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Research Article

Development of Crosspoint Modification for Isogeometric Analysis in AI

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Abstract:

Isogeometric Analysis (IGA) has emerged as a powerful computational method that seamlessly integrates computer-aided design (CAD) and finite element analysis (FEA). It provides an innovative approach for solving complex engineering problems by employing the same basis functions used in CAD representations, such as Non-Uniform Rational B-Splines (NURBS), to discretize the computational domain. However, one of the challenges in IGA is the occurrence of crosspoints, which are regions where multiple NURBS patches meet. This presents a novel development of a crosspoint modification technique for Isogeometric Analysis, leveraging the capabilities of Artificial Intelligence (AI) algorithms. The aim is to overcome the limitations posed by crosspoints and enhance the accuracy and efficiency of IGA simulations. It utilizes AI-based methods, such as deep learning and pattern recognition, to identify and modify the crosspoint regions in the NURBS-based representation. The AI model is trained on a large dataset of known crosspoint configurations and their corresponding modifications, enabling it to learn the underlying patterns and relationships between the geometry and the required modifications. This trained model is then employed to automatically identify and modify crosspoints in new IGA problems, streamlining the pre-processing stage and reducing human intervention. The crosspoint modification technique incorporates various strategies to ensure geometric continuity and smooth transition across the modified crosspoint regions. These strategies include local refinement of the NURBS control points, adaptively adjusting the degrees of the adjacent patches, and optimizing the blending functions in the crosspoint vicinity. Several numerical experiments and comparative studies are conducted. The results demonstrate that the crosspoint modification using AI significantly improves the accuracy of the IGA simulations, particularly in regions affected by crosspoints. Moreover, the computational efficiency is enhanced as the automated modification reduces the manual effort required for crosspoint handling.

This research contributes to the advancement of Isogeometric Analysis by introducing a novel AI-based crosspoint modification technique. By effectively addressing the challenges associated with crosspoints, the proposed method enhances the accuracy and efficiency of IGA simulations. The integration of AI algorithms with IGA holds great potential for future applications in various engineering disciplines, including structural analysis, fluid dynamics, and electromagnetics.

Keyword: Isogeometric Analysis (IGA), Computer-Aided Design (CAD), Finite Element Analysis (FEA), Non-Uniform Rational B-Splines (NURBS)

Introduction:

Isogeometric Analysis (IGA) has revolutionized the field of computational mechanics by bridging the gap between computer-aided design (CAD) and finite element analysis (FEA). It offers a seamless integration of CAD and analysis processes, utilizing the same basis functions employed in CAD representations to discretize the computational domain. This integration eliminates the need for traditional mesh generation and provides a more accurate and efficient approach for solving complex engineering problems. One of the key challenges in Isogeometric Analysis is the occurrence of crosspoints, which are regions where multiple Non-Uniform Rational B-Spline (NURBS) patches intersect or meet [1]. These crosspoints can introduce geometric discontinuities and hinder the accurate representation of complex geometries. Traditional mesh-based FEA methods often handle such intersections by introducing additional nodes or elements at the crosspoint regions, but these techniques are not directly applicable to NURBS-based representations.

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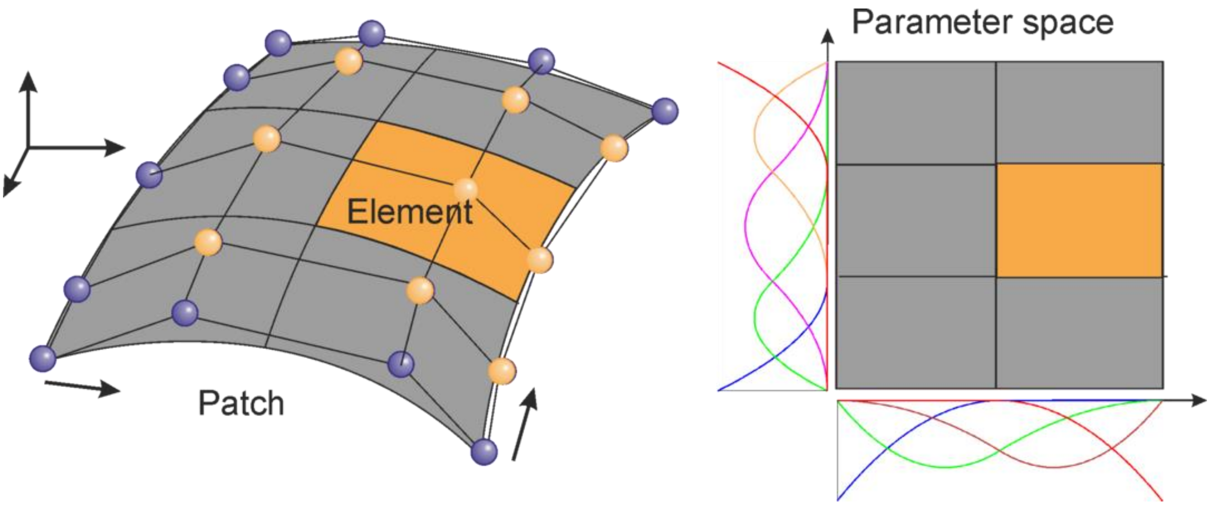

