An Efficient Modeling Method for CAD Data in Virtual Reality System

Hao Su[1] and Li Cheng[2,*]

[1]Changzhou Vocational Institute of Textile and Garment, Changzhou, Jiangsu 213000, China, hsu@cztgi.edu.cn
[2]Changzhou Vocational Institute of Textile and Garment, Changzhou, Jiangsu 213000, China, lcheng@cztgi.edu.cn

Corresponding author: Li Cheng, lcheng@cztgi.edu.cn

Abstract. The class idea of object-oriented programming. The encapsulation ensures that the module has good independence, and makes the program maintenance, modification and expansion easier. The response of different classes of objects to the same message is called polymorphism. Polymorphic languages have the advantages of flexibility, abstraction, behavior sharing, and code sharing, which further lays the foundation for the expansion of applications. Computer aided design (CAD) is a modern design technology that uses computer aided designers to complete product design tasks quickly, efficiently, high-quality, low-cost and conveniently. The use of models for prediction, diagnosis, analysis and evaluation has always been a key means of industrial process optimization research. With the complexity of industrial processes, it has become very difficult to establish mathematical models based on physical and chemical mechanisms. People have turned to data driven modeling research, which has made rapid development in decades. As a kind of data-driven modeling, artificial intelligence has become one of the hotspots in the modeling field with its powerful nonlinear mapping ability. Such adaptive simplification algorithm based on classification is used to simplify the grid in multi-resolution, that is, first classify the grid models according to their characteristics, and then simplify them based on classification. After adding materials and textures to the VegaPrime. Such results show that the above method is effective.

Keywords: Artificial Intelligence; Cad; Data Modeling; Virtual Reality System.
DOI: https://doi.org/10.14733/cadaps.2023.S5.11-21

1 INTRODUCTION

The core technology of virtual reality technology is to establish the model system of virtual environment. At present, there are many mainstream 3D modeling software, such as 3DMAX, MAYA, CATIA, CREATOR, etc. The more accurate and real the model is, the larger the model data will be drawn. This contradicts the real-time requirements of virtual reality. Therefore, when ensuring the accuracy of the model, the real-time of virtual reality should also be taken into account. The establishment of virtual 3D model is no longer a simple problem [1]. After the CAD model expressed in accurate mathematical form is converted to the VR polygon patch model format, the number of patches is often very large, which cannot meet the real-time rendering requirements of the VR system [2].

Geometric model is a tool used by CAD/CAM system to describe and record the geometric shape of design objects. CAD/CAM users do not have direct access to these models, but operate through appropriate design commands [3]. Another method is to purchase existing 3D models from relevant commercial databases (such as Viewport Catalog and Multigen OpenFlight models). In commercial databases, each model usually has three levels of detail: Low, Medium, and High, which are divided according to the number of polygons and surfaces used in the model [4].

The researchers combined the research of virtual assembly and analyzed some effective iterative methods of bipolar fuzzy system of linear equations. The artificial intelligence method to predict hERG channel suppression in the age of big data is explored. The results show that the method has the advantages of high accuracy and good universality. Survey results of skills requirements in recruitment advertisements for artificial intelligence and machine learning. The model obtained through PolyTrans transformation [5]. Business process optimization, cognitive decision algorithm and artificial intelligence data driven animal network system in sustainable intelligent manufacturing are analyzed.

A high resolution improved projective 3D positioning algorithm based on virtual reality and precise assembly of parts is studied. Finite Element Model Generator (FEM) This product also has the function of automatic mesh generation, which can easily generate finite element models. The finite element model generator has an open architecture and can interface with other commercial or special solvers. The product is closely integrated with CATIA, which is helpful to complete the modeling and analysis of the entire finite element model in CAD/CAM/CAE system. The generative part stress analysis (GPS) provides designers with a stress analysis tool at the beginning of the product development process as a design guide for castings, forgings or thick walled parts. Interacting with components instead of finite element models, designers can check components in only six simple steps.

