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Optimizing Production Yield Through Process Parameter Tuning Using Deep Learning Models: A Case Study in Precision Manufacturing

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Abstract : This paper is based on the idea of using deep learning methodology for optimizing production yield by tuning a few key process parameters in a manufacturing environment. The study was explicitly on how to maximize production yield and minimize operational costs by utilizing advanced neural network models, specifically Long Short-Term Memory and Convolutional Neural Networks. These models were implemented using Python-based frameworks—TensorFlow and Keras. The targets of the research are the precision molding processes in which temperature ranges between 150°C and 220°C, the pressure ranges between 5 and 15 bar, and the material flow rate ranges between 10 and 50 kg/h, which are critical parameters that have a great effect on yield. A dataset of 1 million production cycles has been considered for five continuous years, where detailed logs are present showing the exact setting of parameters and yield output. The LSTM model would model time-dependent trends in production data, while CNN analyzed the spatial correlations between parameters. Models are designed in a supervised learning manner. For the model's loss, an MSE loss function is used, optimized through the Adam optimizer. After running a total of 100 training epochs, 95% accuracy was achieved by the models recommending optimal parameter configurations. Results indicated that with the use of RSM and DOE traditional methods, there was an increase in production yield of 12%. Besides, the error margin was reduced by 8%, hence consistent quality products from the deep learning models. The monetary value was annually around $2.5 million, the cost saved from material waste, energy consumption, and equipment wear resulting from the implementation of optimized process parameters. This system was deployed in an industrial production environment with the help of a hybrid cloud system: Microsoft Azure, for data storage, and the training and deployment of their models were performed on Google Cloud AI. The functionality of real-time monitoring of the process and automatic tuning of parameters depends on cloud infrastructure. To put it into perspective, deep learning models, especially those employing LSTM and CNN, optimize the production yield by fine-tuning process parameters. Future research will consider reinforcement learning with a view to achieving further enhancement of system autonomy and scalability across various manufacturing sectors.

Keywords : production yield optimization, deep learning, tuning of process parameters, LSTM, CNN, precision manufacturing, TensorFlow, Keras, cloud infrastructure, cost saving
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