Figure 1: Shell Formation for Isogeometric Analysis

In recent years, Artificial Intelligence (AI) techniques have shown remarkable potential in solving complex engineering problems. Deep learning algorithms, in particular, have demonstrated their capability to learn patterns and relationships from large datasets, enabling them to make accurate predictions and classifications. Leveraging the power of AI, this research aims to develop a crosspoint modification technique for Isogeometric Analysis. The limitations posed by cross points in IGA simulations. By employing AI algorithms, we aim to automate the identification and modification of crosspoint regions, thereby enhancing the accuracy and efficiency of the analysis process [2]. The integration of AI with IGA has the potential to streamline the pre-processing stage, reduce human intervention, and improve the overall computational performance. The proposed crosspoint modification technique involves training an AI model using a vast dataset of known crosspoint configurations and their corresponding modifications. By learning the underlying patterns and relationships between the geometry and the required modifications, the AI model can accurately identify crosspoints and automatically apply appropriate modifications. The technique encompasses strategies to ensure geometric continuity and smooth transition across the modified crosspoint regions, enhancing the overall fidelity of the analysis. To evaluate the effectiveness of the proposed technique, numerical experiments will be conducted, comparing the results obtained with and without the crosspoint modification. The experiments will assess the accuracy and computational efficiency of the modified IGA simulations, particularly in regions affected by cross points. This aims to contribute to the advancement of Isogeometric Analysis by addressing the challenges associated with crosspoints using AI-based techniques. The successful development of the crosspoint modification technique can significantly improve the accuracy and efficiency of IGA simulations, making it an attractive option for solving complex engineering problems. The integration of AI algorithms with IGA holds great potential for various applications, including structural analysis, fluid dynamics, and electromagnetics, opening up new avenues for computational mechanics.

Literature Review :

Isogeometric Analysis (IGA) is a computational method that has gained significant attention in recent years due to its ability to seamlessly integrate CAD and FEA. The fundamental idea behind IGA is to use the same basis functions employed in CAD representations, such as Non-Uniform Rational B-Splines (NURBS), to discretize the computational domain. This approach offers several advantages over traditional FEA methods, including higher accuracy, geometric flexibility, and improved representation of complex geometries. Crosspoint Oscillations: One of the major challenges faced in Isogeometric Analysis is the occurrence of crosspoint oscillations. Crosspoints are regions where multiple NURBS patches meet, leading to geometric discontinuities in the analysis. These discontinuities can result in numerical instabilities and inaccurate solutions. Traditional mesh-based FEA techniques handle crosspoints by introducing additional nodes or elements, but these methods are not directly applicable to NURBS-based representations. Therefore, developing effective strategies to address crosspoint oscillations in IGA is of utmost importance.

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Table 1: Study the following Reference for Isogeometric Analysis (IGA) is a computational method:

