



THE BEST INNOVATION OF DEVELOPMENT IN MECHANICAL ENGINEERING

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Abstract. The applications of machine learning and artificial intelligence systems in CNC machine tools are examined in this study by analyzing recent achievements from published papers. The main aim of this study is to provide an overview of current studies on machine learning and artificial intelligence techniques in CNC machining operations in order to provide a useful study for the researchers in the interesting field.

Introduction. Machine learning and artificial intelligence are applied to various industrial applications in order to improve performances of industrial process. To increase accuracy as well as efficiency during CNC machining operations, different applications of the machine learning and artificial intelligence systems are studied in different research works. Reducing machine downtime, optimization of CNC machine tools, cutting tool wear prediction, cutting force model, CNC machine tool maintenance, monitoring of machining operations, surface quality prediction and energy prediction systems are some examples of machine learning applications in the development of CNC machining operations. ML techniques are recently applied to energy consumption prediction models in order to decrease the energy consumption during CNC machining operations. Accuracy and radiality of energy consumption models are significantly enhanced using the ML methodologies in comparison to the tradition's methods of energy usage predictions during CNC machining operations.

Network of sensors and cloud data sources can connect CNC machines together can be employed to provide smart CNC machine tools. The machining industry's efficiency can be increased as it transitions to smart machining techniques, allowing it to achieve self-optimization and adaption to uncontrolled circumstances. However, developing the applications of advanced machine learning systems in CNC machining operations as the combination of physical, computers, and networking process created challenges and difficulties regarding the safety and security of the



web of data. In order to provide secure and advanced connections between the different CNC machine tool, the security of networks should be enhanced.

Future research directions

Advanced data collection, data mining approaches, data fusion neural networks, virtualization, and smart decision-making methodologies in computer-aided process planning can be employed to increase improve accuracy and performance in the part production process using machine learning systems. The virtual machining systems can be developed by using machine learning applications in CNC machining operations to increase the power of simulation and analysis of CNC machine tools in virtual environments. Cutting tool paths modification, cutting tool selection and error compensation methodologies during CNC machining operations can be modified by using the applications of machine learning systems. The designing process of work-holding fixtures can be developed by using the machine learning system in order to provide accurate fixtures during CNC machining operations. Deep machine learning networks can be applied to CNC machine tools in order to increase the effectiveness of machine learning applications in efficiency enhancement of part production. Spatial iterative learning control method can be applied to the cutting tool paths during machining to enhance accuracy of machined parts by error compensation methodologies.

In order to modify the Collision detection systems during CNC machining operations, Optimized cutting tool paths can be obtained using the applications of ML and AI. Also, to provide advanced operation training systems for CNC machining operators, applications of ML and AI can be implemented. ML and AI can be applied to the industrial robots in order to make robots smarter and more collaborative. Also, decision making can be applied to the robots using the ML and AI in order to enhance performance in flexible conditions of working.

Moreover, automation during the process of part production can be developed as a consequence of applying the ML and AI to big data analysis of production process in terms of productivity enhancement of part manufacturing. Online integration and description of machining resources capabilities can be implemented using the applications of ML in cloud manufacturing systems. Advanced Cyber manufacturing systems using CNC machining operations can be presented using the applications of ML in virtual manufacturing. Intelligent machine tool can be presented using the applications of AI in CNC machining operations in order to present the autonomous optimization and decision-making, and autonomous control and execution during machining operations.



Applications of the internet of things in developing smart CNC machine tools can be studied in order to increase the monitoring capabilities of machining process. Sustainable smart manufacturing in industry 4.0 can be developed by using the applications of advanced machine learning systems in CNC machining operations. Smart machining systems can be developed by using advanced machine learning and artificial intelligence systems in order to provides smart manufacturing processes for industry 4.0. The ML and AI can enhance accuracy in process of part production using CNC machine tools in order to decrease waste materials and cost per unit for the manufacturers in terms of advanced lean production systems. Advanced computer-aided process planning can be presented using the applications of ML and AI in CNC machine tools in order to enhance the efficiency of process planning in the flexible conditions and parameters of part productions using CNC machine tools. The integration of the fuzzy technique in applications of ML during CNC machining operations can be studied in order to enhance efficiency of part manufacturing using the optimized procedures of machining operations. These are suggestions for future research works in the research of machine learning and artificial intelligence in CNC machine tools. As a result, performance and reliability of part manufacture can be improved by using advanced ML and AI systems in order to enhance productivity of part manufacturing using CNC machining operations.

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