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# MACHINE LEARNING-BASED ALGORITHM FOR CIRCULARITY ANALYSIS

***Najmiddinov Shakhzodbek Shukhrat ugli***
*Tashkent University of Information Technologies*
*named after Muhammad al-Khwarizmi, PhD student*

**Abstract.** A crucial component of quality control in industrial processes is circularity analysis. It refers to the measuring of an object's roundness or circularity, which is crucial for making sure the product fits and performs as intended. Precision parts like pistons, gears, and bearings are frequently made using circularity analysis. Comparing an object's real form to its ideal circular shape is a common method for determining how circular it is. Usually, a coordinate measuring machine (CMM) or a laser scanner are used for this comparison. The circularity of the object is then ascertained by analysis of the measurement data.

**Key words.** circularity analysis, pistons, gears, , a coordinate measuring machine (CMM).

**Introduction.** Manual circularity analysis can be labor-intensive, costly, and prone to mistakes. Accurate measurements and data analysis require trained operators. Furthermore, the capabilities of the measurement apparatus and the operator's skill in accurately interpreting the data place a limit on manual circularity analysis. By automating the measurement and analysis steps, a circularity analysis technique [1] based on machine learning can overcome these drawbacks. By minimizing operator error and variability, it can also increase circularity analyses' accuracy and consistency.

Machine learning is a subfield of artificial intelligence that involves the development of algorithms that can learn and make predictions or decisions based on data. Machine learning algorithms are designed to identify patterns in data and use those patterns to make predictions or decisions. There are three main types of machine learning algorithms: supervised learning, unsupervised learning, and reinforcement learning. In supervised learning, the algorithm is trained on labeled data, where the input data is paired with the correct output. The algorithm learns to identify patterns in the input data and use those patterns to predict the output for new, unseen data.

Unsupervised learning uses unlabeled data, where the input and output are not matched, to train the algorithm. The algorithm gains the ability to recognize patterns in the incoming data and combine comparable data points. In reinforcement learning, the algorithm picks up new information by interacting with its surroundings and getting positive or negative feedback. The algorithm gains the ability to respond in ways that maximize rewards and minimize penalties.

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The proposed machine learning-based algorithm for circularity analysis involves the following steps:

*Data acquisition* - The algorithm acquires data from a coordinate measuring machine (CMM) [2] or laser scanner. The data consists of a set of points that describe the object's shape.

*Preprocessing* - The algorithm preprocesses the data to remove noise and outliers. This step is important to ensure that the data is accurate and reliable.

*Feature extraction* - The algorithm extracts features from the preprocessed data. Features are characteristics of the data that are relevant to circularity analysis. Examples of features include the object's diameter, roundness, and surface texture.

*Model training* - The algorithm uses a supervised learning approach to train a machine learning model [3] on the extracted features. The model learns to identify patterns in the features that are associated with circularity.

*Circularity analysis* - The trained model is used to predict the circularity of new, unseen data. The algorithm compares the predicted circularity to a threshold value [4] to determine whether the object is circular or not.

***Advantages of the proposed algorithm*** - The proposed machine learning-based algorithm for circularity analysis offers several advantages over traditional manual methods [5], including:

1. *Automation* - The algorithm automates the measurement and analysis process, reducing the need for skilled operators and the potential for human error.

2. *Consistency* - The algorithm can perform circularity analysis consistently and accurately, regardless of the operator's skill level or the measuring equipment's capabilities.

3. *Efficiency* - The algorithm can perform circularity analysis quickly and efficiently, reducing the time and cost associated with manual methods.

4. *Adaptability* - The algorithm can be adapted to different types of objects and measurement equipment, making it a versatile tool for circularity analysis.

5. *Improved accuracy* - The algorithm can improve the accuracy of circularity analysis by reducing the influence of noise and outliers in the data.

The proposed machine learning-based algorithm for circularity analysis also has some limitations and challenges that need to be addressed. These include:

*Data quality* - The accuracy and reliability of circularity analysis are highly dependent on the quality of the data. Poor data quality can lead to inaccurate or unreliable results.

*Training data* - The accuracy and reliability ofthe machine learning model are highly dependent on the quality and quantity of training data. Sufficient and representative training data are required to ensure that the model can generalize well to new, unseen data.

*Interpretability* - Machine learning models are often considered black boxes because they do not provide explicit explanations for their predictions. This lack of interpretability can make it challenging to understand why the model makes certain predictions, which can make it difficult to diagnose and correct errors.

*Model bias* - Machine learning models can be biased if the training data is biased. It is essential to ensure that the training data is representative of the population to avoid bias in the model.

*Maintenance* - Machine learning models require regular maintenance to ensure that they remain accurate and up-to-date. This maintenance can involve retraining the model on new data, updating the model's parameters, or addressing changes in the measurement equipment.

*Cost* - Developing a machine learning-based algorithm for circularity analysis can be expensive, requiring specialized expertise and computing resources.

**Conclusion.** In conclusion, a circularity analysis technique based on machine learning has substantial potential advantages for industrial processes. It can automate measurement and analysis, increase accuracy and consistency, and cut the time and expense involved with manual approaches. However, there are a number of issues that must be resolved before creating a machine learning-based method for circularity analysis, including issues with data quality, training data, interpretability, model bias, and maintenance. To fully utilize machine learning in circularity analysis and achieve high-quality manufacturing processes, several issues must be resolved.

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