structure in the drug-delivery applications (Habibi *et al*. 2017, 2019a, c, Safarpour *et al*. 2018, 2019b, 2020, Alipour *et al*. 2020, Ebrahimi *et al*. 2020a, Ghazanfari *et al*. 2020, Chen *et al*. 2022). de Lázaro and Mooney (de Lázaro and Mooney 2021) explored the barriers in the effectiveness of nano-medicines and suggested two possible solutions to improve the efficiency of nano-medicines. Cellot *et al*. (2021) gathered recent studies on the graphene based nano materials used in the brain pathologies. They discussed the wide application of the graphene in the drug delivery system and concluded that successful applications of graphene in multi-purpose nano-devices make them a proper choice of controlling active molecules in different diseases. Nieto González *et al*. (2021) explored applications of polymeric and lipid nanoparticles in development of nano-medicine with emphasis on pediatrics diseases. The various usages of both categories were discussed in detail and it was concluded that these NPs could be utilized not only in cancer treatment but also in chronic diseases. However, there few studies on the actual therapeutic effectiveness of them. Thus, in vivo experiments are necessary to assess effects of these NPs prior to further investigations on the topic. In the case of brain cancer, standard treatment of using chemotherapy usually has the risk of brain damage in children (Guido *et al*. 2022). Thus, the novel treatment development is a must in the case of pediatric brain cancer. Using nano-medicine showed a promising method which could overcome brain and blood obstacles in brain (Ebrahimi *et al*. 2019b, c, 2020b, Hashemi *et al*. 2019, Moayedi *et al*. 2019, 2020a, b, Mohammadgholiha *et al*. 2019, Mohammadi *et al*. 2019, Habibi *et al*. 2020, Oyarhossein *et al*. 2020, Shariati *et al*. 2020a, b, Shokrgozar *et al*. 2020).

First phase in evaluation of nanoparticles as drug

*Corresponding author, Ph.D.,
E-mail: yangfan@sj-hospital.org

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delivery vehicles is molecular dynamics (MD) method in which a detailed chemical and physical calculations are performed on the interaction of nanoparticles with its circumstances inside the body (Habibi *et al*. 2016, 2018a, b, 2019b, d, e, Ebrahimi *et al*. 2019a, Esmailpoor Hajilak *et al*. 2019, Pourjabari *et al*. 2019, Safarpour *et al*. 2019a, Zhu *et al*. 2022). Lee (2021) gathered published MD simulations on the interaction of NPs' surface with different protein in blood during its journey inside body. The simulations accurately revealed the interactions of proteins and NPs and covering NPs by proteins. These simulations had capability to show reactions which were hardly followed by experiments. Different simulation method in modeling drug delivery system were reviewed by Moradi Kashkooli *et al*. (2021). They mentioned several discrete and continuous mathematical models used in simulations and concluded that using simulation and in vitro experiments drug delivery behavior could be predicted.

Computational costs of the MD and finite elements method (FEM) (Hashemi *et al*. 2019, Al-Furjan *et al*. 2020c, e, g, f, Bai *et al*. 2020, Cheshmeh *et al*. 2020, Li *et al*. 2020a, Lori *et al*. 2020, Najaafi *et al*. 2020, Shariati *et al*. 2020c, Xiong *et al*. 2020, Guo *et al*. 2021b, Liu *et al*. 2021a) triggered employment of novel approaches in predictions of nano-medicines behavior and body responses (Amelirad and Assempour 2019, Amelirad and Assempour 2021). Ho *et al*. (2019) discussed the role of the artificial intelligence (AI) methods (Cavaleri *et al*. 2017) in the case when multiple nano-medicine are used for treatment. They concluded that the dose of each medicine could be optimized in an effective way using AI. Rashid *et al*. (2018) presented an experimental evaluations of combination of multiple nano-medicines on mics. They presented a response surface optimization method to acquire the best combination of the drug to improve efficiency of the results. Several studies showed that personalized drug dosing in a must in many cases (Zarrinpar *et al*. 2016, Rashid *et al*. 2018). The possible combination of nanofluidics and artificial intelligence methods was discussed in detail using previously published study by Liu *et al*. (2021d). The design and optimization of drug delivery systems were collected by Serov and Vinogradov (2022). In this review paper, the employment of different machine learning (ML) and artificial neura networks in the field of drug delivery were discussed. There could be found many review articles on the application of Ai in nano-medicine, nanotechnology, drug design which are related to the pediatric patients (Casañola-Martin and Pham-The 2019, Adir *et al*. 2020, Singh *et al*. 2020a, b, Hayat *et al*. 2021). Using artificial intelligence and machine learning (ML) methods in cytotoxicity are widely used in the biology and nano-midicine. The toxicity of nano-carriers was gathered in an article by Singh *et al*. (2020b). They presented a roadmap to use AI methods in nano-cytotoxicity. Liu *et al* (Liu *et al*. 2021e) explored cytotoxicity of metal NPs were using two approaches of ML: random forest and decision tree. They discussed the application ML in improvement of design of drug vehicles. Using the experimental results, Fjodorova *et al*. (2017) evaluated toxicity of metal oxide NPs and presented several effective factors in NPs. Several different ML models were used by Kar *et al*. (2021) to detect the most toxic metal oxide nanoparticles.

Scaling of nano-medicine is a challenging issue in the therapy of pediatric patients. Dose and type multiple nano-drugs have to be designed using new methods since the conventional methods may not responsive in the case of nano-medicines (Maojo *et al*. 2010). In addition to the dose and type of drug, timing of the drug delivery is another essential parameters in optimizing process (Zarrinpar *et al*. 2016).

In the present study, aspects of the applications and effectiveness of nano-medicine in pediatrics patients are studied. In this regard, using experimental data of previous published researches, combination and dose of nano-medicines are optimized using response surface method (RSM) and adaptive neural-network fuzzy inference system (ANFIS). The input parameters of the selected multiple nano-medicines are dose and type and the output is the effectiveness of the combinations using IC_{50} parameter and A detailed parameter study is presented to observe effects of each inputs on the IC_{50}.

2. Materials and methods

2.1 Experimental data

Experimental data of different nano-medicines is acquired from (Rashid *et al*. 2018) and it is available online from supplementary tables along with the published article. In this article, effects of concentration and type of medicines on the inhibition of some blood cells to 50%, i.e. IC_{50}. The drugs and inhibitors include dactinomycin (Dac), decitabine (Dec), mechlorethamine hydrochloride (Mech), mitomycin C (MitoC) and bortezomib (Bort). Also concentration and combinations of these materials are also considered as effective factors on IC_{50}.

2.2 Response surface method (RSM)

The response surface method provides a platform for fitting the available data using quadratic polynomial function (Adamian *et al*. 2020, Al-Furjan *et al*. 2020a, b, Li *et al*. 2020b, Liu *et al*. 2020c, d, 2021b, Wang *et al*. 2020, Zare *et al*. 2020, Zhou *et al*. 2020, Dai *et al*. 2021a, b, Guo *et al*. 2021a, Habibi *et al*. 2021, He *et al*. 2021, Huang *et al*. 2021a, Shao *et al*. 2021, Wu and Habibi 2021, Zhang *et al*. 2021, Kong *et al*. 2022) to obtain effect of each parameter as well as effects of combinations of factors. The fitted functions are further use to find optimum point of the output, here is minimization of IC_{50}. Moreover, the most effective factor can be achieved using this method.

2.3 Neural fuzzy network

Combination of neural network with fuzzy logic provides a suitable approach for prediction of different responses of a system with a high accuracy and lower computational effort compared to conventional artificial neural networks (ANNs) (Jang 1993). In this type of neural network, input data (values of each factor) converted to their respective fuzzy values using membership function (Cai *et al*. 2020, Liu *et al*. 2020b, Xiang *et al*. 2021b, 2022a, Lu *et al*. 2022). The effects of all input factors from concentration to the proportion of each drug further combined into one factor using AND statement (Ma *et al*. 2022, Zhao *et al*. 2022, Hou *et al*. 2021, Huang *et al*. 2021b, c, Jiao *et al*. 2021, Liu *et al*. 2021f, Moradi *et al*. 2021, Xu *et al*. 2021, Dong *et al*. 2022, Luo *et al*. 2022a, Michael *et al*. 2022, Wang *et al*. 2022c, Yang *et al*. 2022b, Yu *et al*. 2022):

$$w_i = \prod_{k=1}^{N} \mu(A_k) \tag{1}$$

where w_i is the combined fuzzy factor of the membership values $\mu(A_k)$ for each effective factor. Each fuzzy value following a rule in which N number of the factors are taken into effect in the rule (Liu *et al*. 2020a, Xiang *et al*. 2021a, 2022b, Xiang 2022). Number of rules in each network are governed by the physics of the problem. The obtained combined fuzzy factor for all rules are normalized according to the below equations (Fan *et al*. 2022, Luo *et al*. 2022b, Michael *et al*. 2022, Wang *et al*. 2022b, c, Yang *et al*. 2022a, Zheng *et al*. 2022):

$$\overline{w}_i = \frac{w_i}{\sum w_j} \tag{2}$$

Membership function has different forms from triangular shape to bell shape functions. In this study, we adopt a triangular shape function for simplicity. This method makes it possible to obtain the values of IC_{50} in the case of new combination of inputs with high accuracy. Since, in contrast to the RSM, in this method correlation factor are very high and the network is evaluated by test data to observe its functionality and efficiency.

