Non-contact inspection, Quality assurance, Traceability

Burn-through prediction and weld depth estimation by deep learning model monitoring the molten pool in gas metal arc welding with gap fluctuation

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Abstract

In a single bevel gas metal arc welding with gap fluctuation, a deep learning model was constructed using the monitoring image during the welding to predict the welding quality. We utilized Python and the library Keras and created a CNN (Convolutional neural network) model using the top surface image including the molten pool as an input. The classification model was used to predict the burn-through, and the regression model was used to estimate the penetration depth. As a result, the excessive penetration and burn-through could be predicted in advance and more than 95% of estimated results of penetration depth were less 1 mm error for stepped and tapered sample shapes.

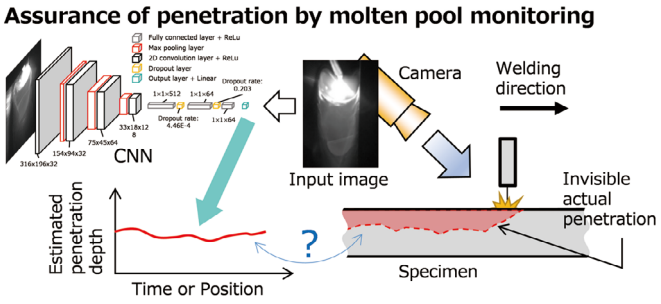
Background & Results

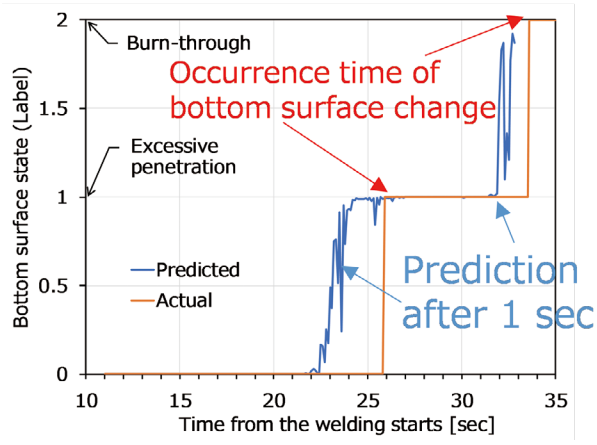
The arc welding method is an indispensable technique in manufacturing industrial fields because of its usability and high energy efficiency among other joining processes. However, in actual, many problems remain due to various disturbances and uncertainties associated with the arc welding process, and a complete guarantee of joint performance has not yet been accomplished. For example, an uncontrollable gap occurs between the base metals due to the influence of the component accuracy and welding thermal strain. As a result, welding defects such as excessive penetration and burn-through may occur on the backside of the plate. In addition to the presence or absence of burn-through, penetration depth, which is an important indicator of welded joint performance, becomes unstable for the same reason.

In this study, the welding quality was predicted or estimated by the CNN model using the molten pool image obtained by a single camera for the single bevel groove gas metal arc welding including the gap fluctuation of tapered or stepped. The input image was a top-surface image including the molten pool obtained using a band-pass filter of 980 nm every 0.1 sec during the welding. First, we constructed a burn-through prediction model as a classification problem, thereby, excessive penetration and burn-through could be predicted in advance. In addition, we constructed the penetration depth estimation model as a regression problem. As a result of the estimation of each test sample by using training data composed of both tapered and stepped gap samples, it was found that approximately more than 95% were less 1 mm error, and more than 87% were less 0.5 mm error for both shapes. They were good estimation results.

Significance of the research and Future perspective

This study can estimate the invisible welding quality only by monitoring the arc process with one camera, and it can be applied to various welding processes other than the targeted joint in this study. The output is expected to be expanded not only to the penetration state but also to the presence or absence of defects. This technique will be an innovative monitoring tool for quality assurance of welding work.





Manufacturing technologies

Patent	
Treatise	Nomura, Kazufumi; Matsumura, Takumi; Asai, Satoru et al. Burn-through prediction and weld depth estimation by deep learning model monitoring the molten pool in gas metal arc welding with gap fluctuation, JOURNAL OF MANUFACTURING PROCESSES, 61 (2021) 590-600. doi: 10.1016/j.jmapro.2020.10.019 Nomura, Kazufumi; Matsumura, Takumi; Asai, Satoru. Study on Weld Depth Estimation by Molten Pool Monitoring and Deep Learning Model in MAG Welding Process(Review article), JOURNAL OF THE JAPAN WELDING SOCIETY, 90, 8 (2021) 13-17 (in Japanese)
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