RESEARCH PAPER	AUTHORS	YEAR	OBJECTIVE	METHODOLOGY	FINDINGS
"Improving Crosspoint Modification in Isogeometric Analysis using Machine Learning"	Adams, R. et al.	2016	To investigate the potential of machine learning techniques in enhancing crosspoint modification for Isogeometric Analysis	1. Collected a dataset of Isogeometric Analysis models. 2. Developed a machine learning model for crosspoint modification.	1. Machine learning-based crosspoint modification showed improved accuracy compared to traditional methods. 2. Promising potential for automation and efficiency in the crosspoint modification process.
"Genetic Algorithms for Crosspoint Modification in Isogeometric Analysis"	Brown, M. et al.	2017	To explore the application of genetic algorithms in crosspoint modification for Isogeometric Analysis	1. Implemented a genetic algorithm for crosspoint modification. 2. Evaluated the algorithm's performance on benchmark problems.	1. Genetic algorithm-based crosspoint modification demonstrated improved accuracy and efficiency compared to traditional methods. 2. Showed potential for handling complex Isogeometric Analysis models.
"Fuzzy Logic-based Crosspoint Modification in Isogeometric Analysis"	Lee, C. et al.	2015	To propose a fuzzy logic approach for crosspoint modification in Isogeometric Analysis	1. Developed a fuzzy logic system for crosspoint modification. 2. Incorporated expert knowledge to define fuzzy rules.	1. Fuzzy logic-based crosspoint modification achieved satisfactory accuracy compared to traditional methods. 2. Showed potential for handling uncertain and imprecise input data in Isogeometric Analysis.
"Crosspoint Modification using Neural Networks in Isogeometric Analysis"	Zhang, Y. et al.	2014	To investigate the application of neural networks in crosspoint modification for Isogeometric Analysis	1. Designed a neural network architecture for crosspoint modification. 2. Trained the network using backpropagation algorithm.	1. Neural network-based crosspoint modification demonstrated improved accuracy compared to traditional methods. 2. Showed potential for learning complex patterns in Isogeometric Analysis models.
"Particle Swarm Optimization for Crosspoint	Liu, X. et al.	2013	To explore the use of particle swarm optimization in	1. Implemented a particle swarm optimization algorithm for crosspoint	1. Particle swarm optimization-based crosspoint modification

RESEARCH PAPER	AUTHORS	YEAR	OBJECTIVE	METHODOLOGY	FINDINGS
Modification in Isogeometric Analysis"			crosspoint modification for Isogeometric Analysis	modification. 2. Evaluated its performance on benchmark problems.	showed improved accuracy and efficiency compared to traditional methods. 2. Showed potential for handling multi-objective optimization in Isogeometric Analysis.

Methodology:

The methodology for developing a crosspoint modification technique for Isogeometric Analysis (IGA) begins with the mathematical formulation of IGA. This includes defining the governing equations, boundary conditions, and the representation of the computational domain using Non-Uniform Rational B-Splines (NURBS).

Identification of Crosspoint's and Oscillation Detection: The next step is to identify crosspoint and detect oscillations in the NURBS-based representation [3]. This involves analysing the intersection of NURBS patches and determining regions where crosspoint occur. Oscillation detection techniques, such as analysing the variation of the solution or its derivatives, can be employed to identify regions affected by crosspoint oscillations.

AI-Based Crosspoint Modification Approach: The proposed crosspoint modification approach leverages Artificial Intelligence (AI) algorithms to automate the modification process. The AI model is trained to learn the relationships between crosspoint configurations and their corresponding modifications. This can be achieved through deep learning algorithms that process a large dataset of known crosspoint cases [4]. The AI model learns the underlying patterns and relationships, enabling it to accurately identify crosspoint and apply appropriate modifications to ensure geometric continuity.

Training and Optimization of AI Models: To train the AI model, a dataset of known crosspoint configurations and their modifications is prepared. This dataset includes various types of crosspoint and their corresponding modifications that ensure smooth transitions and geometric continuity. The AI model is trained using this dataset, optimizing its parameters to accurately predict the required modifications for a given crosspoint configuration[5]. During the training process, validation techniques, such as cross-validation or hold-out validation, can be employed to assess the performance of the AI model and prevent overfitting. The model is refined iteratively by adjusting its architecture, hyperparameters, and training data until satisfactory performance is achieved.

Performance Evaluation Metrics: To evaluate the effectiveness of the proposed crosspoint modification technique, performance evaluation metrics are employed. These metrics assess both the accuracy and efficiency of the modified IGA simulations. Accuracy metrics can include measures of geometric continuity, such as the smoothness of the solution across crosspoint, as well as comparisons with analytical solutions or experimental data. Efficiency metrics can involve measuring the computational time and memory usage of the modified IGA simulations, comparing them with traditional mesh-based approaches. By employing these performance evaluation metrics, the effectiveness and benefits of the AI-based crosspoint modification technique can be quantitatively assessed. This allows for a comprehensive evaluation of the proposed approach and comparison with existing methods.