3. Results and discussion

3.1 RSM results

The fitted equation in the RSM method are obtained as following:

$$\begin{aligned} IC_{50} = {} & 202 - 8.05\, concentration - 202\, Bort \\ & - 201\, Dac - 202\, Dec - 201\, Mech - 201\, MitoC \\ & + 0.000321\, concentration * concentration \\ & + 0.375\, Bort * Bort + 1.130\, Dec * Dec \\ & + 8.03\, concentration * Bort + 8.03\, concentration * Dac \\ & + 8.03\, concentration * Dec + 8.01\, concentration * Mech \\ & + 8.03\, concentration * MitoC \end{aligned} \tag{3}$$

This a simple quadratic equation which can be used to deduce many conclusions. The factors and combination of factors absent in the equations are not influential on the IC_{50}. The importance of each parameters are demonstrated using Poreto chart in Fig. 1. As seen, the most important parameter is square value of concentration of the drugs. The second important factor is the square of the partition of Dec drug in the drug combination. On the other hand, the least important factor is presence of Mech nano-drug in the combination which can be a conclusive results. This results can be utilized to design new nano-medicines in the for pediatric cancers.

Table 1 Optimum values of concentration and drug fraction for minimizing, maximizing the value of IC_{50}

	Concentration [μM]	Bort	Dac	Dec	Mech	MitoC
Max. IC_{50}	100	1	1	1	1	1
Min. IC_{50}	0.0	1	1	1	1	1
$IC_{50} = 0.6$	45.27	0	0	0.5024	0	0.5010

Difference between RSM output (quadratic fitting) and the actual values of IC_{50} for all data set is plotted in several ways in Fig. 2. It is deduced that the quadratic equations provide an acceptable agreement with actual values since the residuals fall between -0.5 to 0.5. However, it should be mentioned that this is not true for all problems. There are many experimental values which do not follow quadratic equations and the residuals may be extremely large in those cases.

The most powerful aspect of the RSM (Zhu *et al*. 2022) is the prediction of the optimum condition for the output IC_{50} based on the concentrations and fraction of the drugs. Table 1 provides the conditions in which minimum and maximum values of IC_{50} could be obtained. Moreover, the condition of obtaining a desirable value of IC_{50} is also presented. As seen, for maximizing the value of IC_{50} the model predicts, as expected, the concentration of 100 of the drugs. On the other minimum value also obtained for zero concentration. However, for other conditions the optimum value cannot be easily deduced from the data. In this table, the combination condition for $IC_{50} = 0.6$ is also presented which can be used in certain circumstances.

Effects of different individual effective factors are presented in this section. Fig. 3 shows the effect of Bort inhibitor fraction on the IC_{50} as predicted by RSM. It is observed that increasing Bort fraction cause decrease in IC_{50} and hence improvement in inhibition of the cell. However, caution must be taken when using these results since they are only a fitted result from experiment which may not follow a quadratic curve. It is also seen, increase in concentration of the nano-medicine dramatically reduces IC_{50} as expected in the absent of other drugs. On the other hand, combination of only two nano-medicine Bort and Dac results in improvement in inhibition of cancer cells.

Fig. 4 demonstrates effect of nano-medicine concentr-ation on the IC_{50} for different Bort fraction in combination with other nano-medicine. It can be seen that with only Bort as drug in the combination at concentration = 24 μM the best results are obtained in terms of minimizing IC_{50} regardless of the fraction of the nano-medicine. In lower concentration, increase in the Bort fraction results in significant drop in IC_{50}. But in the Bort fraction equal to unity there observed slight increase in the IC_{50} and in the concentrations above 24 μM for Bort fraction of unity, increase in concentration cause inverse results. In this figure it is also depicted combination of Bort with only one other drug in various concentration. The general theme of the graph is the appearance of minimum point in the IC_{50}-

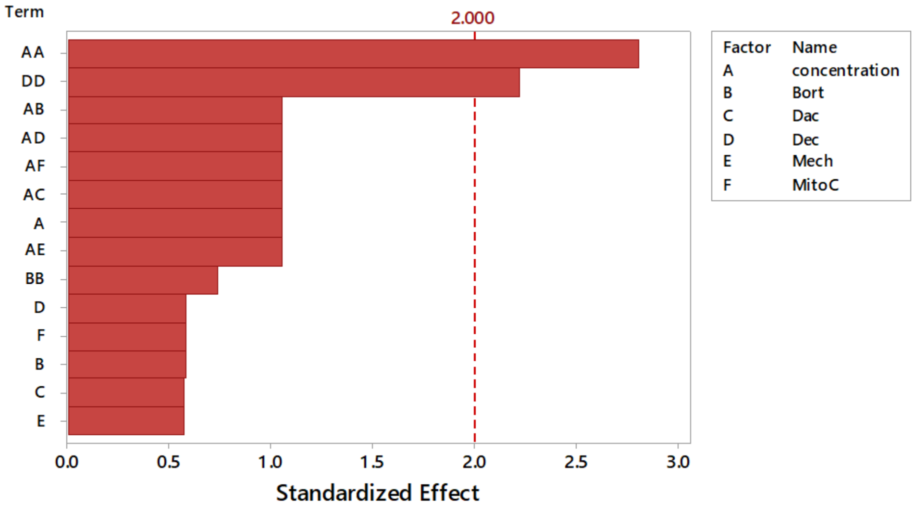

Fig. 1 Importance of different input factors of nano-medicines on IC_{50}

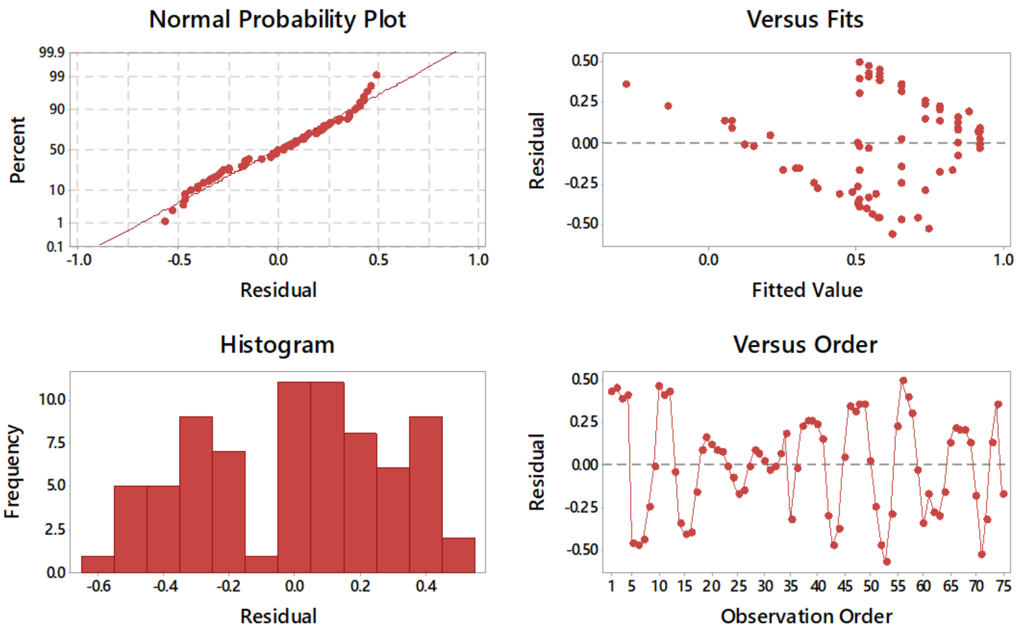

Fig. 2 Representation of residuals of the fitted quadratic functions in comparison to actual IC_{50}

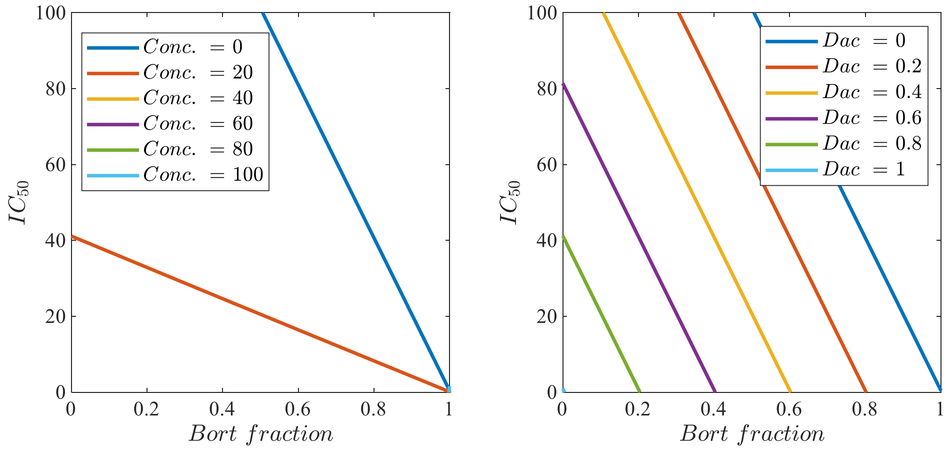

Fig. 3 Effect of Bort fraction on the IC_{50} for different values of concentration and Dec fraction in the absence of other nano-medicines

