The role of the Artificial Intelligence in the field of biomechanics

Peter Ficzere[1], Lajos Borbás[2*]

[1] Department of Railway Vehicles and Vehicle System Analysis, Faculty of Transportation Engineering and Vehicle Engineering, Budapest University of Technology and Economics, Hungary

[2] Engineering Institute, Edutus University, Hungary

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Abstract

Artificial Intelligence (AI) has a wide range of potential applications in industries such as healthcare, finance, transportation, and education. In the field of biomechanics, AI has the potential to improve the understanding of the human body and provide new insights for diagnosis, treatment, and prevention of injuries and diseases. AI has been used for applications such as image and motion analysis, and the prediction of injury risk, and involves a process of data collection, preprocessing, feature extraction, algorithm training, model validation, and deployment. This paper aims to explore the potential of AI in the field of biomechanics.

Keywords: artificial intelligence, biomechanics, implant design, simulation

Introduction

Artificial Intelligence (AI) has the potential to impact a wide range of industries and applications. Some of the areas where AI is being used or has the potential to be used include:

1. Healthcare: AI[1] is being used for medical diagnosis, drug discovery, and personalized treatment plans.
2. Finance: AI is being used for fraud detection, risk management, and algorithmic trading.
3. Retail: AI is being used for demand forecasting, pricing optimization, and personalized shopping recommendations.
4. Transportation: AI[2] is being used for optimizing delivery routes, autonomous vehicles, and traffic management.
5. Manufacturing: AI is being used for predictive maintenance, quality control, supply chain optimization and generative design.[3]
6. Education: AI is being used for personalized learning[4], grading and scoring, and adaptive testing.
7. Marketing: AI is being used for customer segmentation, lead scoring, and sentiment analysis.
8. Security: AI is being used for threat detection[5], face recognition, and cyber security.

***Corresponding author contact data:** Edutus University, Engineering Institute, Tatabánya, Stúdium tér 1, H-2800, Hungary. **E-mail:** borbas.lajos@edutus.hu **Tel.:** +36 34 520-400

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These are just a few examples of the many areas where AI is having an impact. The technology is still relatively new, and its full potential has yet to be realized.

Artificial intelligence (AI) has the potential to revolutionize the field of biomechanics by providing new insights and improving our understanding of the human body. Biomechanics is the study of the mechanical properties and behavior of living organisms, and it plays a critical role in the fields of medicine, sports science, and rehabilitation. In this paper, we will explore the current state of AI in biomechanics and discuss the potential applications and benefits of AI in this field.

Background: Biomechanics is a multidisciplinary field that combines principles of physics, engineering, and biology to study the movement[6] and function of living organisms. The field encompasses a wide range of topics, including musculoskeletal mechanics, cardiovascular mechanics, and biomaterials.[7] In recent years, advances in technology have allowed for the collection of large amounts of data on the human body, making it possible to use AI to analyze and interpret this data.

Methods

AI has been used in biomechanics for a variety of applications, including image analysis, motion analysis, and the prediction of injury risk. For example, AI algorithms have been used to analyze medical images of the human body, such as x-rays and MRI scans, to detect and diagnose injuries and diseases. AI has also been used to analyze motion data, such as from cameras and sensors, to study human movement and identify patterns that can indicate injury or dysfunction.[8]

AI has also been used to predict injury risk by analyzing data from various sources, such as medical records and sensor data. This can be used to identify individuals at high risk of injury and provide targeted interventions to prevent injury.[9]

Results

AI has the potential to revolutionize the field of biomechanics by providing new insights and improving our understanding of the human body. AI-based methods can be used to analyze large amounts of data and extract new insights, which can be used to improve diagnosis, treatment, and prevention of injuries and diseases.[10]

For example, Artificial Intelligence (AI) has the ability to revolutionize the way we diagnose and treat injuries and diseases. Image analysis, in particular, has the potential to detect issues earlier and more accurately than traditional methods, leading to better patient outcomes.

The process involves using machine learning algorithms to analyze medical images, such as X-rays, CT scans[11], and MRI scans. These algorithms are trained on large datasets of medical images, allowing them to identify patterns and anomalies in the images that may indicate an injury or disease. This technology can help doctors make more informed decisions, leading to faster and more accurate diagnoses. The process of using machine learning algorithms to analyze medical images typically involves the following steps:

1. Data Collection: The first step is to gather a large dataset of medical images that will be used to train the algorithm. This dataset should include images of both healthy and abnormal cases, along with corresponding labels or annotations indicating the presence or absence of specific conditions.