2 STATE OF THE ART

2.1 CAD Technology Status

The development of CAD technology has a history of more than 50 years. The development of CAD technology is related to the needs of industrial application and close planning. With the need of practical application, some new technologies and algorithms

of computer application are constantly emerging and developing in CAD, mainly in the research and development of standardized technology modeling. In recent years, Dong et al. [6] have made some achievements in the development and application of CAD systems. In the 1990s, fierce market competition promoted advanced manufacturing models, such as Computer Integrated Manufacturing System (CIMS) and Concurrent Engineering (CE). Estes et al. [7] analyzed the problem of the transceiver receiving signals in the wireless communication system. ICAD itself is a system, which embeds expert system into CAD. CAD relies on knowledge base, database and expert system to solve various design problems. Lv [8] believe that ICAD is a general design software or support environment and should not be a product specific design software. In recent years, Man and Gao [9] have done a lot of work in the development of CAD, which involves architecture, engineering design, mechanical product design, processing, etc. In the development process, some new methods and ideas are proposed for the principle, structure and construction of expert system.

2.2 CAD System Modeling

On the basis of the general 3D CAD platform, a professional design system oriented to the design process is developed. On this basis, Mourtzis and Angelopoulos [10] from the perspective of classes in object-oriented technology, each functional part of the system is divided into modules according to the flow direction and processing of data. Nabavinejad et al. [11] analyzed the deep neural network accelerator efficient interconnection network. The difference between module and class division is that the former emphasizes the flow direction of data. Sometimes several function modules are classified to realize the function of the class. The module architecture of the intelligent CAD system is shown in Figure 1.

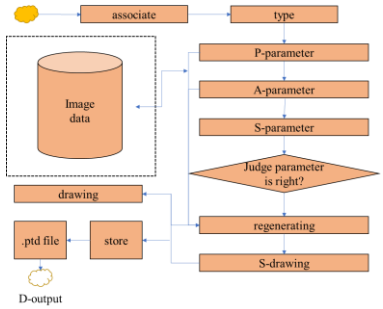

Figure 1: Modular ICAD system model.

2.3 Overview of Artificial Intelligence

Such neurophysiology, psychology, philosophy, linguistics and other disciplines. At the Dartmouth Conference in 1956, the term AI (A1) was first used, which was defined as "computer processes that require the use of intelligence". Sahu et al. [12] analyzed artificial intelligence in augmented reality (AR) assisted manufacturing applications. Modern period: from the second half of the 1970s to the present, its main characteristics are technology and application. Human computer interactive CAD system is to rapidly

complete some design resource navigation and information navigation of part design by providing users with direct interaction with computers, and by providing users with corresponding auxiliary functions in the system, so as to carry out part design parameter input, query, calculation and part design.

Human computer interaction is realized through user interface. Different from the traditional human-computer system, the interaction form in the human-computer system has become the communication and dialogue between the user and the computer's two "intelligent systems". Software interface is the information interface of man machine state. In a sense, the structure of human-computer dialogue.

3 METHODOLOGY

3.1 Construction of Data Modeling System Theory

In structured data, data is composed of rows and columns. We usually call a row of data a sample or observation, and a column of data a variable or attribute. Among them, there may be a special variable that describes a certain result or state of the sample. Usually, such variables representing the output results are called target variables or response variables, or dependent variables.

For the general sense of sample space, we do not require that every sample point must be a real number, that is, the result of uncertain event 5 may be a number, character, or even a set of any size. Let the structured sample space S be the Cartesian product of all S in a set composed of random events:

$$\boldsymbol{S} = s|\ s = \left\{s_1, s_2, \ldots, s_p\right\}, s \in S_1 S_2 \cdots S_p \tag{1}$$

$$f_A : s_A \to 0 \tag{2}$$

It is called a complete modeling process, which can also be expressed in functional form as:

$$o_A = f_A\left(s_1, s_2, \ldots s_p, h_1, h_2, \ldots h_q\right) \tag{3}$$

For the surjection from Sv to O:

$$f_V : s_V \to 0 \tag{4}$$

It is called an explicit modeling process, which can also be expressed in the form of functions:

$$o_V = f_V\left(s_1, s_2, \ldots s_p\right) \tag{5}$$

Even though the explicit modeling process fv as described in Formula (5) removes the factor of implicit sample space compared with fA, a mapping relationship like fv is often extremely complex.

Set mapping f, f1 and f2, if:

$$f(s) = f_2\left(f_1(s), s\right) \tag{6}$$

Then f1 and f2 are called a mapping decomposition of f. The definition is shown in the following equation (7):

$$f_1 \to f_2 = f_2\left(f_1(s), s\right) \tag{7}$$

It can be seen from equation (7) that the mapping decomposition actually splits f into two mappings. By splitting the nested functions, the complex mapping f can be represented by two relatively simple mappings f1 and f2.

