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AI Applications in Stochastic Optimal Control for Production Activity Planning in Manufacturing Systems

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Abstract

This paper presents an approach for predicting the parameter values of a production strategy for an uncertain manufacturing system. The problem of predicting or determining the values of the parameters or structures of production policies is considered to be a complex optimisation problem in a dynamic and stochastic context. This study explores the integration of Artificial Intelligence (AI) with stochastic optimal control for planning production activities in manufacturing systems. The main features of this approach include the development of algorithms that leverage machine learning techniques to the parameters of the optimal control law structure using algorithms namely K-Nearest Neighbours (KNN), Random Forest (RF) and Deep Neural Network (DNN).

The system under study consists of a production unit subject to random breakdowns and repairs. A comprehensive database will be built from solving stochastic optimization problems. Then, artificial intelligence techniques will be utilized to predict or determine production policies in unsolved cases. K-nearest neighbors (KNN) and deep neural network algorithms were employed, and their performance was evaluated in terms of the average relative error calculated on the test set.

The results showed that these algorithms were able to predict the threshold value of the so called Hedging Point Policy, enabling the optimal policy to be determined. A sensitivity analysis was then carried out to validate the results, by varying several system parameters and showing that in all cases, the optimal policy was predicted and determined. In conclusion, the integration of AI with stochastic optimal control not only enhances production planning but also contributes to solve problems that take a long time to solve, especially when the grid is refined using numerical methods; since the optimality conditions are solved using a numerical approach in order to build the database.

Keywords

Artificial intelligence; Neural network; Manufacturing systems; Production planning; Control policies; Stochastic process