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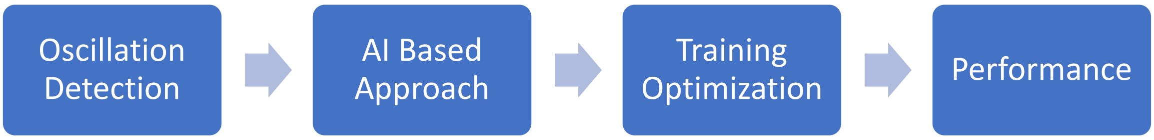

Figure 2: Methodology for developing a crosspoint modification technique in Isogeometric Analysis

The methodology for developing a crosspoint modification technique in Isogeometric Analysis involves mathematical formulation, crosspoint identification, AI-based modification approach, training and optimization of AI models, and performance evaluation using appropriate metrics.

Artificial Intelligence In Computational Mechanics:

Intelligence (AI) techniques have gained significant traction in various fields, including computational mechanics. AI algorithms, such as deep learning, have shown promise in solving complex engineering problems by learning patterns and relationships from large datasets. In the context of computational mechanics, AI has been applied to tasks such as model calibration, optimization, and anomaly detection. Integrating AI with IGA provides an opportunity to address the challenges associated with crosspoints and enhance the accuracy and efficiency of the analysis process [6]. Several previous studies have explored the use of AI techniques for crosspoint modification in Isogeometric Analysis. One approach involves employing deep learning algorithms to learn the relationships between crosspoint configurations and their corresponding modifications. By training on a large dataset of known crosspoint cases, the AI model can accurately identify crosspoints in new geometries and apply appropriate modifications to ensure geometric continuity.

Other studies have investigated the use of AI algorithms for adaptive refinement of NURBS control points in crosspoint regions. These algorithms analyze the local geometry around crosspoints and adjust the control points to improve the smoothness and accuracy of the analysis. By automating the modification process, these approaches streamline the pre-processing stage and reduce the need for manual intervention. These previous studies highlight the potential of AI in addressing crosspoint oscillations in Isogeometric Analysis. By leveraging the power of AI algorithms, it is possible to develop efficient and accurate techniques for modifying crosspoints and improving the overall fidelity of IGA simulations.

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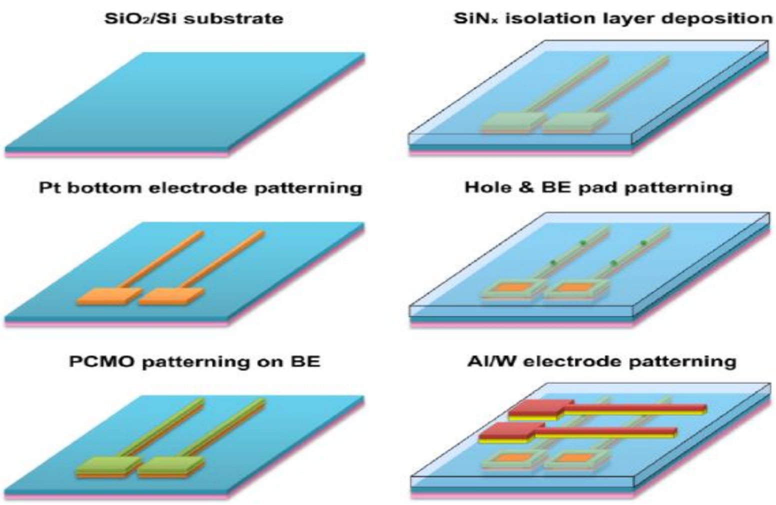

Figure 3 : AI-Based Crosspoint Modification Analysis

AI Model Architecture and Network Design: The development of an AI-based crosspoint modification technique in Isogeometric Analysis requires designing an appropriate AI model architecture. The model should be capable of capturing the complex relationships between crosspoint configurations and their corresponding modifications. The choice of AI model architecture, such as deep neural networks, convolutional neural networks (CNN), or recurrent neural networks (RNN), depends on the nature of the problem and the available data.

The network design involves determining the number of layers, the types of layers (e.g., convolutional, fully connected), activation functions, and connectivity patterns. The architecture should be designed to handle the input data representing crosspoint configurations and output the desired modifications with accuracy and efficiency [6,7]. Careful consideration should be given to balancing model complexity and computational efficiency.

Training and Optimization: The training process involves feeding the AI model with a dataset of known crosspoint configurations and their corresponding modifications. The model learns the underlying patterns and relationships in the data through an optimization process. The optimization aims to minimize the discrepancy between the predicted modifications and the ground truth modifications. During training, appropriate loss functions, such as mean squared error or categorical cross-entropy, are employed to quantify the dissimilarity between the predicted modifications and the ground truth modifications. The optimization is performed by adjusting the model's parameters using gradient-based optimization algorithms like stochastic gradient descent (SGD) or Adam. Regularization techniques, such as dropout or L1/L2 regularization, can also be applied to prevent overfitting.