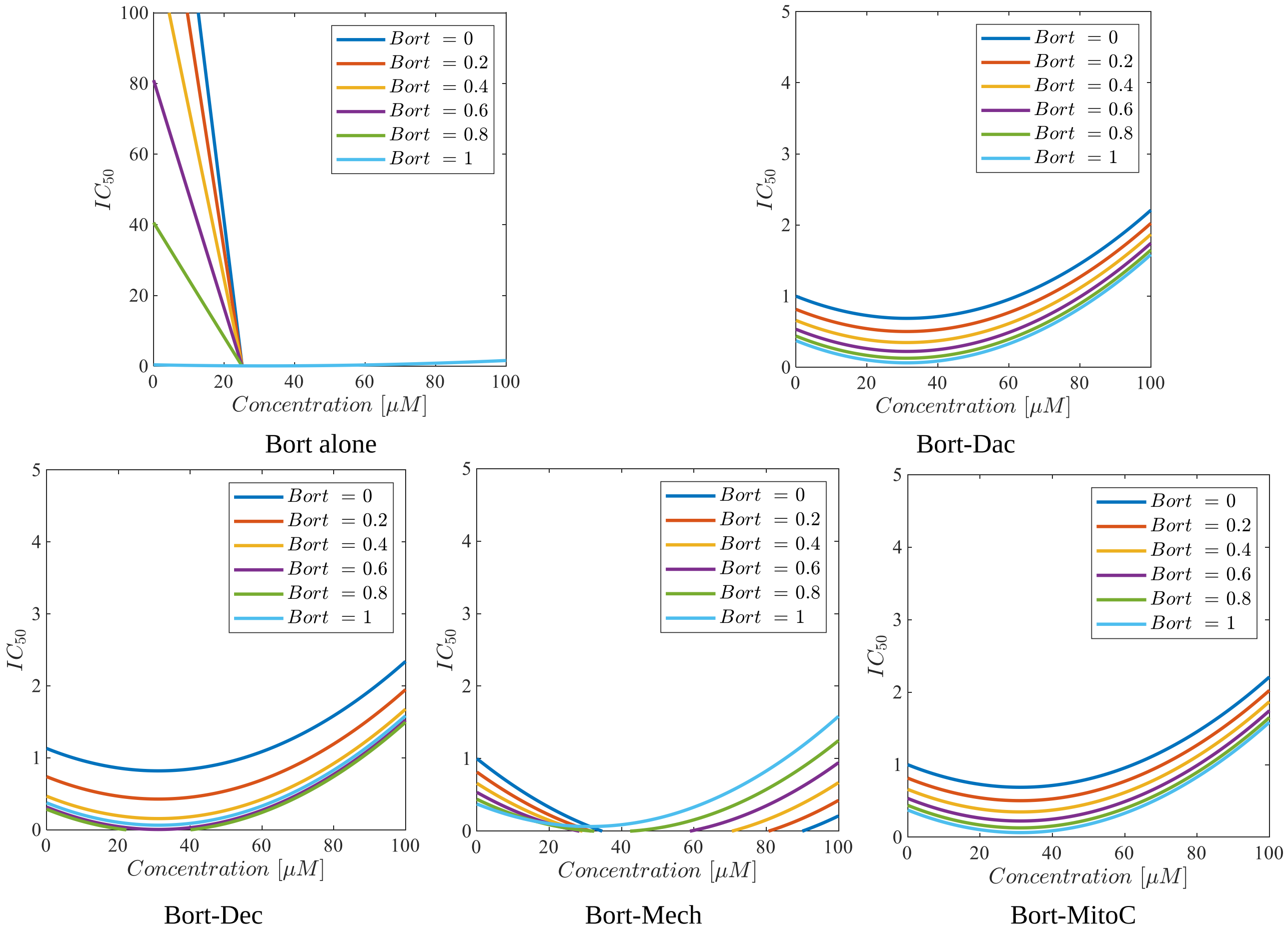

Fig. 4 Effect of the concentration and combination of nano-medicine with Bort on the IC_{50}

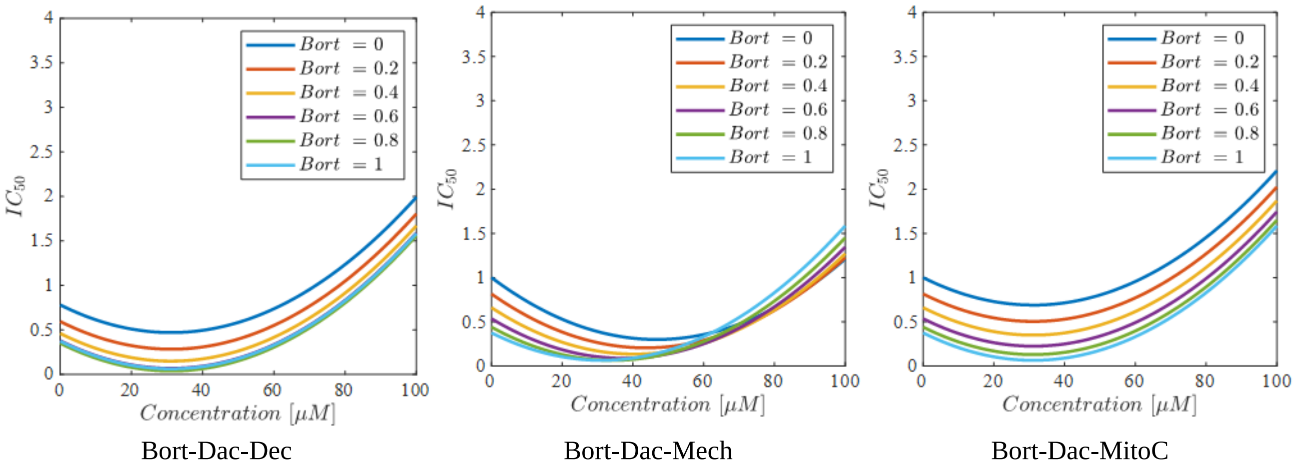

Fig. 5 Effect of Bort fraction on the IC_{50} for different values of concentration and Dec fraction in the absence of other nano-medicines

concentration curve between 20 t0 40 μM. Therefore, regardless of the combinations of the nano-medicine against cancer cells, the concentration of the drug should keep between 20-40μM. The specific value for each drug combination must be determined in each case. Among different combination of Bort nano-medicine with other drugs, the best results is obtained for Bort fraction = 0.6 and Mech fraction =0.4 at 2-60 μM concentration which minimizes the value of IC_{50}. In other cases, except for combination of Bort and Dec, the best results are obtained when Bort fraction is maximum or unity. However, and interesting results is obtained when Bort nano-medicine combined with Dec. In this case best results are at Bort fraction 0.8 and Dec fraction 0.2. In this case the IC_{50} curve is lower than all other fractions of these two nano-drugs.

Combinations of 3 nano-medicines are also possible in pediatric cancer therapy. In Fig. 5 the combination of Bort and Dec nano-medicine are depicted with only on another drug. The fraction of Dec and the third drug kept equal in these graphs. In the case of Bort-Dac-Dec the best results in terms of minimizing IC_{50} is obtained when Bort fraction equals to 0.8 and, consequently, the other two nano-medicine fraction equal to 0.1 each. In Bort-Dac-Mech combination, there is seen a turning point around 60 μM concentration in all combinations depicted. Prior to this value increase in Bort fraction cause deterioration of the drug efficacy. However, in the higher concentrations, the reverse effect is observed. The combination of Bort-Dac-MitoC effect is similar to combination of two medicine of Bort-Dac and Bort-MitoC in which maximum value of Bort gives the best results.

The above RSM results show the importance of nano-medicine design in terms of combination and concentration which hardly obtained from conventional methods.

3.2 ANFIS results

The ANFIS model described in Section 2 is employed to train a neural network capable of prediction of IC_{50} value in different nano-medicine combination and concentration. For this purpose, among total 75 set of experimental data 60 set is randomly selected to train the network and 15 set is used to test the model. The results of predicted values of IC_{50} and the actual measured values in different condition is shown in Figure 6. The correlation between data from trained network and the provided data for training is 0.921 after 50 epochs. At the same time the time the test set of input data is fed in the trained network to observe the differences between predicted IC_{50} and the actual measured value. The trained model satisfactorily predicts results with correlation equal to 0.892 which is regarded a high value.

The above results are obtained with time and computational effort much lower than RSM and experimental methods. The high correlation coefficients ensures us about the reliability of such methods. Therefore, artificial intelligence method have a great potential to be used alongside experimental methods to avoid some tedious experiments and scaling of nano-medicine in pediatric patients.

