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LaserWel: 레이저용접 모니터링 및 용접불량 분석 시스템
A Laser Welding Process Monitoring & Fault Classification System

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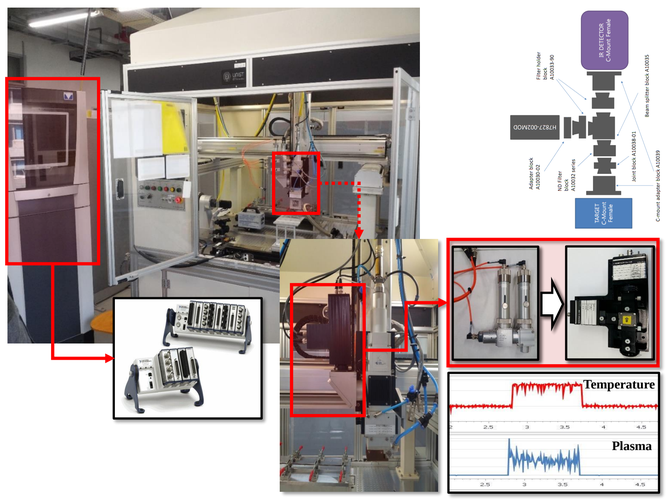
Remote laser welding is an emerging joining technology to meet the increasing demand of corrosion resistance, fast, non-contacted and single sided joining for automotive body-in-white assemblies. This paper presents a developed laser welding monitoring system, LaserWel, characterized by sensor fusion-based fault detection and analysis using rich information from multiple sensors and easy-to-use graphical interface that is an essential feature for industrial usage. The system consists mainly of two photodiode sensors with signal amplifiers, optical filters, a data acquisition system, and a monitoring/analysis software.

System Configuration

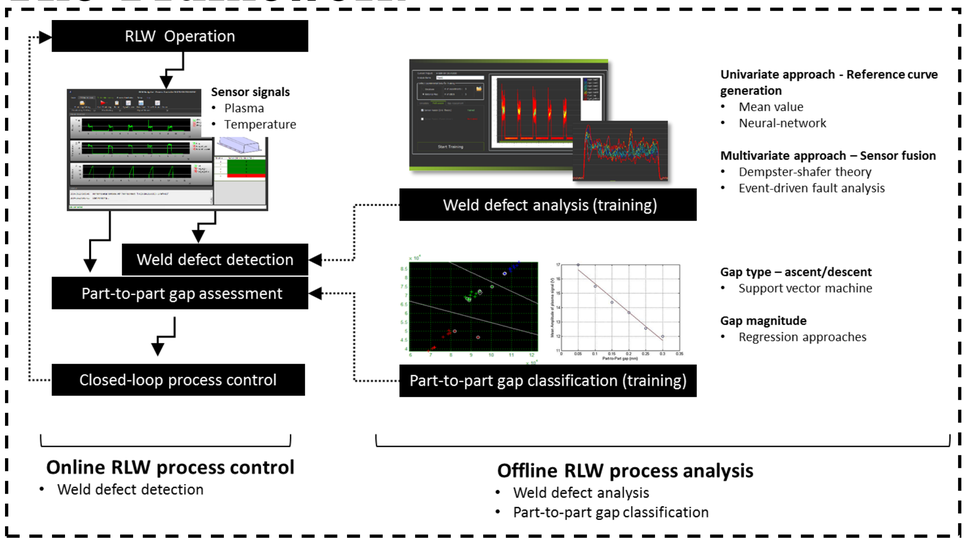
❖**Laser source**
- ✓ 2.5-Axis gantry machine with high power laser head
- ✓ IPG 2kW YLS-2000(Fiber laser)

❖**Sensor blocks**
- ✓ 300nm~650nm wavelength bandwidth UV photodiode sensor (for plasma signal)
- ✓ 500nm~1700nm wavelength bandwidth IR photodiode sensor (for temperature signal nearby the weld pool)

❖**DAQ module**
- ✓ NI cDAQ 9215 - ±10V analog signal with 10k sampling rate



The Framework



Software

Off-line Weld Defect Analysis

***Off-line Weld Defect Analysis*: Training and reference generation module.**

The tool is characterized by sensor fusion features and the gap assessment models which will be used for on-line(real-time) weld defect detection, gap identification, and eventually process parameter(laser power, feed rate, and etc.) adjustment.

Automatic specification of detection thresholds by advanced statistical training methods

❖ Univariate approaches (reference curves)
- ✓ by mean value
- ✓ by neural-network

❖ Multivariate approaches (sensor fusion)
- ✓ by estimation of probability distribution and Dempster-Shafer Theory
- ✓ by event-driven fault analysis

Gap assessment
- ✓ by support vector machine
- ✓ Gap type(ascent/descent) training

On-line Process Monitoring

***On-line Process Monitoring*: Real-time weld defect detection and process.**

The tool provides active information of joint quality and part-to-part gap status. It also provide practical advices how to adjust process parameters.