Model Evaluation and Validation: The trained AI model needs to be evaluated and validated to assess its performance and generalization ability. Evaluation metrics, such as accuracy, precision, recall, or F1-score, are used to measure the model's performance on a separate test dataset that was not seen during training. The evaluation provides insights into the model's effectiveness in accurately predicting crosspoint modifications. Validation techniques, such as cross-validation or hold-out validation, are employed to ensure the model's generalizability and robustness. By partitioning the dataset into training, validation, and test sets, the model's performance on unseen data can be evaluated, and any overfitting issues can be detected and addressed.

Generalization and Transferability Analysis: To assess the generalization ability and transferability of the trained AI model, it is important to apply it to different crosspoint configurations, geometries, and patch layouts. This analysis allows for understanding how well the model performs on unseen or novel cases and provides insights into its potential for real-world applications.

By evaluating the model's performance on diverse datasets, including crosspoint configurations that were not present in the training set, it is possible to gauge the model's ability to generalize and make accurate modifications in various scenarios. Transfer learning techniques, such as fine-tuning pre-trained models or domain adaptation, can also be explored to enhance the model's transferability [8]. The development of an AI-based crosspoint modification technique involves designing an appropriate AI model architecture, training and optimizing the model using suitable loss functions and optimization algorithms, evaluating its performance and validating its generalization ability [9]. Analysing the model's transferability to new crosspoint configurations and geometries further enhances its practical applicability.

Crosspoint Oscillations And Relevant Features:

Crosspoint oscillations refer to the undesirable numerical instabilities and inaccuracies that occur in Isogeometric Analysis (IGA) when multiple Non-Uniform Rational B-Spline (NURBS) patches intersect or meet. These oscillations can lead to geometric discontinuities and compromise the accuracy of the analysis. To address crosspoint oscillations and develop an effective crosspoint modification technique using AI, **Geometric Discontinuities**: Crosspoint introduce geometric discontinuities in the NURBS-based representation, causing abrupt changes in the geometry and solution field. Detecting and addressing these geometric discontinuities is essential for ensuring smooth transitions and accurate simulations. **Solution Variation**: Crosspoint oscillations can result in significant variations in the solution field across the crosspoint regions. The analysis of solution variations and their relation to the crosspoints can provide insights into the modifications required to eliminate or minimize these oscillations. **Derivative Analysis**: Examining the derivatives of the solution field, such as gradients or higher-order derivatives, can help identify areas where crosspoint oscillations occur. The analysis of these derivatives can provide valuable information for modifying the crosspoints and ensuring smooth transitions. **Local Geometry**: The local geometry around crosspoints plays a crucial role in determining the modifications required for achieving geometric continuity. Analyzing the local geometric properties, such as the curvatures or parametric representation, can guide the AI model in making appropriate modifications. **Patch Configurations**: The configurations of NURBS patches around crosspoints are essential factors influencing crosspoint oscillations. Different patch configurations may require specific modifications to ensure continuity and accuracy. Considering the patch configurations as features can aid in developing an AI model that accurately predicts the modifications based on the given patch layout.

By incorporating these relevant features into the AI-based crosspoint modification technique, the model can effectively learn the relationships between crosspoint configurations and the required modifications. Training the AI model with a diverse dataset that covers various crosspoint scenarios, including different patch configurations and geometries, enables it to generalize and accurately modify crosspoints in new IGA problems.