4. Conclusions

In the present study, aspects of the applications and effectiveness of nano-medicine in pediatrics patients were studied. Using experimental data of previous published researches, combination and dose of nano-medicines were optimized using response surface method (RSM) and adaptive neural-network fuzzy inference system (ANFIS). The input parameters of the selected multiple nano-medicines were dose and type and the output is the effectiveness of the combinations using IC_{50} parameter and A detailed parameter study is presented to observe effects of each inputs on the IC_{50}. The main outcome of the study can be encapsulated in the below:

- The most important parameter is square value of concentration of the drugs and the least important factor is presence of Mech nano-drug in the combination.
- The condition of obtaining a desirable value of IC_{50} can be calculated using RSM.
- Regardless of the combinations of the nano-medicine against cancer cells, the concentration of the drug should keep between 20-40μM.
- With only Bort as drug in the combination at concentration = 24 μM the best results are obtained in terms of minimizing IC_{50}.
- When Bort nano-medicine combined with Dec, best results is at Bort fraction 0.8 and Dec fraction 0.2.
- Artificial intelligence method have a great potential to be used alongside experimental methods to avoid some tedious experiments and scaling of nano-medicine in pediatric patients

References

Adamian, A., Safari, K.H., Sheikholeslami, M., Habibi, M., Al-Furjan, M. and Chen, G. (2020), “Critical temperature and frequency characteristics of GPLs-Reinforced composite doubly curved panel”, *Appl. Sci*., **10**(9), 3251. https://doi.org/10.3390/app10093251

Adir, O., Poley, M., Chen, G., Froim, S., Krinsky, N., Shklover, J., Shainsky-Roitman, J., Lammers, T. and Schroeder, A. (2020), “Integrating artificial intelligence and nanotechnology for precision cancer medicine”, *Adv. Mater*.,**32**(13), 1901989. https://doi.org/10.1002/adma.201901989

Al-Furjan, M., Dehini, R., Khorami, M., Habibi, M. and won Jung, D. (2020a), “On the dynamics of the ultra-fast rotating cantilever orthotropic piezoelectric nanodisk based on nonlocal strain gradient theory”, *Compos. Struct*., 112990. https://doi.org/10.1016/j.compstruct.2020.112990

Al-Furjan, M., Fereidouni, M., Habibi, M., Abd Ali, R., Ni, J. and Safarpour, M. (2020b), “Influence of in-plane loading on the vibrations of the fully symmetric mechanical systems via dynamic simulation and generalized differential quadrature framework”, *Eng. Comput*., 1-23. https://doi.org/10.1007/s00366-020-01177-7

Al-Furjan, M., Fereidouni, M., Sedghiyan, D., Habibi, M. and won Jung, D. (2020c), “Three-dimensional frequency response of the CNT-Carbon-Fiber reinforced laminated circular/annular plates under initially stresses”, *Compos. Struct*., 113146. https://doi.org/10.1016/j.compstruct.2020.113146

Al-Furjan, M., Habibi, M., won Jung, D., Sadeghi, S., Safarpour, H., Tounsi, A. and Chen, G. (2020d), “A computational framework for propagated waves in a sandwich doubly curved nanocomposite panel”, *Eng. Comput*., 1-18. https://doi.org/10.1007/s00366-020-01130-8

Al-Furjan, M., Habibi, M., won Jung, D. and Safarpour, H. (2020e), “Vibrational characteristics of a higher-order laminated composite viscoelastic annular microplate via modified couple stress theory”, *Compos. Struct*., 113152. https://doi.org/10.1016/j.compstruct.2020.113152

Al-Furjan, M., Habibi, M., Won Jung, D., Safarpour, H. and Safarpour, M. (2020f), “On the buckling of the polymer-CNT-fiber nanocomposite annular system under thermo-mechanical loads”, *Mech. Based Des. Struct*., 1-21. https://doi.org/10.1080/15397734.2020.1830106

Al-Furjan, M., Moghadam, S.A., Dehini, R., Shan, L., Habibi, M. and Safarpour, H. (2020g), “Vibration control of a smart shell reinforced by graphene nanoplatelets under external load: Semi-numerical and finite element modeling", *Thin Wall*. *Struct*., 107242. https://doi.org/10.1016/j.tws.2020.107242

Al-Furjan, M., Oyarhossein, M.A., Habibi, M., Safarpour, H. and Jung, D.W. (2020h), "Frequency and critical angular velocity characteristics of rotary laminated cantilever microdisk via two-dimensional analysis", *Thin Wall*. *Struct*., **157**, 107111. https://doi.org/10.1016/j.tws.2020.107111

Al-Furjan, M.S.H., Habibi, M., Ebrahimi, F., Mohammadi, K. and Safarpour, H. (2020i), "Wave dispersion characteristics of high-speed-rotating laminated nanocomposite cylindrical shells based on four continuum mechanics theories", *Wave*. *Random Complex Med*., 1-27. https://doi.org/10.1080/17455030.2020.1831099

Al-Furjan, M.S.H., Habibi, M., Jung, D.w., Sadeghi, S., Safarpour, H., Tounsi, A. and Chen, G. (2020j), "A computational framework for propagated waves in a sandwich doubly curved nanocomposite panel", *Eng*. *Comput*., **38**(2), 1679-1696. https://doi.org/10.1007/s00366-020-01130-8

Alipour, M., Torabi, M.A., Sareban, M., Lashini, H., Sadeghi, E., Fazaeli, A., Habibi, M. and Hashemi, R. (2020), "Finite element and experimental method for analyzing the effects of martensite morphologies on the formability of DP steels", *Mech*. *Based Des*. *Struct*., **48**(5), 525-541. https://doi.org/10.1080/15397734.2019.1633343

Amelirad, O. and Assempour, A. (2019), "Experimental and crystal plasticity evaluation of grain size effect on formability of austenitic stainless steel sheets", *J*. *Manuf*. *Proc*., **47** 310-323. https://doi.org/10.1016/j.jmapro.2019.09.035

Amelirad, O. and Assempour, A. (2021), "Coupled continuum damage mechanics and crystal plasticity model and its application in damage evolution in polycrystalline aggregates", *Eng*. *Comput*., 1-15. https://doi.org/10.1007/s00366-021-01346-2

Bai, Y., Alzahrani, B., Baharom, S. and Habibi, M. (2020), "Semi-numerical simulation for vibrational responses of the viscoelastic imperfect annular system with honeycomb core under residual pressure", *Eng*. *Comput*., 1-26. https://doi.org/10.1007/s00366-020-01191-9

Cai, J., Zhao, J., Xiang, Y., Liu, J., Chen, G., Hu, Y. and Chen, J. (2020), "Can i trust you? Estimation models for e-bikers stop-go decision before amber light at urban intersection", *J*. *Adv*. *Transp*., **2020**. https://doi.org/10.1155/2020/6678996

Casañola-Martin, G.M. and Pham-The, H. (2019), "Machine learning applications in nanomedicine and nanotoxicology: An overview", *Int*. *J*. *Appl*. *Nanotech*. *Res*., **4**(1), 1-7. https://doi.org/10.4018/IJANR.2019010101

Cavaleri, L., Chatzarakis, G.E., Di Trapani, F., Douvika, M.G., Roinos, K., Vaxevanidis, N.M. and Asteris, P.G. (2017), "Modeling of surface roughness in electro-discharge machining using artificial neural networks", *Adv*. *Mater*. *Res*., **6**(2), 169. https://doi.org/10.12989/amr.2017.6.2.169

Cellot, G., Franceschi Biagioni, A. and Ballerini, L. (2021), "Nanomedicine and graphene-based materials: advanced technologies for potential treatments of diseases in the developing nervous system", *Pediatr*. *Res*., **92**(1), 71-79. https://doi.org/10.1038/s41390-021-01681-6

Chen, F., Chen, J., Duan, R., Habibi, M. and Khadimallah, M.A. (2022), "Investigation on dynamic stability and aeroelastic characteristics of composite curved pipes with any yawed angle", *Compos*. *Struct*., 115195. https://doi.org/10.1016/j.compstruct.2022.115195

Cheshmeh, E., Karbon, M., Eyvazian, A., Jung, D.w., Habibi, M. and Safarpour, M. (2020), "Buckling and vibration analysis of FG-CNTRC plate subjected to thermo-mechanical load based on higher order shear deformation theory", *Mech*. *Based Des*. *Struct*., 1-24. https://doi.org/10.1080/15397734.2020.1744005

Dai, H. and Safarpour, H. (2021), "Frequency and thermal buckling information of laminated composite doubly curved open nanoshell", *Adv*. *Nano Res*., **10**(1), 1-14. https://doi.org/10.12989/anr.2021.10.1.001

Dai, Z., Jiang, Z., Zhang, L. and Habibi, M. (2021a), "Frequency characteristics and sensitivity analysis of a size-dependent laminated nanoshell", *Adv*. *Nano Res*., **10**(2), 175. https://doi.org/10.12989/anr.2021.10.2.175

Dai, Z., Zhang, L., Bolandi, S.Y. and Habibi, M. (2021b), "On the vibrations of the non-polynomial viscoelastic composite open-type shell under residual stresses", *Compos*. *Struct*., 113599. https://doi.org/10.1016/j.compstruct.2021.113599

De Lázaro, I. and Mooney, D.J. (2021), "Obstacles and opportunities in a forward vision for cancer nanomedicine", *Nature Mater*., **20**(11), 1469-1479. https://doi.org/10.1038/s41563-021-01047-7

Dong, Y., Gao, Y., Zhu, Q., Moradi, Z. and Safa, M. (2022), "TE-GDQE implementation to investigate the vibration of FG composite conical shells considering a frequency controller solid ring", *Eng*. *Anal*. *Bound*. *Elem*., **138**, 95-107. https://doi.org/10.1016/j.enganabound.2022.01.017

Ebrahimi, F., Habibi, M. and Safarpour, H. (2019a), "On modeling of wave propagation in a thermally affected GNP-reinforced imperfect nanocomposite shell", *Eng*. *Comput*., **35**(4), 1375-1389. https://doi.org/10.1007/s00366-018-0669-4

