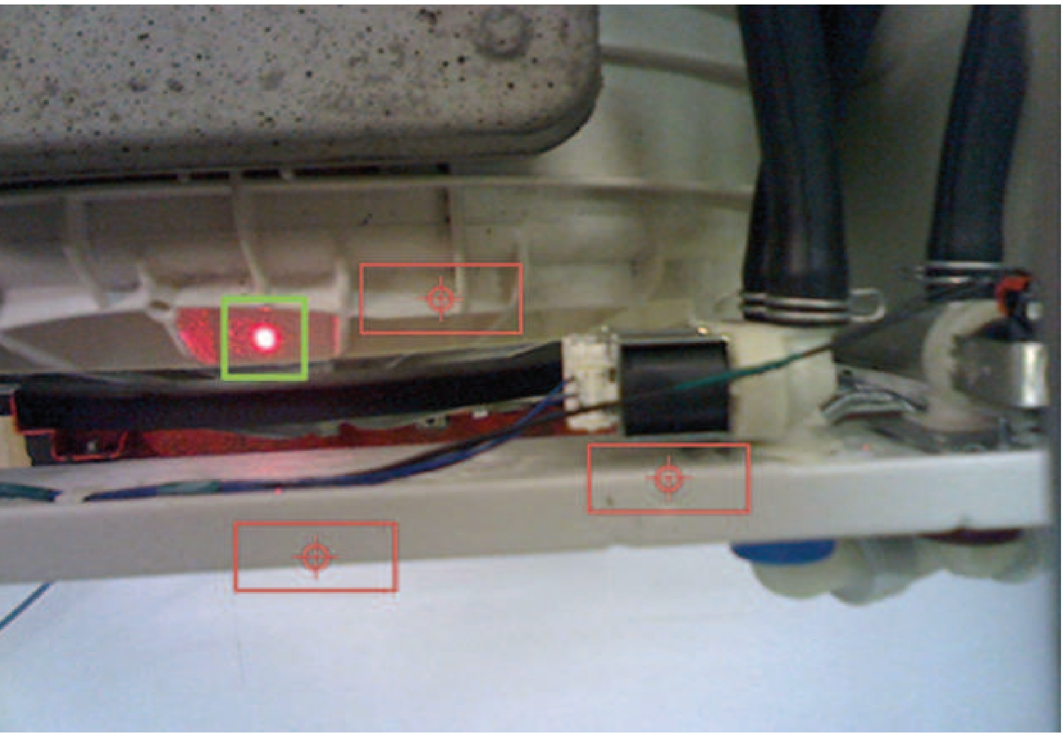
Grace

inteGration of pRocess and quAlity
Control using multi-agEnt technology



1 Automatic recognition of measurement point

Grace project

The EU FP7 Grace project aims at **integrating process and quality control within a production line**. This goal is fully in line with the trend to develop modular, intelligent and distributed manufacturing control systems.
The system is based on a collaborative Multi-Agent System (MAS) which operates at all stages of a production line and it is complemented by self-adaptive control schemes developed at the level of process resources and quality control stations as well as at line or factory level. The MAS aims to individually tune parameters of each product taking into account information collected during the whole production process, so to compensate production process variance.
The innovation is the **new vision of the production process which leads to a deep integration of process control with quality control and finally product value**.

Adaptive Laser Vibrometry

Self-adaptive laser Doppler vibrometry for on-line quality control

At the end of an assembly line, a vibration test provides information useful for 100% quality control of appliances before packaging. Laser Doppler Vibrometry (LDV) has been already used to perform such tests on-line.
Improved performance of such systems is achieved by implementing self-adaption and reconfigurability of the laser vibrometer. Such behaviours are achieved by adding scanning mirrors and a dedicated camera, thus realizing scanning LDV which can displace the measurement beam at different locations.

Self-adaption consists in the following behaviours:

> **Automatic recognition of target point**: the system aims at the desired target point over the washing machine (WM), by displacing the laser beam so to compensate effects of WM mis-positioning due to production line inaccuracies (Figure 1);

> **Automatic search of sufficiently large Doppler signal**: the system searches for an optimal optical signal by slightly displacing laser beam in the surrounding of the desired target point thus optimizing measurement uncertainty.

Figure 2 shows the laboratory prototype of the test station.