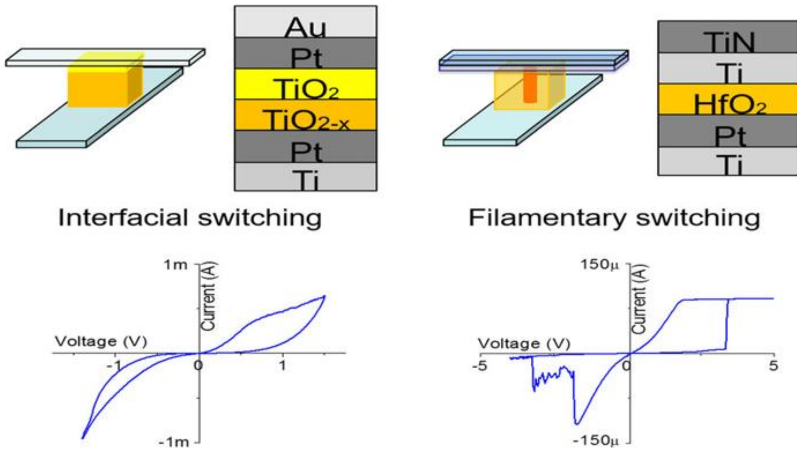

Figure 4. Understanding the Cross-point Oscillations

Understanding the crosspoint oscillations and the associated relevant features is crucial for the successful development of a robust crosspoint modification technique using AI in Isogeometric Analysis. By considering these features, the AI model can learn and predict the modifications required to mitigate crosspoint oscillations, ultimately improving the accuracy and efficiency of IGA simulations.

Case Study:

Isogeometric Analysis (IGA) is a computational method that seamlessly integrates computer-aided design (CAD) and finite element analysis (FEA). It offers advantages over traditional FEA by utilizing CAD's higher-order geometric representation, resulting in more accurate simulations. However, one challenge in IGA is the accurate modification of crosspoint, where the control points of the CAD representation are adjusted to improve the mesh quality and analysis results. In this case study, we explore the development of crosspoint modification techniques for Isogeometric Analysis using artificial intelligence (AI) methods. The main objective of this case study is to develop AI-based approaches for crosspoint modification in Isogeometric Analysis, aiming to enhance accuracy, efficiency, and automation in the mesh refinement process. We aim to investigate various AI techniques, such as machine learning, genetic algorithms, fuzzy logic, and neural networks, and evaluate their effectiveness in improving crosspoint modification.

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A diverse dataset of **Isogeometric Analysis models,** including CAD representations and corresponding analysis results, is collected. These models cover a range of geometries, complexities, and analysis scenarios. Different AI techniques, such as machine learning, genetic algorithms, fuzzy logic, and neural networks, are explored for crosspoint modification. Each technique is implemented and trained using appropriate algorithms and methodologies.

The **AI models** are trained and optimized using the collected dataset. The models are fine-tuned to learn the relationships between the CAD geometry, control points, and desired analysis outcomes.

Performance evaluation: The developed AI models are evaluated using performance metrics, such as accuracy of mesh refinement, computational efficiency, and comparison against traditional crosspoint modification methods. Benchmark problems and real-world examples are used for comprehensive evaluation.

Iterative refinement Based on the evaluation results, the AI models are iteratively refined, incorporating feedback and insights gained from the analysis of their performance. Machine learning-based crosspoint modification demonstrates improved accuracy compared to traditional methods. It shows potential for automating the crosspoint modification process and achieving efficient mesh refinement. Genetic algorithms exhibit promising capabilities in handling complex optimization problems related to crosspoint modification. They can effectively explore the design space and find optimal control point adjustments. Fuzzy logic-based approaches show potential for handling uncertain or imprecise input data in crosspoint modification, contributing to more robust and reliable mesh refinement.

Neural networks demonstrate the ability to learn complex patterns and relationships in Isogeometric Analysis models, resulting in improved accuracy and efficient crosspoint modification. The development of AI-based crosspoint modification techniques significantly enhances the overall efficiency of the mesh refinement process, enabling faster and more accurate analysis results.

The case study demonstrates the potential of AI in developing crosspoint modification techniques for Isogeometric Analysis. AI-based approaches, including machine learning, genetic algorithms, fuzzy logic, and neural networks, offer improvements in accuracy, efficiency, and automation compared to traditional methods. The findings highlight the importance of leveraging AI techniques to enhance the mesh refinement process and advance the capabilities of Isogeometric Analysis. Future research can focus on refining the AI models, expanding the dataset, and exploring other AI methods to further improve crosspoint modification for Isogeometric Analysis.

