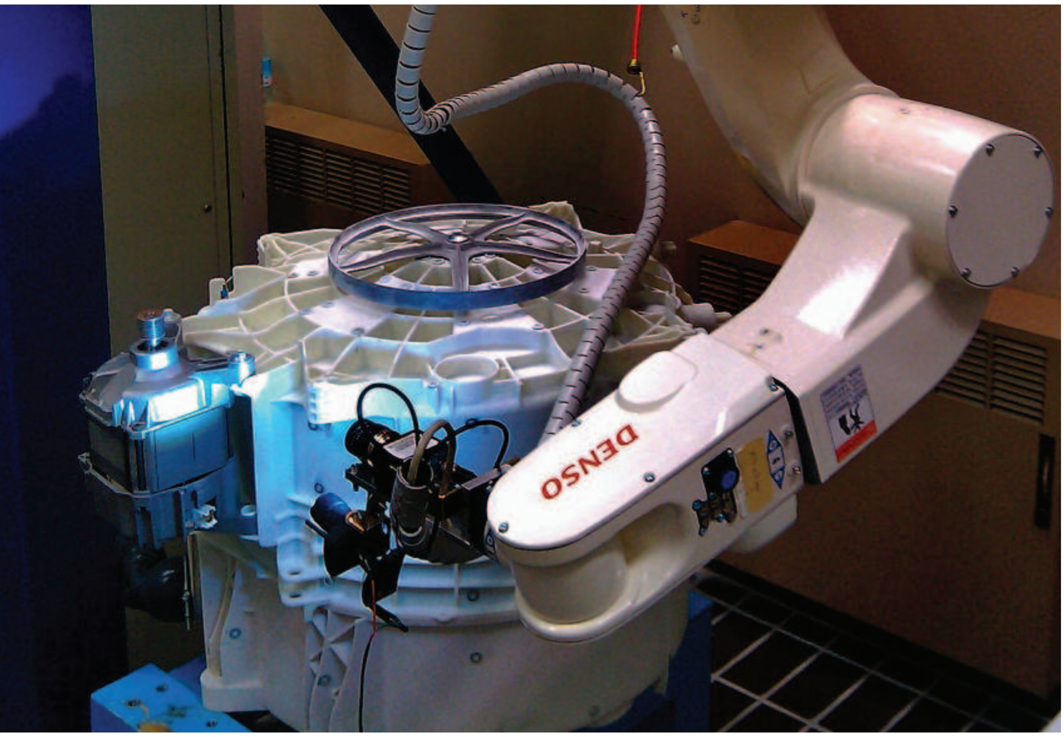
Grace

inteGration of pRocess and quAlity Control using multi-agEnt technology



1 The robotized vision system

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 Visual Inspection

Self-adaptive robot vision for quality control

Robot vision is already state-of-art in a variety of on-line quality control systems. Performance of robot vision systems can be improved by implementing self-adaptive behaviors, which allow to increase the confidence level of the diagnosis performed by the system when complex scenarios occur.

The robot vision system

A prototype robotized vision system has been designed, using a six degrees of freedom anthropomorphic arm, for self-adaptive vision based quality control on an assembly line for washing machines (WM).
The robot allows displacing the camera in the workspace so to inspect a washing unit (WU) or a complete WM on a pallet. The vision system is equipped with a 1360x1024 pixels GigE camera and a RGB nearly axial ring illuminator. The illuminator can be controlled in colour and intensity. During an inspection sequence, the robot moves at a number of selected fixed positions and acquires a set of images (for example the series reported in figure 2); it therefore substitutes a fixed constellation of cameras. Positions can be reprogrammed depending on the model of the part to be inspected, allowing flexibility. Trajectory has been optimized by genetic algorithms.
This implementation is realized for the inspection of the WU or of the complete WM and controls take place at different locations on an assembly line.
Figure 2 represents a sequence of control to be done on a WU: three clamps and one electric connector, whose presence and position has to be verified. Similar sequences are collected depending on the inspections to be done. The robot vision system runs feature based matching algorithms to recognize the parts of the WU or WM under inspection.
The robot vision system prototype