3.2 Data Based Modeling Method

Multivariate linear regression, assuming that the independent variable sample constitutes matrix X:

$$y = Xb + e \tag{8}$$

Where e is the model error and b is the linear regression coefficient. And the regression coefficient b as:

$$\boldsymbol{b} = \left(\boldsymbol{X}^{\mathrm{T}}\boldsymbol{X}\right)^{-1}\boldsymbol{X}^{\mathrm{T}}\boldsymbol{y} \tag{9}$$

The principal component analysis is adopted in the principal component regression method. The principal component regression model can be solved by spectral decomposition of data covariance. The covariance matrix can be expressed as:

$$\Sigma = \frac{X^{\mathrm{T}}\boldsymbol{X}}{n-1} \tag{10}$$

By spectral decomposition, we can get:

$$\Sigma p_i = \lambda_i p_i \tag{11}$$

Then select representative principal components to explain the parts of the data with large changes, namely:

$$X = t_1 p_1^{\mathrm{T}} + t_2 p_2^{\mathrm{T}} + \cdots + t_h p_h^{\mathrm{T}} + E_h \tag{12}$$

Here is the ti principal component vector. After PCA analysis, the original p-dimensional variable space is transformed into the h-dimensional principal component space, and the components are independent of each other.

Intelligent method, which mainly consists of three parts. The types of commonly used neural networks mainly include multilayer perceptron, thermal process. However, ANN uses a random way to train the parameters of the network model, and repeated training cannot get a consistent model. In addition, when using known samples to train the model, it is easy to fall into the local minimum and over fit. Moreover, neural network is a black box modeling method, that is, the trained ANN model cannot provide the relationship expression between input and output variables. It has structural risk minimization principle to replace the traditional empirical for the nonlinear fitting problem, it uses SVM nonlinear mapping to transform the nonlinear problem in the original space into a high Dimensional space.

3.3 Model Validation

The essence of model validation is the reason shall be analyzed, and the model shall be rebuilt until the obtained model meets the inspection criteria. The commonly used model accuracy evaluation standards mainly include: determination coefficient R2, and maximum relative error. Among them, the determination coefficient refers to the

variation ratio of the data variation that can be explained by the model to the observed sample data. RMSE, ARE, MAE and are used to describe calculation formula of each indicator is as follows:

$$R^2 = 1 - \sum_{n}^{i=1} \hat{y}_i - yi2 \sum_{n}^{i=1} y_i - yi2 \tag{13}$$

$$R_{MSE} = \sqrt{\frac{1}{n} \sum_{n}^{j=1} \left(\hat{y}_i - y_i \right)^2}. \tag{14}$$

$$A_{RE} = \frac{1}{n} \sum_{n}^{j=1} \left| \frac{\hat{y}_i - y_i}{y_i} \right| * 100\% \tag{15}$$

When building a model, model training is generally carried out based on the fitting accuracy of the model. The model thus obtained will have better training accuracy, but the prediction accuracy of the model for new samples cannot be guaranteed. Sometimes the prediction accuracy of the model is far lower than that of other similar models. The reasons for this phenomenon mainly are: (1) The complexity of the model is too high, which leads to the over fitting of the model, The result will be too high, and the prediction accuracy to the test sample is poor; (2) The local distribution of samples, when the coverage of training sample data is limited, and the test samples are not distributed within the range of training samples, will also lead to low prediction accuracy of the model for test samples. Figure 2 shows the segmentation diagram of the data, where the black curve is voltage data, the sampling points of red, blue and green segments are 75, and 38 points overlap between two adjacent segments.

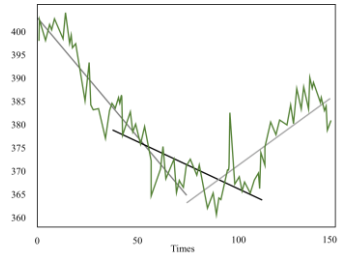

Figure 2: Schematic diagram of adaptive filtering algorithm.

4 RESULT ANALYSIS AND DISCUSSION

4.1 Extraction of CAD 3D Model Mesh Information

In the three-dimensional world of computer, people usually use three-dimensional mesh to describe the physical model. In this 3D mesh model, these surface patches are approximately represented by triangular patches connected with each other. The more triangles, the higher the fidelity of the model. But the greater the burden on the computer when the model is stored, analyzed, displayed, interacted, processed and transmitted. VRML format files generated from CAD software, involve the following

nodes: Indexed Face Set node, Coordinated node, Normal node, and so on. A collection of nodes will in listed in Figure 3.