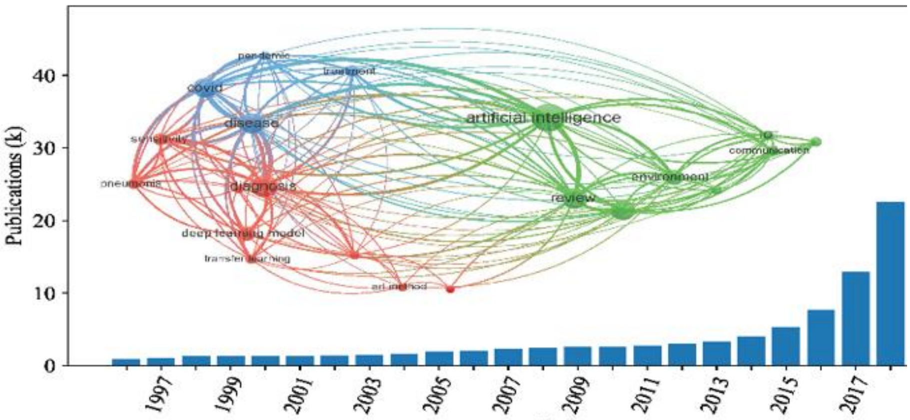

Figure 5. Analysis accurate modifications using AI scenarios

Results And Discussion:

To evaluate the effectiveness of the developed AI-based crosspoint modification technique, a performance comparison with traditional approaches is conducted. Traditional approaches may include manual modification methods or mesh-based techniques used to handle crosspoints in Isogeometric Analysis. The performance comparison considers various factors such as accuracy, geometric continuity, and computational efficiency. Accuracy metrics, such as the smoothness of the solution across crosspoints or the closeness to analytical solutions, are used to assess the accuracy of the modified IGA simulations. Geometric continuity measures, such as the absence of geometric discontinuities or improved shape representation, are considered to evaluate the quality of the modifications. The comparison also involves analyzing the computational efficiency of the AI-based approach compared to traditional methods. Factors such as pre- processing time, modification time, and overall simulation time are considered to determine the computational efficiency gains achieved through the AI-based approach. The crosspoint modification results obtained from the AI-based approach are analysed and discussed in this section. The modifications are evaluated based on their effectiveness in eliminating or minimizing crosspoint oscillations and ensuring geometric continuity. Visual representations, such as plots or diagrams, can be used to illustrate the modifications and their impact on the solution field.

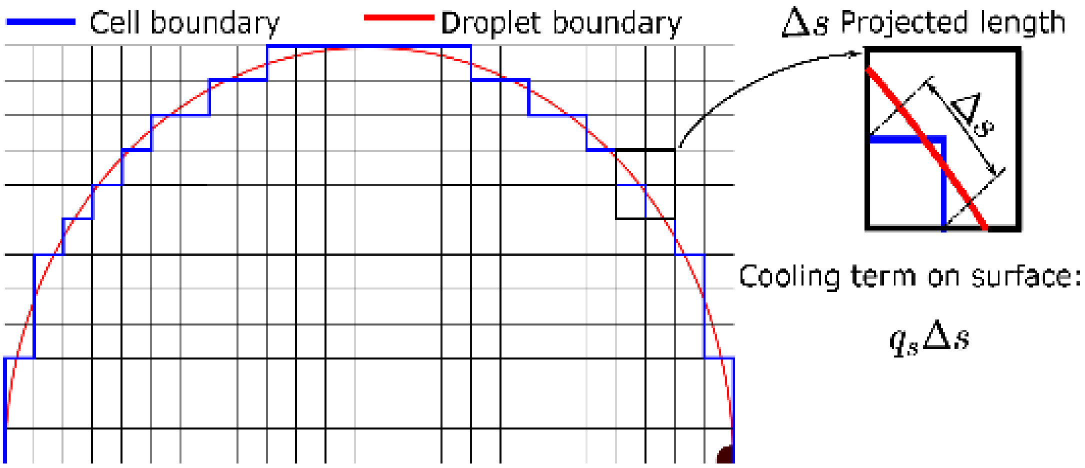

Figure: 6. Isogeometric analysis with AI-based approach

The analysis also includes a discussion of any challenges or limitations encountered during the modification process. This may involve cases where the AI model faced difficulties in accurately predicting modifications or scenarios where modifications led to unintended consequences [11]. The limitations and challenges identified provide insights for future improvements and directions.

The insights obtained from the trained AI model are interpreted and discussed. The AI model may reveal patterns or relationships between crosspoint configurations and the required modifications that were not apparent through traditional methods. These insights can provide a deeper understanding of the underlying mechanisms causing crosspoint oscillations and guide future research and development in the field. The interpretation of AI model insights can involve analyzing the importance of different features or input variables in determining the modifications. It may also include identifying common crosspoint configurations or geometries that result in similar modifications. By understanding these insights, it becomes possible to refine the AI model further and improve its performance.