Contacts

Paolo Castellini
p.castellini@univpm.it

Nicola Paone
n.paone@univpm.it

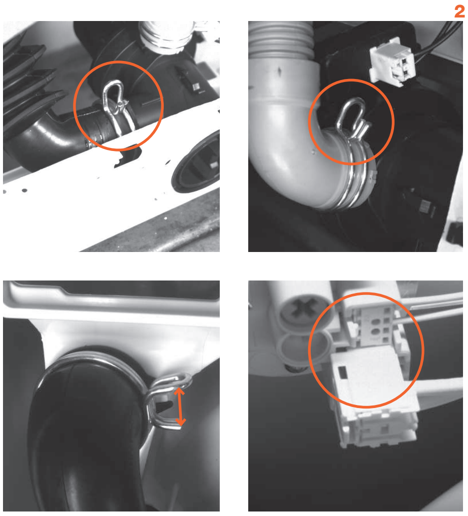
Lorenzo Stroppa
l.stroppa@univpm.it

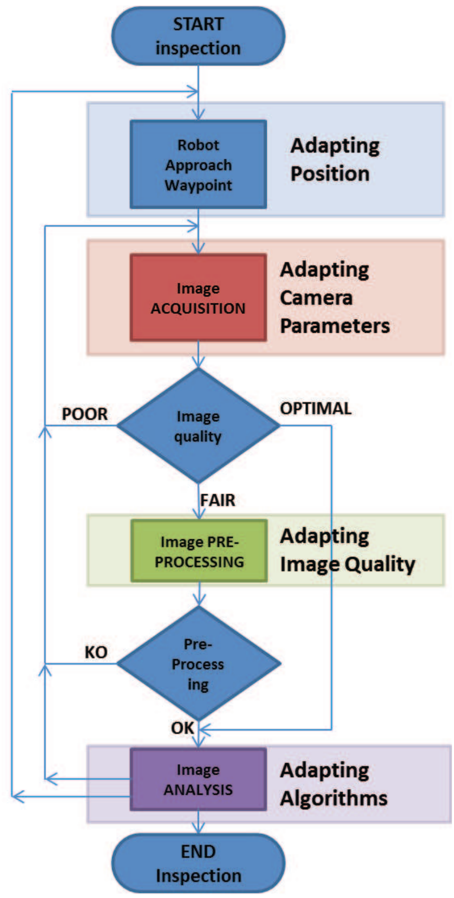
Università Politecnica delle Marche
Department of Industrial Engineering and Mathematical Science - DIISM
via Brecce Bianche
60131 Ancona, Italy
www.meccanica.univpm.it/it/node/45

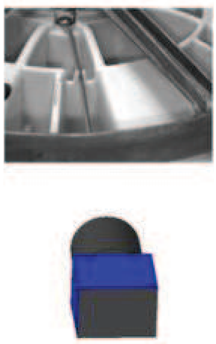
Project Coordinator
Nicola Paone
n.paone@univpm.it
Università Politecnica delle Marche
Department of Industrial Engineering and Mathematical Science - DIISM
via Brecce Bianche
60131 Ancona, Italy
www.meccanica.univpm.it/it/node/45

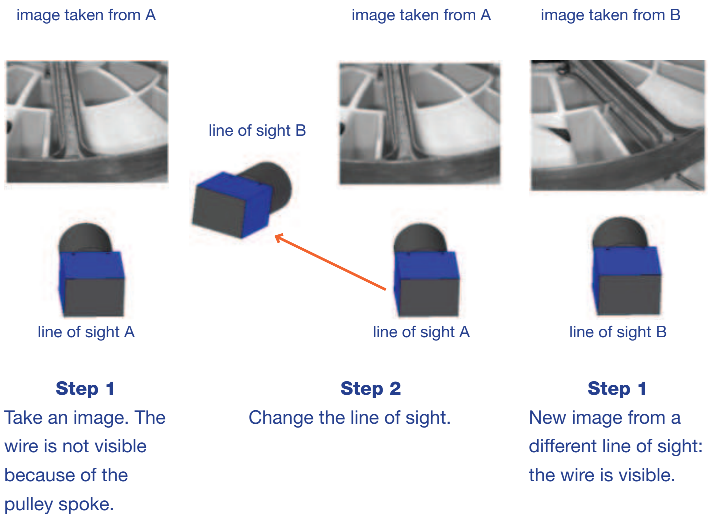
Scientific/Technical Project Manager
Cristina Cristalli
c.cristalli@loccioni.com
Loccioni-AEA
via Fiume 16
60030 Angeli di Rosora
Ancona, Italy
www.loccioni.com

grace-project.org









2 Controls made in the vision station on complete washing machine

3 Self-adaptation and self-optimization strategy for the robotized vision system

4 Wire inspection: the wire is visible

5 Wire inspection in presence of obstacles

is capable of performing a complete sequence of inspections on the WU (up to 6 features to check) in less than 10s. This time matches typical cycle-time constraint of an assembly line.

Self-adaptation of robot vision system

The robotized vision system allows several strategies of adaptation and optimization to increase the level of confidence on the inspection, in particular:

- For each feature to inspect, the colour of light is chosen so to optimize the contrast of the image;
- The exposure time of the camera is adapted in 'real time' to overcome local changes in the environment light condition while performing optimization. This exposure time can be used to update the default value to speed up following inspections;
- If, for some unpredictable reason, the reference feature is hidden or displaced with respect to its normal appearance, the system recognizes an anomalous situation and instead of performing a wrong diagnosis, it adapts the position of the camera and acquires a new image;
- Finally the system implements a multi-template matching strategy to recognize features in the image, if they can occur in a variety of forms: in practice the inspection software adapts itself by creating new templates in order to cope with changes in feature position or in feature appearance.

The whole self-adaptation and self-optimization characteristics for the robotized vision system is described in the block diagram of figure 3.
The purpose of the vision test is to detect if the electrical ground wire is correctly inserted in the plastic clamp and connected to its end, as it appears in figure 4. The image is taken by the camera located at a specific position. Unfortunately, sometimes the spoke of the pulley of the WM can obstruct the vision of the electrical wire (see figure 5) and this may happen randomly during operation of the assembly line. If the camera is fixed, the inspection fails and this is a serious limitation of state-of-art vision inspection systems based on fixed cameras.
If the camera is mounted on the robotized vision system, the displacement of the camera to a different location allows for a proper imaging of the electric wire; this strategy is implemented as a self-adaptive process in the realized prototype. Being the target object acquired from a different direction, a different template has to be used for image matching.