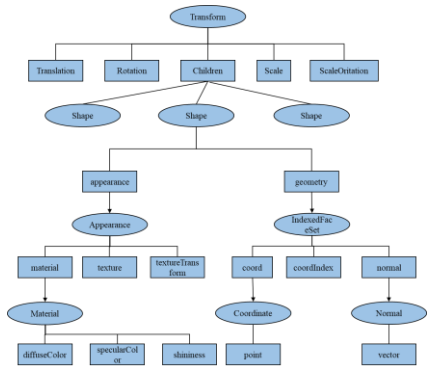

Figure 3: Nodes and their relationships.

4.2 Analysis of Experimental Results

In the thermal process, each variable has a certain symmetry relationship. For example, the primary air volume is usually set to be in a certain proportion to the coal supply, and the total fuel volume and load also have a certain coupling relationship. As shown in Figure 4, the variation relationship between the main steam flow, generator power and total fuel volume is roughly the same, and there is a serious coupling between the three variables.

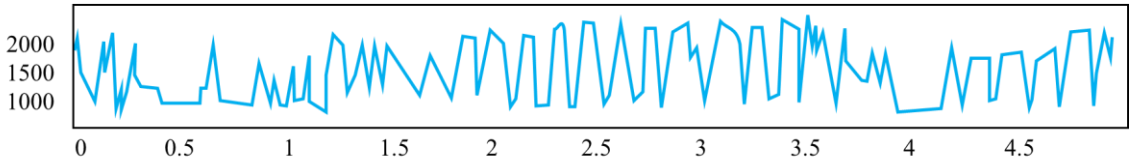

Figure 4: Sample sequence of main steam flow, generator power and total fuel quantity.

The fourth order Runge Kutta formula is used to solve the system and save the value of element x, which is recorded as setting the number of sampling points to 104 and the sampling interval to 0.01 s. At this time, the phase diagram of S (i) is shown in Figure 5 (a). Add a Gaussian white noise with zero mean value to S (i) to obtain noisy data X (i), and its phase diagram is shown in Figure 5 (b).

In order to verify the prediction performance of the model PLS-LSSVM, this paper also establishes a reheat steam temperature prediction model based on the PLS traditional linear method and a single LSSVM method, and compares them. The prediction errors of each model for training samples and test samples are shown in Figure 6 and Figure 7

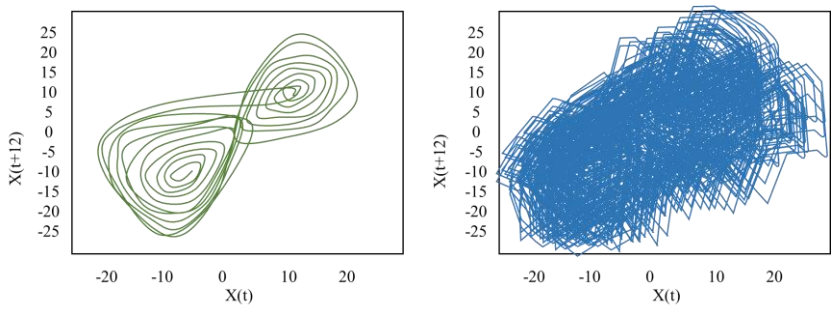

Figure 5: Bitmap (time delay is set to 12): (a) pure Lorentz data (b) noisy Lorentz data

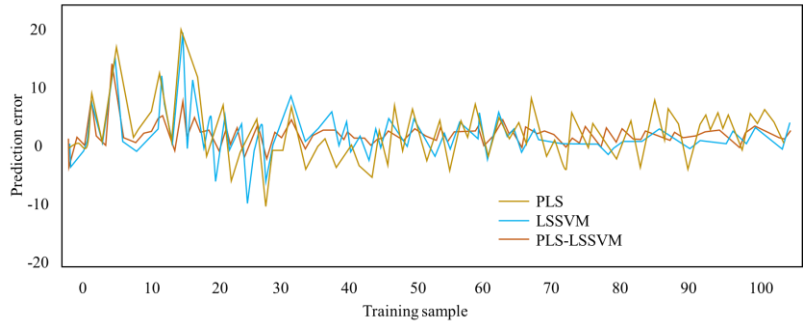

Figure 6: Comparison of prediction errors of models for training samples.