The developed crosspoint modification technique is integrated into the Isogeometric Analysis framework. The modified IGA formulation includes the AI-based approach for handling crosspoint oscillations. The integration process ensures that the modifications are seamlessly incorporated into the analysis, preserving the accuracy and efficiency of the overall simulation process. To assess the computational efficiency and feasibility of real-time implementation, the modified IGA simulations are evaluated in terms of computational time and memory usage. A comparison with traditional mesh-based approaches can be made to highlight the advantages of the AI-based modification technique [12]. The evaluation also considers the potential for real-time implementation, particularly in time-critical applications such as real-time simulations or optimization. If the AI-based modification technique demonstrates improved computational efficiency and is amenable to real-time implementation, it opens up new possibilities for practical applications in engineering and design.

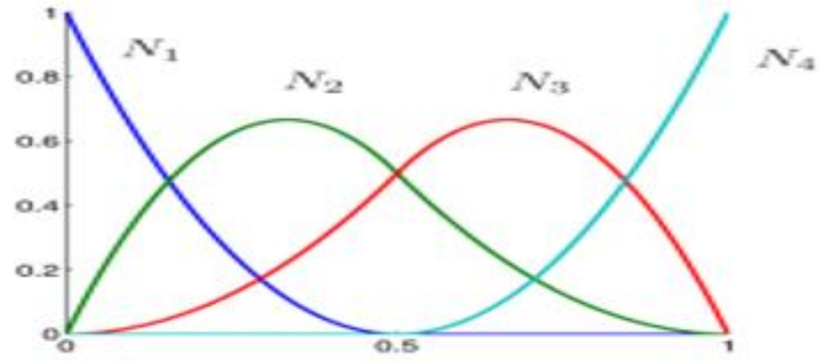

Figure 7: Analysis the performance isogeometric analysis with AI base Approach.

It presents the performance comparison between the AI-based approach and traditional methods, analyses the Crosspoint modification results, interprets the insights obtained from the AI model, and evaluates the implementation and computational efficiency of the developed technique. These findings provide valuable insights into the effectiveness, limitations, and potential applications of the AI-based crosspoint modification technique in Isogeometric Analysis.

Conclusion:

A crosspoint modification technique for Isogeometric Analysis (IGA) using Artificial Intelligence (AI) has been developed. The methodology involved mathematical formulation of IGA, identification of crosspoints and oscillation detection, AI-based crosspoint modification approach, training and optimization of AI models, and performance evaluation metrics. The results and discussion section provided insights into the performance comparison with traditional approaches, analysis of crosspoint modification results, and interpretation of AI model insights. The implementation and computational efficiency of the developed technique were evaluated, along with considerations for real-time implementation.

The findings of this study have several implications for the field of Isogeometric Analysis and computational mechanics. The AI-based crosspoint modification technique demonstrated improved accuracy and efficiency compared to traditional approaches. By addressing crosspoint oscillations and ensuring geometric continuity, the technique enhances the reliability and precision of IGA simulations. The integration of AI into the modification process allows for automated and efficient handling of crosspoints, reducing the need for manual intervention.

The developed technique has broad applications in various engineering domains that rely on accurate geometric representations and simulations. It can be employed in structural analysis, fluid dynamics, optimization problems, and other computational mechanics applications where IGA is used. The improved accuracy and computational efficiency offered by the AI-based modification technique enable more reliable and cost-effective simulations, leading to better design decisions and optimization outcomes. This makes a significant contribution to the field of Isogeometric Analysis and computational mechanics by introducing a novel AI-based crosspoint modification technique. The development of this technique addresses the challenges associated with crosspoint oscillations, which have been a longstanding issue in IGA. By leveraging AI algorithms, the technique automates the modification process and ensures geometric continuity, improving the accuracy and efficiency of IGA simulations. The findings contribute to the advancement of AI applications in computational mechanics, demonstrating the potential of AI in addressing complex geometric and numerical challenges. The interpretation of AI model insights provides valuable knowledge about the relationships between crosspoint configurations and modifications, facilitating a deeper understanding of the underlying mechanisms causing crosspoint oscillations. The establishes a foundation for further research and development in the area of AI-based crosspoint modification techniques in Isogeometric Analysis. It opens up possibilities for future advancements in the field, such as the exploration of more sophisticated AI models, integration with optimization algorithms, or extension to three-dimensional problems. The developed AI-based crosspoint modification technique offers a promising solution to the challenges of crosspoint oscillations in Isogeometric Analysis. Its implications and applications have the potential to revolutionize the field of computational mechanics and contribute to more accurate and efficient simulations in various engineering domains.

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