University of South-Eastern Norway

Development of Machine learning methods for extracting data from furnaces and IR camera to enhance tapping process

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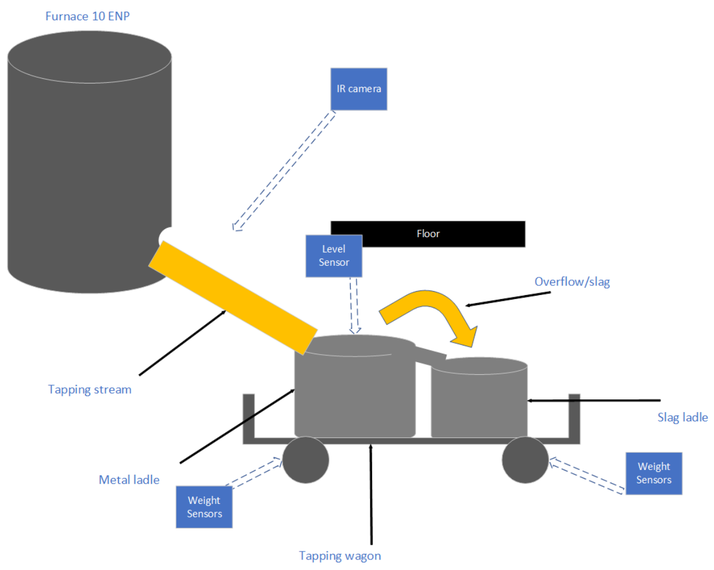
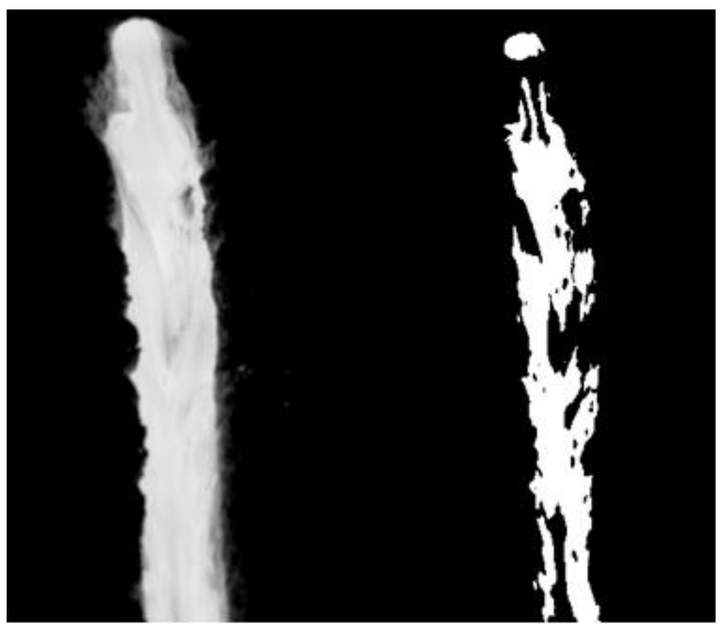
Introduction

The purpose of the study was to enhance the tapping process of Eramet Norway, using machine learning methods to extract new useful information for the process engineers. An IR camera, weight sensors and a level sensor was placed in the tapping area to get continuous measurements of metal ladle level, temperature and the weights.



Methods

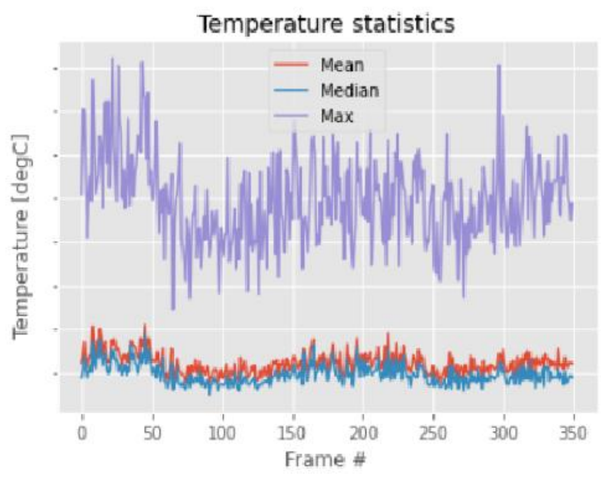
Convolutional Neural Network models were created to classify flaming (into three categories) in the tapping hole and to detect coked coal or electrode material in the tapping stream. Random forest regression was used to estimate the level of the metal ladle using weight measurements as inputs. Separation between slag and metal was a vital step to provide the tapping operators with continuous slag temperature measurements.



Results

Temperature statistics

- All non-slag elements were filtered out of the image using thresholding operations and applying a binary mask.
- All slag pixels were colored white, while the other elements were black.
- Indexes of all white pixels were extracted; statistical analysis of the temperature was created (y-axis removed due confidentiality)

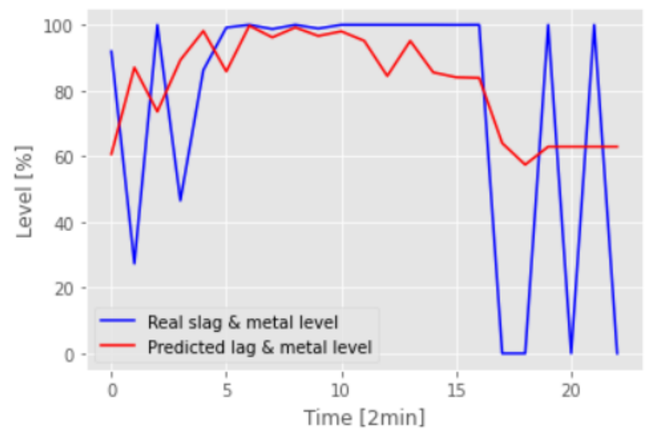


Flaming classification and coke detection

- Three convolutional neural network models were tested for both applications; ShallowNet, LeNet and MiniVGGNet.
- The models used Stochastic Gradient Descent as optimizers to adjust weights and kernels.
- For flaming classification, the models classified flaming into no flames, medium flaming and severe flaming.
- The LeNet model performed the best in the shortest amount of time, it had an prediction accuracy of 0.93 for flaming and 1.0 for coke detection.
- The results showed little indication of overfitting
- The training data consisted of 300 images for flaming classification and 202 images for coke detection, where 25% of images were used as validation data

Level Estimation

- Two models were used for level estimation random forest regression and artificial neural network.
- The models used raw data from four weights sensors and total weight for slag and metal ladles as input data to predict the level.
- RMSE method was used to score the algorithms, random forest provided the best results with 0.9 and 0.69 for training and validation, respectively.
- Indicating that overfitting was an issue with the models



Conclusion

The convolutional neural network models could accurately classify coke and flaming detection images and can be integrated into the proposed solution for real time extraction of data from IR camera.

Estimation of metal and slag level will need more data of better quality to estimate the level with any acceptable accuracy.

Separation of metal and slag can be utilized to extract only the slag temperature during the tapping operation. Afterwards a tapping report can be generated where statistical analysis of the slag temperature can be aggregates and provided to metallurgists and tapping operators.

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