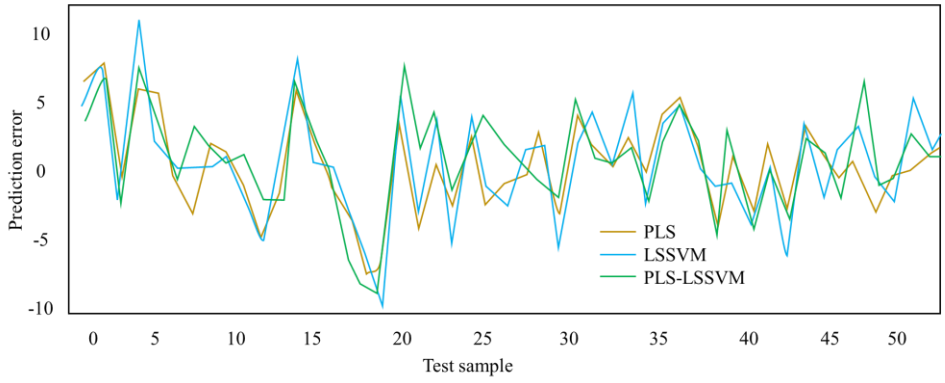

Figure 7: Comparison of prediction errors of models on test samples.

It can be seen from the comparison of the above modeling methods that the PLS linear model has a large prediction error for training samples and test samples, with the maximum error reaching 16.24 and 9.62 respectively, indicating that as a linear regression method, the PLS method still has a large error in dealing with nonlinear problems. Compared with the traditional linear model PLS, LSSVM model reduces the

prediction error of training samples and test samples due to the introduction of nonlinearity. Compared with LSSVM model, the prediction effect of PLS-LSSVM model is improved, because the reduction of input variables will reduce the complexity of the model, suppress irrelevant interference noise, and eliminate the correlation between variables, thus improving the prediction ability of the model

On a Pentium 4, 2.93GHz, 1G memory PC, CAD software (CATIA) and Visual C++are used NET has compiled the analysis, simplification and conversion program of CAD model. Figure 8 shows the staged use of users after modeling the user data of power industry with CAD. In order to meet the requirements of CAD models in virtual reality systems, this chapter proposes and implements a classification, simplification and transformation method for virtual reality-oriented CAD models. The experimental results show that this method is feasible. The simplified model keeps the geometric characteristics of the original model well in the shape, and also meets the real-time rendering requirements of the visual system, which can be used in the actual system.

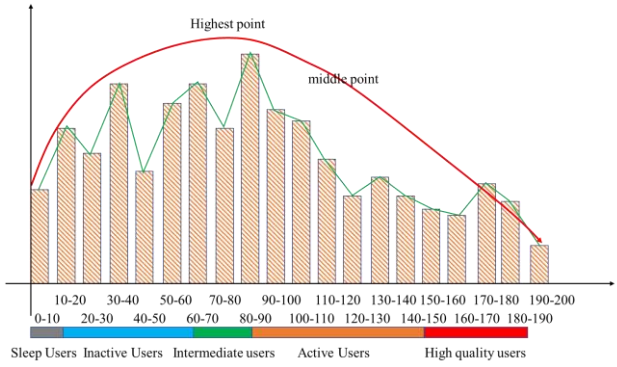

Figure 8: Data modeling results of power users by CAD.

5 CONCLUSION

It has fundamentally changed the past technology management and working methods in the whole production process from design to product manufacturing, and has brought profound changes to the design field. However, the development and application of CAD systems in China are mainly shown in the following aspects: there are few 3D CAD applications, CAD systems are only used as a drawing tool, enterprises have not yet formed a good CAD environment, and information integration technology is backward. In view of the current situation, taking the actual environment of domestic enterprises as the application background, on the basis of summing up the experience of predecessors, this paper puts forward the idea of object-oriented intelligent CAD system with both pertinence and universality, develops the FJCAD system, and promotes the further promotion and application of CAD technology in China. On the basis of summarizing and analyzing the development and application of current CAD systems, this paper has done the research and development of object-oriented intelligent CAD systems. In view of the limitations of application software at home and abroad and the problem that CAD system is only used as a drawing tool in enterprises, this paper integrates the knowledge of

gradually mature artificial intelligence and KBE technology, integrates relevant design knowledge into the CAD system of knife and hair, and studies the intelligent CAD system of human-computer interaction. It renders the original model using Open GL to realize visualization. The research on data modeling system theory belongs to an interdisciplinary field. This dissertation takes statistics as the main body, machine learning as the auxiliary, mathematics as the theoretical basis, algorithms and computing science as the technical realization means, and system science as the guiding ideology to form the theoretical system of this dissertation.