The system can support also reconfigurability, which consists in the following behaviours:

> **The system allows selection of the target point** so to measure vibration at the desired location over the washing machine; target point may vary depending on the WM model;

> **The system allows moving the LDV beam** so to measure at single or multiple measurement points (selection depending on production scenarios);

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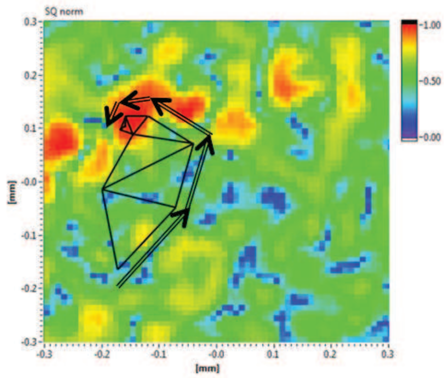

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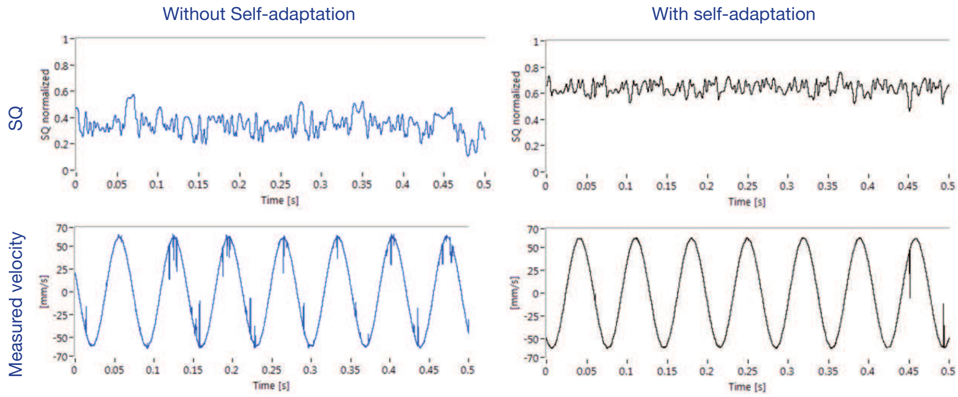

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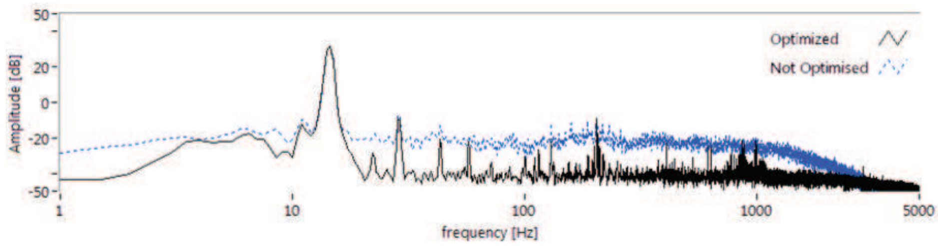

2 Measurement station prototype

3 Laser position sequence (shown by arrows) for searching maximum optical signal quality SQ

4 Effect on vibration time history of the self-adaptation procedure

5 Effect on vibration spectrum of the self-adaptation procedure

- > **The system allows a variable time window lenght for data acquisition and data averaging**, thus reducing the effect of random disturbances and reducing measurement uncertainty and increasing resolution in spectral analysis;
- > **The system allows the possibility to plug-in/plug-out of different post-processing algorithms** for deeper analysis of vibration, with consequent change in acquisition parameters.

The output information of this quality control station can be used for the Pass/Fail diagnosis and for assembly process control, if proper correlations to other process are known.

Self-adaptation of laser vibrometer for reduced measurement uncertainty

During the test of each WM on the production line, the relative position between WM and LDV can vary.
One first kind of self-adaptation is the **repositioning of laser beam at the desired measurement set point**. This is done through a feedback loop based on image processing by pattern matching algorithms, so to compensate for WM variable position.
The second kind of self-adaptation is performed by slightly **displacing the laser beam in a narrow region around the desired set-point**, in order to increase the amplitude of the optical signal of the LDV. Indeed, when a laser beam is shone over a rough surface, optical interference forms a speckle pattern; its movement during vibration causes unwanted noise (speckle noise and drop-out noise). Processing noisy vibration signals may cause uncertainty in following diagnosis. A self-adaptive procedure to search for an optimal signal quality has been implemented; it runs the down-hill algorithm to relocate the laser beam in the surrounding of the target measurement point within a sub-millimetric range. A typical path, made of small triangles, followed by the LDV beam during this process is depicted in figure 3.
After self-adaptation the optical signal quality (SQ) increases significantly and the vibration signal appears less noisy, as in figure 4. A significant improvement in signal-to-noise ratio is moreover visible in the spectrum of vibration of figure 5.