Ebrahimi, F., Hajilak, Z.E., Habibi, M. and Safarpour, H. (2019b), "Buckling and vibration characteristics of a carbon nanotube-reinforced spinning cantilever cylindrical 3D shell conveying viscous fluid flow and carrying spring-mass systems under various temperature distributions", *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, **233**(13), 4590-4605. https://doi.org/10.1177/0954406219832323

Ebrahimi, F., Hashemabadi, D., Habibi, M. and Safarpour, H. (2020a), "Thermal buckling and forced vibration characteristics of a porous GNP reinforced nanocomposite cylindrical shell", *Microsyst*. *Technol*., **26**(2), 461-473. https://doi.org/10.1007/s00542-019-04542-9

Ebrahimi, F., Mohammadi, K., Barouti, M.M. and Habibi, M. (2019c), "Wave propagation analysis of a spinning porous graphene nanoplatelet-reinforced nanoshell", *Wave*. *Random Complex Med*., 1-27. https://doi.org/10.1080/17455030.2019.1694729

Ebrahimi, F., Supeni, E.E.B., Habibi, M. and Safarpour, H. (2020b), "Frequency characteristics of a GPL-reinforced composite microdisk coupled with a piezoelectric layer", *Eur*. *Phys*. *J*. *Plus*, **135**(2), 144. https://doi.org/10.1140/epjp/s13360-020-00217-x

Esmailpoor Hajilak, Z., Pourghader, J., Hashemabadi, D., Sharifi Bagh, F., Habibi, M. and Safarpour, H. (2019), "Multilayer GPLRC composite cylindrical nanoshell using modified strain gradient theory", *Mech*. *Based Des*. *Struct*., **47**(5), 521-545. https://doi/10.1080/15397734.2019.1566743

Fan, L., Huang, Y., Ji, D., Moradi, Z., Safa, M. and Amine Khadimallah, M. (2022), "Interaction of angular velocity and temperature rise in the thermo-inertia bifurcation buckling of FG laminated nanocomposite annular plates", *Eng*. *Struct*., **265**, 114518. https://doi.org/10.1016/j.engstruct.2022.114518

Fjodorova, N., Novic, M., Gajewicz, A. and Rasulev, B. (2017), "The way to cover prediction for cytotoxicity for all existing nano-sized metal oxides by using neural network method", *Nanotoxicology*, **11**(4), 475-483. http://doi.org/10.1080/17435390.2017.1310949

Forsat, M., Musharavati, F., Eltai, E., Zain, A.M., Mobayen, S. and Mohamed, A.M. (2021), "Vibration characteristics of microplates with GNPs-reinforced epoxy core bonded to piezoelectric-reinforced CNTs patches", *Adv*. *Nano Res*., **11**(2), 115-140. https://doi.org/10.12989/anr.2021.11.2.115

Gao, H., Hsu, P.H., Li, K. and Zhang, J. (2020), "The real effect of smoking bans: Evidence from corporate innovation", *J. Financ. Quant. Anal.*, **55**(2), 387-427. https://doi.org/10.1017/S0022109018001564

Ghamkhar, M., Khadimallah, M.A., Iqbal, M.Z., Hussain, M., Yahya, A., Khedher, K.M., Naeem, M.N. and Tounsi, A. (2021), "Performance of FGM bilayered cylindrical shell placed on cantilever edge", *Adv. Nano Res.*, **11**(4), 339-345. https://doi.org/10.12989/anr.2021.11.4.339

Ghazanfari, A., Soleimani, S.S., Keshavarzzadeh, M., Habibi, M., Assempuor, A. and Hashemi, R. (2020), "Prediction of FLD for sheet metal by considering through-thickness shear stresses", *Mech. Based Des. Struct.*, **48**(6), 755-772. https://doi.org/10.1080/15397734.2019.1662310

Guido, C., Baldari, C., Maiorano, G., Mastronuzzi, A., Carai, A., Quintarelli, C., De Angelis, B., Cortese, B., Gigli, G. and Palamà, I.E. (2022), "Nanoparticles for diagnosis and target therapy in pediatric brain cancers", *Diagnostics*, **12**(1), 173. https://doi.org/10.3390/diagnostics12010173

Guo, J., Baharvand, A., Tazeddinova, D., Habibi, M., Safarpour, H., Roco-Videla, A. and Selmi, A. (2021a), "An intelligent computer method for vibration responses of the spinning multi-layer symmetric nanosystem using multi-physics modeling", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-021-01433-4

Guo, Y., Mi, H. and Habibi, M. (2021b), "Electromechanical energy absorption, resonance frequency, and low-velocity impact analysis of the piezoelectric doubly curved system", *Mech. Syst. Signal Pr.*, **157**, 107723. https://doi.org/10.1016/j.ymssp.2021.107723

Habibi, M., Darabi, R., Sa, J.C.d. and Reis, A. (2021), "An innovation in finite element simulation via crystal plasticity assessment of grain morphology effect on sheet metal formability", *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, **235**(8), 1937-1951. https://doi.org/10.1177/14644207211024686

Habibi, M., Ghazanfari, A., Assempour, A., Naghdabadi, R. and Hashemi, R. (2017), "Determination of forming limit diagram using two modified finite element models", *Mech Eng.* **48**(4), 141-144. https://doi.org/10.22060/MEJ.2016.664

Habibi, M., Hashemabadi, D. and Safarpour, H. (2019a), "Vibration analysis of a high-speed rotating GPLRC nano-structure coupled with a piezoelectric actuator", *Eur. Phys. J. Plus*, **134**(6), 307. https://doi.org/10.1140/epjp/i2019-12742-7

Habibi, M., Hashemi, R., Ghazanfari, A., Naghdabadi, R. and Assempour, A. (2018a), "Forming limit diagrams by including the M–K model in finite element simulation considering the effect of bending", *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, **232**(8), 625-636.

Habibi, M., Hashemi, R., Sadeghi, E., Fazaeli, A., Ghazanfari, A. and Lashini, H. (2016), "Enhancing the mechanical properties and formability of low carbon steel with dual-phase microstructures", *J. Mater. Eng. Perform.*, **25**(2), 382-389. https://doi.org/10.1007/s11665-016-1882-1.

Habibi, M., Hashemi, R., Tafti, M.F. and Assempour, A. (2018b), "Experimental investigation of mechanical properties, formability and forming limit diagrams for tailor-welded blanks produced by friction stir welding", *J. Manuf. Proc.*, **31**, 310-323. https://doi.org/10.1016/j.jmapro.2017.11.009

Habibi, M., Mohammadgholiha, M. and Safarpour, H. (2019b), "Wave propagation characteristics of the electrically GNP-reinforced nanocomposite cylindrical shell", *J. Brazil. Soc. Mech. Sci. Eng.*, **41**(5), 221. https://doi.org/10.1007/s40430-019-1715-x

Habibi, M., Mohammadi, A., Safarpour, H. and Ghadiri, M. (2019c), "Effect of porosity on buckling and vibrational characteristics of the imperfect GPLRC composite nanoshell", *Mech. Based Des. Struct.*, 1-30. https://doi.org/10.1080/15397734.2019.1701490

Habibi, M., Mohammadi, A., Safarpour, H., Shavalipour, A. and Ghadiri, M. (2019d), "Wave propagation analysis of the laminated cylindrical nanoshell coupled with a piezoelectric actuator", *Mech. Based Des. Struct.*, 1-19. https://doi.org/10.1080/15397734.2019.1697932

Habibi, M., Safarpour, M. and Safarpour, H. (2020), "Vibrational characteristics of a FG-GPLRC viscoelastic thick annular plate using fourth-order Runge-Kutta and GDQ methods", *Mech. Based Des. Struct.*, 1-22. https://doi.org/10.1080/15397734.2020.1779086

Habibi, M., Taghdir, A. and Safarpour, H. (2019e), "Stability analysis of an electrically cylindrical nanoshell reinforced with graphene nanoplatelets", *Compos. Part B Eng.*, **175**, 107125. https://doi.org/10.1016/j.compositesb.2019.107125

Hashemi, H.R., Alizadeh, A.a., Oyarhossein, M.A., Shavalipour, A., Makkiabadi, M. and Habibi, M. (2019), "Influence of imperfection on amplitude and resonance frequency of a reinforcement compositionally graded nanostructure", *Wave. Random Complex Med.*, 1-27. https://doi.org/10.1080/17455030.2019.1662968

Hayat, H., Nukala, A., Nyamira, A., Fan, J. and Wang, P. (2021), "A concise review: The synergy between artificial intelligence and biomedical nanomaterials that empowers nanomedicine", *Biomed. Mater.*, **16**(5), 052001. https://doi.org/10.1088/1748-605x/ac15b2

He, X., Ding, J., Habibi, M., Safarpour, H. and Safarpour, M. (2021), "Non-polynomial framework for bending responses of the multi-scale hybrid laminated nanocomposite reinforced circular/annular plate", *Thin Wall. Struct.*, **166**, 108019. https://doi.org/10.1016/j.tws.2021.108019

Ho, D., Wang, P. and Kee, T. (2019), "Artificial intelligence in nanomedicine", *Nanosc. Horizons*, **4**(2), 365-377. https://doi.org/10.1039/C8NH00233A