6 ACKNOWLEDGEMENT

This work was supported by Research on the Interactive Communication Mode of Jiangsu Folk Intangible Cultural Heritage in the Form of Smart Museum (No.2022SJYB1367).

Hao Su, https://orcid.org/0000-0002-3602-4667
Li Cheng, https://orcid.org/0000-0002-4870-1514

REFERENCES

[1] Aggour, K.-S.; Gupta, V.-K.; Ruscitto, D.; Ajdelsztajn, L.; Bian, X.; Brosnan, K.-H.; Vinciquerra, J.: Artificial intelligence/machine learning in manufacturing and inspection: A GE perspective, MRS Bulletin, 44(7), 2019, 545-558. https://doi.org/10.1557/mrs.2019.157

[2] Alexopoulos, K.; Nikolakis, N.; Chryssolouris, G.: Digital twin-driven supervised machine learning for the development of artificial intelligence applications in manufacturing, International Journal of Computer Integrated Manufacturing, 33(5), 2020, 429-439. https://doi.org/10.1080/0951192X.2020.1747642

[3] Benotsmane, R.; Kovács, G.; Dudás, L.: Economic, social impacts and operation of smart factories in Industry 4.0 focusing on simulation and artificial intelligence of collaborating robots, Social Sciences, 8(5), 2019, 143. https://doi.org/10.3390/socsci8050143

[4] Chandra, S.-S.; Yap, H.-J.; Musa, S.-N.; Liew, K.-E.; Tan, C.-H.; Aman, A.: The implementation of virtual reality in digital factory—a comprehensive review, The International Journal of Advanced Manufacturing Technology, 115(5), 2021, 1349-1366. https://doi.org/10.1007/s00170-021-07240-x

[5] Chen, A.: The Efficient Finite Element Methods for Time-Fractional Oldroyd-B Fluid Model Involving Two Caputo Derivatives, Computer Modeling in Engineering & Sciences, 125(1), 2020, 173-195. https://doi.org/10.32604/cmes.2020.011871

[6] Dong, Y.; Song, Y.; Wei, G.: Efficient model-predictive control for networked interval type-2 T–S fuzzy system with stochastic communication protocol, IEEE Transactions on Fuzzy Systems, 29(2), 2020, 286-297. https://doi.org/10.1109/TFUZZ.2020.3004192

[7] Estes, N.; Gao, K.; Hochwald, B.; Laneman, J. N.; Chisum, J.: Efficient modeling of low - resolution millimeter - wave transceivers for massive MIMO wireless communications systems, Microwave and Optical Technology Letters, 63(4), 2021, 1134-1140. https://doi.org/10.1002/mop.32727

[8] Lv, Z.: Virtual reality in the context of Internet of Things, Neural Computing and applications, 32(13), 2020, 9593-9602. https://doi.org/10.1007/s00521-019-04472-7
[9] Man, S.; Gao, Z.: Digital immersive interactive experience design of museum cultural heritage based on virtual reality technology, Journal of Electronic Imaging, 32(1), 2022, 011208. https://doi.org/10.1117/1.JEI.32.1.011208
[10] Mourtzis, D.; Angelopoulos, J.: An intelligent framework for modelling and simulation of artificial neural networks (ANNs) based on augmented reality, The International Journal of Advanced Manufacturing Technology, 111(5), 2020, 1603-1616. https://doi.org/10.1007/s00170-020-06192-y
[11] Nabavinejad, S.-M.; Baharloo, M.; Chen, K.-C.; Palesi, M.; Kogel, T.; Ebrahimi, M.: An overview of efficient interconnection networks for deep neural network accelerators, IEEE Journal on Emerging and Selected Topics in Circuits and Systems, 10(3), 2020, 268-282. https://doi.org/10.1109/JETCAS.2020.3022920
[12] Sahu, C.-K.; Young, C.; Rai R.: Artificial intelligence (AI) in augmented reality (AR)-assisted manufacturing applications: a review, International Journal of Production Research, 59(16), 2021, 4903-4959. https://doi.org/10.1080/00207543.2020.1859636