Weld defect detection

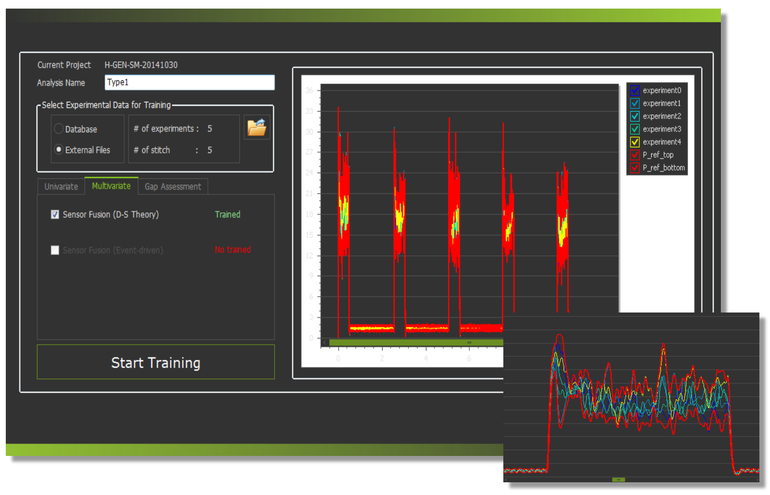
❖Advanced detection methods
- ✓Univariate defect detection using trained reference curves
- ✓Multivariate defect detection using trained sensor fusion features

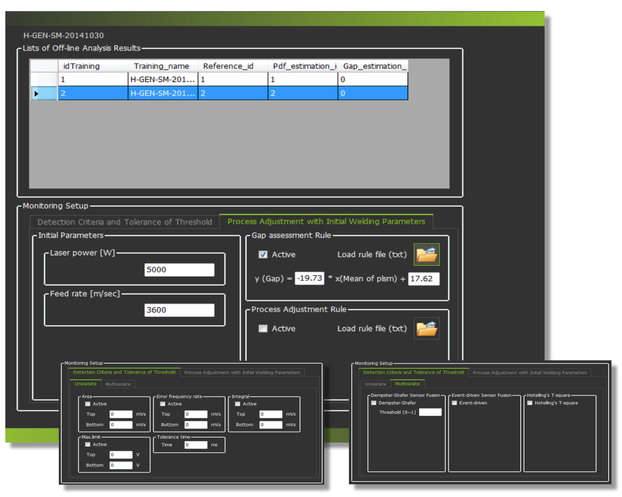
❖Stitch by stich - weld defect classification

Gap assessment and process adjustment

❖Detect the magnitude of part-to-part gap

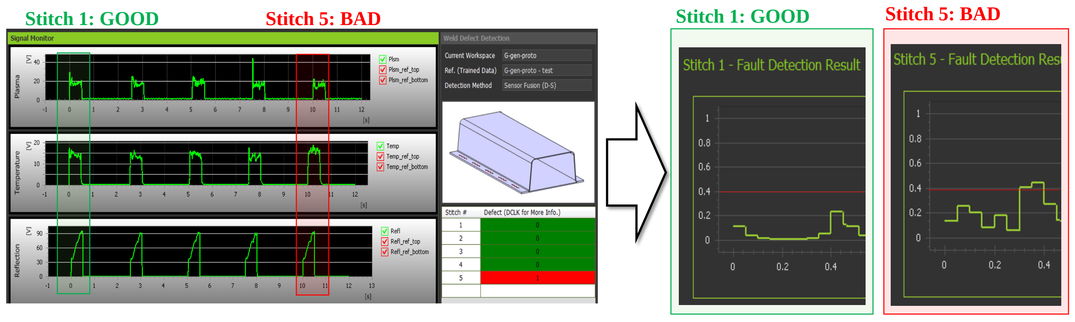
❖Adjust appropriate welding parameter(laser power, feed rate, and etc.) in accordance with part-to-part gap condition





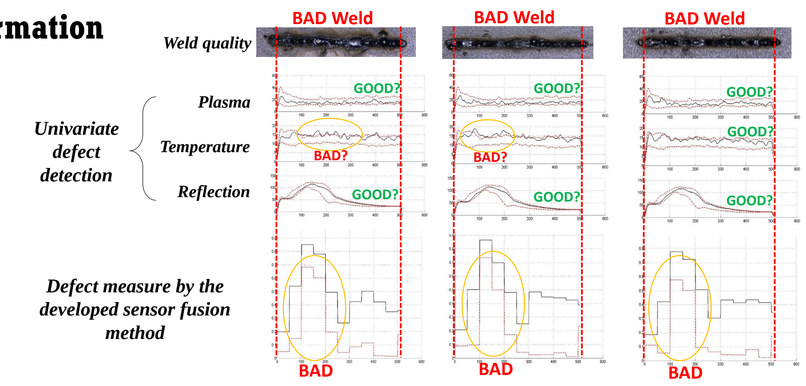
Verification

Weld defect detection results



Handling of conflict information

The sensor fusion method in *LaserWel* resolves conflict between sensor signal.



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