Hou, F., Wu, S., Moradi, Z. and Shafiei, N. (2021), "The computational modeling for the static analysis of axially functionally graded micro-cylindrical imperfect beam applying the computer simulation", *Eng. Comput.*, 1-19. https://doi.org/10.1007/s00366-021-01456-x

Hou, Q., Huang, J., Xiong, X., Guo, Y. and Zhang, B. (2022), "Role of nutrient-sensing receptor GPRC6A in regulating colonic group 3 innate lymphoid cells and inflamed mucosal healing", *J. Crohn's Colitis*, **20**, 1-13. https://doi.org/10.1002/adfm.202202470

Huang, X., Hao, H., Oslub, K., Habibi, M. and Tounsi, A. (2021a), "Dynamic stability/instability simulation of the rotary size-dependent functionally graded microsystem", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-021-01399-3

Huang, X., Zhang, Y., Moradi, Z. and Shafiei, N. (2021b), "Computer simulation via a couple of homotopy perturbation methods and the generalized differential quadrature method for nonlinear vibration of functionally graded non-uniform micro-tube", *Eng. Comput.*, 1-18. https://doi.org/10.1007/s00366-021-01395-7

Huang, X., Zhu, Y., Vafaei, P., Moradi, Z. and Davoudi, M. (2021c), "An iterative simulation algorithm for large oscillation of the applicable 2D-electrical system on a complex nonlinear substrate", *Eng. Comput.*, **38**(Suppl 4), 3217-3235. https://doi.org/10.1007/s00366-021-01320-y

Jang, J.R. (1993), "ANFIS: Adaptive-network-based fuzzy inference system", *IEEE T. Syst. Man Cybernet.*, **23**(3), 665-685. https://doi.org/10.1109/21.256541

Jiao, J., Ghoreishi, S.M., Moradi, Z. and Oslub, K. (2021), "Coupled particle swarm optimization method with genetic algorithm for the static–dynamic performance of the magneto-electro-elastic nanosystem", *Eng. Comput.*, 1-15. https://doi.org/10.1007/s00366-021-01391-x

Jin, H.-Y. and Wang, Z.-A. (2019), "Global stabilization of the full attraction-repulsion Keller-Segel system", *arXiv preprint arXiv:1905.05990*. https://doi.org/10.3934/dcds.2020027

Jin, K., Yan, Y., Chen, M., Wang, J., Pan, X., Liu, X., Liu, M., Lou, L., Wang, Y. and Ye, J. (2022), "Multimodal deep learning with feature level fusion for identification of choroidal neovascularization activity in age-related macular degeneration", *Acta Ophthalmol.*, **100**(2), e512-e520. https://doi.org/10.1111/aos.14928

Kar, S., Pathakoti, K., Tchounwou, P.B., Leszczynska, D. and Leszczynski, J. (2021), "Evaluating the cytotoxicity of a large pool of metal oxide nanoparticles to Escherichia coli: Mechanistic understanding through In Vitro and In Silico studies", *Chemosphere*, **264**, 128428. https://doi.org/10.1016/j.chemosphere.2020.128428

Khadimallah, M.A., Hussain, M., Naeem, M.N., Taj, M. and Tounsi, A. (2021a), "Monitoring and control of multiple fraction laws with ring based composite structure", *Adv. Nano Res.*, **10**(2), 129-138. https://doi.org/10.12989/anr.2021.10.2.129

Khadimallah, M.A., Hussain, M., Taj, M., Ayed, H. and Tounsi, A. (2021b), "Parametric vibration analysis of single-walled carbon nanotubes based on Sanders shell theory", *Adv. Nano Res.*, **10**(2), 165-174. https://doi.org/10.12989/anr.2021.10.2.165

Kim, B.Y.S., Rutka, J.T. and Chan, W.C.W. (2010), "Nanomedicine", *New England J. Med.*, **363**(25), 2434-2443. https://doi.org/10.1056/NEJMra0912273

Kong, F., Dong, F., Duan, M., Habibi, M., Safarpour, H. and Tounsi, A. (2022), "On the vibrations of the Electrorheological sandwich disk with composite face sheets considering pre and post-yield regions", *Thin Wall. Struct.*, **179**, 109631. https://doi.org/10.1016/j.tws.2022.109631

Kumar, Y., Gupta, A. and Tounsi, A. (2021), "Size-dependent vibration response of porous graded nanostructure with FEM and nonlocal continuum model", *Adv. Nano Res.*, **11**(1), 1-17.

Lee, H. (2021), "Molecular modeling of protein corona formation and its interactions with nanoparticles and cell membranes for nanomedicine applications", *Pharmaceutics*, **13**(5), 637. https://doi.org/10.3390/pharmaceutics13050637

Li, H. and Wang, F. (2021), "Core-shell chitosan microsphere with antimicrobial and vascularized functions for promoting skin wound healing", *Mater. Des.*, **204**, 109683. https://doi.org/10.1016/j.matdes.2021.109683

Li, J., Tang, F. and Habibi, M. (2020a), "Bi-directional thermal buckling and resonance frequency characteristics of a GNP-reinforced composite nanostructure", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-020-01110-y

Li, Y., Li, S., Guo, K., Fang, X. and Habibi, M. (2020b), "On the modeling of bending responses of graphene-reinforced higher order annular plate via two-dimensional continuum mechanics approach", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-020-01166-w

Liu, H., Shen, S., Oslub, K., Habibi, M. and Safarpour, H. (2021a), "Amplitude motion and frequency simulation of a composite viscoelastic microsystem within modified couple stress elasticity", *Eng. Comput.*, 1-15. https://doi.org/10.1007/s00366-021-01316-8

Liu, H., Zhao, Y., Pishbin, M., Habibi, M., Bashir, M. and Issakhov, A. (2021b), "A comprehensive mathematical simulation of the composite size-dependent rotary 3D microsystem via two-dimensional generalized differential quadrature method", *Eng. Comput.*, 1-16. https://doi.org/10.1007/s00366-021-01419-2

Liu, K., Ke, F., Huang, X., Yu, R., Lin, F., Wu, Y. and Ng, D.W.K. (2021c), "Deepban: A temporal convolution-based communication framework for dynamic WBANS", *IEEE T. Commun.*, **69**(10), 6675-6690. https://doi.org/10.1109/TCOMM.2021.3094581

Liu, L., Bi, M., Wang, Y., Liu, J., Jiang, X., Xu, Z. and Zhang, X. (2021d), "Artificial intelligence-powered microfluidics for nanomedicine and materials synthesis", *Nanoscale*, **13**(46), 19352-19366. https://doi.org/10.1039/D1NR06195J

Liu, L., Li, B., Götting, G., Xiang, Y., Salem, Q., Hamid, M. and Xie, J. (2020a). "Loss minimization of traction systems in battery electric vehicles using variable dc-link voltage technique—experimental study", *2020 22nd European Conference on Power Electronics and Applications (EPE'20 ECCE Europe)*, Lyon, France, September.

Liu, L., Zhang, Z., Cao, L., Xiong, Z., Tang, Y. and Pan, Y. (2021e), "Cytotoxicity of phytosynthesized silver nanoparticles: A meta-analysis by machine learning algorithms", *Sust. Chem. Pharm.*, **21**, 100425. https://doi.org/10.1016/j.scp.2021.100425

Liu, Y., Qiao, J., Hu, Y., Fang, T., Xu, T., Xiang, Y. and Han, Y. (2020b), "Determination of curve speed zones for mountainous freeways", *Math. Probl. Eng.*, **2020**. https://doi.org/10.1155/2020/8844004

Liu, Y., Wang, W., He, T., Moradi, Z. and Larco Benítez, M.A. (2021f), "On the modelling of the vibration behaviors via discrete singular convolution method for a high-order sector annular system", *Eng. Comput.*, **38**(Suppl 4), 3631-3653. https://doi.org/10.1007/s00366-021-01454-z

Liu, Z., Su, S., Xi, D. and Habibi, M. (2020c), "Vibrational responses of a MHC viscoelastic thick annular plate in thermal environment using GDQ method", *Mech. Based Des. Struct.*, 1-26. https://doi.org/10.1080/15397734.2020.1784201

Liu, Z., Wu, X., Yu, M. and Habibi, M. (2020d), "Large-amplitude dynamical behavior of multilayer graphene platelets reinforced nanocomposite annular plate under thermo-mechanical loadings", *Mech. Based Des. Struct.*, 1-25. https://doi.org/10.1080/15397734.2020.1815544

Lori, E.S., Ebrahimi, F., Supeni, E.E.B., Habibi, M. and Safarpour, H. (2020), "The critical voltage of a GPL-reinforced composite microdisk covered with piezoelectric layer", *Eng. Comput.*, 1-20. https://doi.org/10.1007/s00366-020-01004-z

Lu, J., Li, D., Wang, P., Zheng, F. and Wang, M. (2022), "Security-aware routing protocol based on artificial neural network algorithm and 6LoWPAN in the internet of things", *Wireless Commun. Mobile Comput.*, **2022**. https://doi.org/10.1155/2022/8374473

Luo, J., Song, J., Moradi, Z., Safa, M. and Khadimallah, M.A. (2022a), "Effect of simultaneous compressive and inertia loads on the bifurcation stability of shear deformable functionally graded annular fabrications reinforced with graphenes", *Eur. J. Mech.A Solids*, 104581. https://doi.org/10.1016/j.euromechsol.2022.104581