2. Preprocessing: The next step is to preprocess the medical images to prepare them for analysis. This may include resizing the images, converting them to grayscale, and normalizing their intensity values. The goal of preprocessing is to ensure that the images are consistent and suitable for analysis by the algorithm.
3. Feature Extraction: In this step, relevant features are extracted from the preprocessed medical images. This may include identifying and extracting the regions of interest (ROI), such as tumors, blood vessels, or bones. The extracted features are then used as input to the machine learning algorithm.
4. Algorithm Training: Once the features have been extracted, the algorithm is trained on the dataset using a suitable machine learning technique, such as supervised learning, unsupervised learning, or deep learning. During training, the algorithm learns to associate certain features with specific conditions, allowing it to make predictions about the presence or absence of conditions in new images.
5. Model Validation: After training, the algorithm's performance is evaluated on a separate validation dataset to assess its accuracy. This may involve comparing the algorithm's predictions to ground truth labels or annotations, and calculating metrics such as sensitivity, specificity, and accuracy.
6. Deployment: Finally, if the algorithm performs well on the validation dataset, it can be deployed for use in a clinical setting. This may involve integrating the algorithm into a software application or medical device that can analyze images and provide results to doctors and patients.

These are the general steps in the process of using machine learning algorithms to analyze medical images. However, the specific steps and techniques used can vary depending on the type of medical images being analyzed and the specific conditions being targeted.

AI-based image analysis can be used to detect early signs of cancer, helping doctors to catch the disease in its early stages when it is more treatable. This can greatly improve patient outcomes, as early detection can mean the difference between a cure and a much more serious illness. AI-based image analysis can also be used to detect other types of diseases, such as heart disease and brain conditions, by analyzing images of the heart and brain.

This technology has the ability to transform the way we diagnose and treat medical conditions, leading to better patient outcomes and improved quality of life.

AI can also be used to design personalised medical implants. The steps involved[12] in the design of a custom implant from CT images typically include the following:

1. Image acquisition: A CT scan of the patient's anatomy is taken, usually of the area where the implant is to be placed. The images are then transferred to a computer for processing.
2. Image segmentation: The CT images are segmented to separate the relevant structures from the surrounding tissues. This is typically done using software algorithms or manual techniques.
3. Implant design: Based on the segmented images, the implant design is created using computer-aided design (CAD) software.[13] The implant is designed to fit the patient's specific anatomy and to address the medical condition that requires the implant.
4. Simulation: The implant design is then simulated in a virtual environment to

test its fit and performance.[14] This helps to identify any potential issues before the implant is physically manufactured.
5. Manufacturing: Once the design has been finalized, the implant is manufactured using a variety of techniques, such as 3D printing[15], CNC machining, or casting.
6. Quality control: Before the implant is used, it undergoes a series of quality control tests to ensure that it meets the necessary specifications and standards.
7. Implantation: The custom implant is then surgically implanted into the patient.

Artificial Intelligence can play a significant role in supporting CT image-based customized implant design. The following are some of the ways in which AI can support this process:[16]

- Image Segmentation: AI algorithms can be used to automatically segment images, separating the bones from the surrounding tissue and creating a 3D model of the bone. This enables the design of implants that are specifically tailored to the shape and structure of the patient's bones.
- Implant Optimization: Using AI algorithms, implant design can be optimized to ensure that it provides the best possible fit and stability. This can involve simulating the implant's behavior in various scenarios, such as during movement and stress, to identify potential areas of weakness or instability.
- Material Selection: AI can be used to recommend the best material for an implant based on the patient's specific needs, such as biocompatibility and resistance to wear and tear. This can improve the success rate of the implant and reduce the likelihood of complications.
- Surgical Planning: AI can be used to help plan surgical procedures, providing doctors with information about the best placement and orientation of implants. This can help to minimize the risk of complications and improve patient outcomes.
- Personalized Treatment: AI algorithms can be used to develop personalized treatment plans based on a patient's specific needs, such as age, medical history, and lifestyle. This can help to ensure that the implant is optimized for the patient's unique circumstances.

Conclusion

AI has the potential to revolutionize the field of biomechanics by providing new insights and improving our understanding of the human body. AI-based methods can be used to analyze large amounts of data - based on gender, age, other significant characteristics, -and extract new insights, which can be used to improve diagnosis, treatment, and prevention of injuries and diseases. In this paper, we have discussed the current state of AI in biomechanics and the potential applications and benefits of AI in this field. However, it is important to note that further research is needed to fully understand the potential of AI in biomechanics and to ensure that AI-based methods are used ethically and responsibly.

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Conflict of interest: None.

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