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Deep Learning Model to Predict the Remaining Time to Close Tap-holes for Blast Furnaces

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Manufacturing steel requires extremely challenging industrial processes. In particular, predicting the exact time instance of opening and closing tap-holes in a blast furnace has a great influence on steel production efficiency and operating cost, in addition to human safety. However, currently predicting the time to open and close tap-holes of the blast furnace still highly relies on manual human expertise and labor. Also, most of the prior research is limited to indirectly model the level of liquids in the hearth, using complex mathematical models or classical machine learning approaches. In this paper, we use a data-driven deep learning method to more accurately predict the remaining time to close each tap-hole in a blast furnace and develop an AI-enabled automated prediction system to reduce manual human error as well as reduced the waiting TLC (Torpedo Ladle Car) time before pouring pig-iron in blast furnace.
We develop a multivariate time series forecasting algorithm using Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) models to predict the opening and closing time more accurately for the blast furnace of POSCO. In particular we use and validate data from one of the largest operating furnaces in the world to develop our system. Our proposed Skip-dense CNN (S-CNN) model achieved more than 85% accuracy within ±15 minutes tolerance, compared to the operator's time to close tap-holes for blast furnaces. Our S-CNN model has been successfully deployed at a large-scale blast furnace of POSCO since January 2018 and has achieved similar accuracy. And we even reduced the TLC cycle-time in a real operational environment by reduced the waiting TLC time before pouring pig-iron in blast Furnace.

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