Luo, J., Wu, S., Hou, S., Moradi, Z., Habibi, M. and Khadimallah, M.A. (2022b), "Thermally nonlinear thermoelasticity of a one-dimensional finite domain based on the finite strain concept", *Eur. J. Mech. A Solids*. 104726. https://doi.org/10.1016/j.euromechsol.2022.104726

Ma, L., Liu, X. and Moradi, Z. (2022), "On the chaotic behavior of graphene-reinforced annular systems under harmonic excitation", *Eng. Comput.*, 1-25. https://doi.org/10.1007/s00366-020-01210-9

Madenci, E. (2021), "Free vibration analysis of carbon nanotube RC nanobeams with variational approaches", *Adv. Nano Res.*, **11**(2), 157-171. https://doi.org/10.12989/anr.2021.11.2.157

Maojo, V., Martin-Sanchez, F., Kulikowski, C., Rodriguez-Paton, A. and Fritts, M. (2010), "Nanoinformatics and DNA-based computing: catalyzing nanomedicine", *Pediatr. Res.*, **67**(5), 481-489. https://doi.org/10.1203/PDR.0b013e3181d6245e

Michael, M., Meyyazhagan, A., Velayudhannair, K., Pappuswamy, M., Maria, A., Xavier, V., Balasubramanian, B., Baskaran, R., Kamyab, H. and Vasseghian, Y. (2022), "The content of heavy metals in cigarettes and the impact of their leachates on the aquatic ecosystem", *Sustainability*. **14**(8), 4752. https://doi.org/10.3390/su14084752

Moayedi, H., Aliakbarlou, H., Jebeli, M., Noormohammadiarani, O., Habibi, M., Safarpour, H. and Foong, L. (2020a), "Thermal buckling responses of a graphene reinforced composite micropanel structure", *Int. J. Appl. Mech*., **12**(1), 2050010. https://doi.org/10.1142/S1758825120500106

Moayedi, H., Ebrahimi, F., Habibi, M., Safarpour, H. and Foong, L.K. (2020b), "Application of nonlocal strain–stress gradient theory and GDQEM for thermo-vibration responses of a laminated composite nanoshell", *Eng. Comput*., 1-16. https://doi.org/10.1007/s00366-020-01002-1

Moayedi, H., Habibi, M., Safarpour, H., Safarpour, M. and Foong, L. (2019), "Buckling and frequency responses of a graphene nanoplatelet reinforced composite microdisk", *Int. J. Appl. Mech*., **11**(10), 1950102. https://doi.org/10.1142/S1758825119501023

Mohammadgholiha, M., Shokrgozar, A., Habibi, M. and Safarpour, H. (2019), "Buckling and frequency analysis of the nonlocal strain–stress gradient shell reinforced with graphene nanoplatelets", *J. Vib. Control*, **25**(19-20), 2627-2640. https://doi.org/10.1177/1077546319863251

Mohammadi, A., Lashini, H., Habibi, M. and Safarpour, H. (2019), "Influence of viscoelastic foundation on dynamic behaviour of the double walled cylindrical inhomogeneous micro shell using MCST and with the aid of GDQM", *J. Solid Mech*., **11**(2), 440-453. https://doi.org/10.22034/JSM.2019.665264

Moradi Kashkooli, F., Soltani, M., Souri, M., Meaney, C. and Kohandel, M. (2021), "Nexus between in silico and in vivo models to enhance clinical translation of nanomedicine", *Nano Today*, **36**, 101057. https://doi.org/10.1016/j.nantod.2020.101057

Moradi, Z., Davoudi, M., Ebrahimi, F. and Ehyaei, A.F. (2021), "Intelligent wave dispersion control of an inhomogeneous micro-shell using a proportional-derivative smart controller", *Wave. Random Complex Med*., 1-24. https://doi.org/10.1080/17455030.2021.1926572

Najaafi, N., Jamali, M., Habibi, M., Sadeghi, S., Jung, D.w. and Nabipour, N. (2020), "Dynamic instability responses of the substructure living biological cells in the cytoplasm environment using stress-strain size-dependent theory", *J. Biomol. Struct. Dyn*., 1-12. https://doi.org/10.1080/07391102.2020.1751297

Nieto González, N., Obinu, A., Rassu, G., Giunchedi, P. and Gavini, E. (2021), "Polymeric and Lipid Nanoparticles: Which Applications in Pediatrics?", *Pharmaceutics*. **13**(5), 670. https://doi.org/10.3390/pharmaceutics13050670

Oyarhossein, M.A., Alizadeh, A.a., Habibi, M., Makkiabadi, M., Daman, M., Safarpour, H. and Jung, D.W. (2020), "Dynamic response of the nonlocal strain-stress gradient in laminated polymer composites microtubes", *Sci. Rep*., **10**(1), 1-19. https://doi.org/10.1038/s41598-020-61855-w

Pourjabari, A., Hajilak, Z.E., Mohammadi, A., Habibi, M. and Safarpour, H. (2019), "Effect of porosity on free and forced vibration characteristics of the GPL reinforcement composite nanostructures", *Comput. Math. Appl*., **77**(10), 2608-2626. https://doi.org/10.1016/j.camwa.2018.12.041

Rashid, M.B.M.A., Toh, T.B., Hooi, L., Silva, A., Zhang, Y., Tan, P.F., Teh, A.L., Karnani, N., Jha, S., Ho, C.M., Chng, W.J., Ho, D. and Chow, E.K.H. (2018), "Optimizing drug combinations against multiple myeloma using a quadratic phenotypic optimization platform (QPOP)", *Sci. Transl. Med*., **10**(453), eaan0941. https://doi.org/10.1126/scitranslmed.aan0941

Safarpour, H., Ghanizadeh, S.A. and Habibi, M. (2018), "Wave propagation characteristics of a cylindrical laminated composite nanoshell in thermal environment based on the nonlocal strain gradient theory", *Eur. Phys. J. Plus*, **133**(12), 532. https://doi.org/10.1140/epjp/i2018-12385-2

Safarpour, H., Hajilak, Z.E. and Habibi, M. (2019a), "A size-dependent exact theory for thermal buckling, free and forced vibration analysis of temperature dependent FG multilayer GPLRC composite nanostructures restring on elastic foundation", *Int. J. Mech. Mater. Des*., **15**(3), 569-583. https://doi.org/10.1007/s10999-018-9431-8

Safarpour, H., Pourghader, J. and Habibi, M. (2019b), "Influence of spring-mass systems on frequency behavior and critical voltage of a high-speed rotating cantilever cylindrical three-dimensional shell coupled with piezoelectric actuator", *J. Vib. Control*, **25**(9), 1543-1557. https://doi.org/10.1177/1077546319828465

Safarpour, M., Ebrahimi, F., Habibi, M. and Safarpour, H. (2020), "On the nonlinear dynamics of a multi-scale hybrid nanocomposite disk", *Eng. Comput*., 1-20. https://doi.org/10.1007/s00366-020-00949-5

Serov, N. and Vinogradov, V. (2022), "Artificial intelligence to bring nanomedicine to life", *Adv. Drug Deliv. Rev*., **184**, 114194. https://doi.org/10.1016/j.addr.2022.114194

Shao, Y., Zhao, Y., Gao, J. and Habibi, M. (2021), "Energy absorption of the strengthened viscoelastic multi-curved composite panel under friction force", *Arch. Civil Mech. Eng*., **21**(4), 1-29. https://doi.org/10.1007/s43452-021-00279-3

Shariati, A., Habibi, M., Tounsi, A., Safarpour, H. and Safa, M. (2020a), "Application of exact continuum size-dependent theory for stability and frequency analysis of a curved cantilevered microtubule by considering viscoelastic properties", *Eng. Comput*., 1-20. https://doi.org/10.1007/s00366-020-01024-9

Shariati, A., Mohammad-Sedighi, H., Żur, K.K., Habibi, M. and Safa, M. (2020b), "On the vibrations and stability of moving viscoelastic axially functionally graded nanobeams", *Materials*, **13**(7), 1707. https://doi.org/10.3390/ma13071707

Shariati, A., Mohammad-Sedighi, H., Żur, K.K., Habibi, M. and Safa, M. (2020c), "Stability and dynamics of viscoelastic moving rayleigh beams with an asymmetrical distribution of material parameters", *Symmetry*, **12**(4), 586. https://doi.org/10.3390/sym12040586

Shokrgozar, A., Safarpour, H. and Habibi, M. (2020), "Influence of system parameters on buckling and frequency analysis of a spinning cantilever cylindrical 3D shell coupled with piezoelectric actuator", *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, **234**(2), 512-529. https://doi.org/10.1177/0954406219883312

Silva, M., Ferreira, F.N., Alves, N.M. and Paiva, M.C. (2020), "Biodegradable polymer nanocomposites for ligament/tendon tissue engineering", *J. Nanobiotech*., **18**(1), 23. https://doi.org/10.1186/s12951-019-0556-1

Singh, A.V., Ansari, M.H.D., Rosenkranz, D., Maharjan, R.S., Kriegel, F.L., Gandhi, K., Kanase, A., Singh, R., Laux, P. and Luch, A. (2020a), "Artificial intelligence and machine learning in computational nanotoxicology: Unlocking and empowering nanomedicine", *Adv. Healthcare Mater*., **9**(17), 1901862. https://doi.org/10.1002/adhm.201901862

Singh, A.V., Rosenkranz, D., Ansari, M.H.D., Singh, R., Kanase, A., Singh, S.P., Johnston, B., Tentschert, J., Laux, P. and Luch, A. (2020b), "Artificial intelligence and machine learning empower advanced biomedical material design to toxicity prediction", *Adv. Intell. Syst*., **2**(12), 2000084. https://doi.org/10.1002/aisy.202000084

Sunoqrot, S. and Abujamous, L. (2019), "pH-sensitive polymeric nanoparticles of quercetin as a potential colon cancer-targeted nanomedicine", *J. Drug Deliv. Sci. Technol*., **52**, 670-676. https://doi.org/10.1016/j.jddst.2019.05.035

Tlidji, Y., Benferhat, R., Trinh, L.C., Tahar, H.D. and Abdelouahed, T. (2021), "New state-space approach to dynamic analysis of porous FG beam under different boundary conditions", *Adv. Nano Res.*, **11**(4), 347-359. https://doi.org/10.12989/anr.2021.11.4.347

Wang, H., Habibi, M., Marzouki, R., Majdi, A., Shariati, M., Denic, N., Zakić, A., Khorami, M., Khadimallah, M.A. and Ebid, A.A.K. (2022a), "Improving the self-healing of cementitious materials with a hydrogel system", *Gels*, **8**(5), 278. https://doi.org/10.3390/gels8050278

Wang, P., Gao, Z., Pan, F., Moradi, Z., Mahmoudi, T. and Khadimallah, M.A. (2022b), "A couple of GDQM and iteration techniques for the linear and nonlinear buckling of bi-directional functionally graded nanotubes based on the nonlocal strain gradient theory and high-order beam theory", *Eng. Anal. Bound. Elem.*, **143**, 124-136. https://doi.org/10.1016/j.enganabound.2022.06.007

Wang, Y., Yang, J., Moradi, Z., Safa, M. and Khadimallah, M.A. (2022c), "Nonlinear dynamic analysis of thermally deformed beams subjected to uniform loading resting on nonlinear viscoelastic foundation", *Eur. J. Mech. A Solids*, **95**, 104638. https://doi.org/10.1016/j.euromechsol.2022.104638

Wang, Z., Yu, S., Xiao, Z. and Habibi, M. (2020), "Frequency and buckling responses of a high-speed rotating fiber metal laminated cantilevered microdisk", *Mech. Adv. Mater. Struct.*, 1-14. https://doi.org/10.1080/15376494.2020.1824284

Wu, J. and Habibi, M. (2021), "Dynamic simulation of the ultra-fast-rotating sandwich cantilever disk via finite element and semi-numerical methods", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-021-01396-6

Xia, W., Du, J., Habibi, M., Shariati, M. and Khadimallah, M.A. (2022), "Application of Chebyshev-based GDQ and Newmark methods to viscothermoelasticity responses of FG composite annular systems", *Eng. Anal. Bound. Elem.*, **143**, 28-42. https://doi.org/10.1016/j.enganabound.2022.06.003

Xiang, Y. (2022), *AI and IoT Meet Mobile Machines: Towards a Smart Working Site*, KIT Scientific Publishing.

Xiang, Y., Li, D., Su, T., Zhou, Q., Brach, C., Mao, S.S. and Geimer, M. (2022a), "Where am I? SLAM for mobile machines on a smart working site", *Vehicles*, **4**(2), 529-552. https://doi.org/10.3390/vehicles4020031

Xiang, Y., Li, R., Brach, C., Liu, X. and Geimer, M. (2022b), "A novel algorithm for hydrostatic-mechanical mobile machines with a dual-clutch transmission", *Energies*, **15**(6), 2095. https://doi.org/10.3390/en15062095

Xiang, Y., Liu, K., Su, T., Li, J., Ouyang, S., Mao, S.S. and Geimer, M. (2021a), "An extension of BIM using AI: A multi working-machines pathfinding solution", *IEEE Access*, **9**, 124583-124599. https://doi.org/10.1109/ACCESS.2021.3110937

Xiang, Y., Xu, B., Su, T., Brach, C., Mao, S.S. and Geimer, M. (2021b). "5G meets construction machines: Towards a smart working site", *2021 International Conference on Computing and Communications Applications and Technologies (I3CAT)*.

Xiong, Q.M., Chen, Z., Huang, J.T., Zhang, M., Song, H., Hou, X.F., Li, X.B. and Feng, Z.J. (2020), "Preparation, structure and mechanical properties of Sialon ceramics by transition metal-catalyzed nitriding reaction", *Rare Metals*, **39**(5), 589-596.

Xu, W., Pan, G., Moradi, Z. and Shafiei, N. (2021), "Nonlinear forced vibration analysis of functionally graded non-uniform cylindrical microbeams applying the semi-analytical solution", *Compos. Struct.*, 114395. https://doi.org/10.1016/j.compstruct.2021.114395

Xue, X., Zhang, H., Liu, H., Wang, S., Li, J., Zhou, Q., Chen, X., Ren, X., Jing, Y. and Deng, Y. (2022), "Rational design of multifunctional CuS nanoparticle-PEG composite soft hydrogel-coated 3D hard polycaprolactone scaffolds for efficient bone regeneration", *Adv. Funct. Mater.*, 2202470. https://doi.org/10.1002/adfm.202202470

Yang, N., Moradi, Z., Arvin, H., Muhsen, S. and Khadimallah, M.A. (2022a), "A study on small scale thermal dynamic instability of rotating GPL-reinforced microbeams under principal parametric resonance stimulation of axial and transversal modes regarding the proportional damping", *Thin Wall. Struct.*, **180**, 109806. https://doi.org/10.1016/j.tws.2022.109806

Yang, N., Moradi, Z., Khadimallah, M.A. and Arvin, H. (2022b), "Application of the Chebyshev–Ritz route in determination of the dynamic instability region boundary for rotating nanocomposite beams reinforced with graphene platelet subjected to a temperature increment", *Eng. Anal. Bound. Elem.*, **139**, 169-179. https://doi.org/10.1016/j.enganabound.2022.03.013

Yu, X., Maalla, A. and Moradi, Z. (2022), "Electroelastic high-order computational continuum strategy for critical voltage and frequency of piezoelectric NEMS via modified multi-physical couple stress theory", *Mech. Syst. Signal Pr.*, **165**, 108373. https://doi.org/10.1016/j.ymssp.2021.108373.

Zare, R., Najaafi, N., Habibi, M., Ebrahimi, F. and Safarpour, H. (2020), "Influence of imperfection on the smart control frequency characteristics of a cylindrical sensor-actuator GPLRC cylindrical shell using a proportional-derivative smart controller", *Smart Struct. Syst.*, **26**(4), 469-480. https://doi.org/10.12989/sss.2020.26.4.469

Zarrinpar, A., Lee, D.K., Silva, A., Datta, N., Kee, T., Eriksen, C., Weigle, K., Agopian, V., Kaldas, F., Farmer, D., Wang, S.E., Busuttil, R., Ho, C.M. and Ho, D. (2016), "Individualizing liver transplant immunosuppression using a phenotypic personalized medicine platform", *Sci. Transl. Med.*, **8**(333), 333ra349. https:/doi.org/10.1126/scitranslmed.aac5954

Zhang, Y., Wang, Z., Tazeddinova, D., Ebrahimi, F., Habibi, M. and Safarpour, H. (2021), "Enhancing active vibration control performances in a smart rotary sandwich thick nanostructure conveying viscous fluid flow by a PD controller", *Wave. Random Complex Med.*, 1-24. https://doi.org/10.1080/17455030.2021.1948627

Zhao, Y., Moradi, Z., Davoudi, M. and Zhuang, J. (2022), "Bending and stress responses of the hybrid axisymmetric system via state-space method and 3D-elasticity theory", *Eng. Comput.*, 1-23. https://doi.org/10.1007/s00366-020-01242-1

Zheng, Y., Jin, H., Jiang, C., Moradi, Z., Khadimallah, M.A. and Moayedi, H. (2022), "Analyzing behavior of circular concrete-filled steel tube column using improved fuzzy models", *Steel Compos. Struct.*, **43**(5), 625-637. https://doi.org/10.12989/scs.2022.43.5.625

Zhou, C., Zhao, Y., Zhang, J., Fang, Y. and Habibi, M. (2020), "Vibrational characteristics of multi-phase nanocomposite reinforced circular/annular system", *Adv. Nano Res.*, **9**(4), 295-307. https://doi.org/10.12989/anr.2020.9.4.295

Zhu, L., Ren, H., Habibi, M., Mohammed, K.J. and Khadimallah, M.A. (2022), "Predicting the environmental economic dispatch problem for reducing waste nonrenewable materials via an innovative constraint multi-objective Chimp Optimization Algorithm", *J. Clean. Prod.*, 132697. https://doi.org/10.1016/j.jclepro.2022.132697

Zou, Q., Xing, P., Wei, L. and Liu, B. (2019), "Gene2vec: gene subsequence embedding for prediction of mammalian N6-methyladenosine sites from mRNA", *Rna*, **25**(2), 205-218. https://doi.org/10.1261/rna.069112.118

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