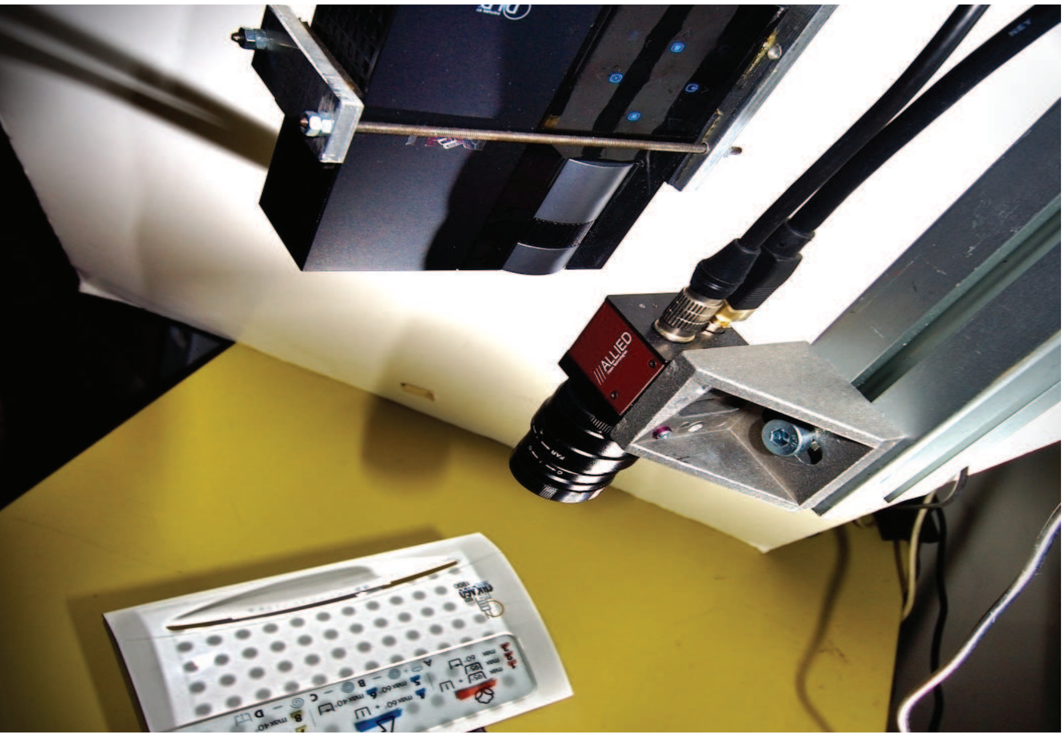
Grace

inteGration of pRocess and quAlity Control using multi-agEnt technology



1 Adaptive illumination bench layout

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**.

Spatially controllable illuminator

Self-optimizing illumination by Digital Light Projector

A spatially controllable illuminator is conceived for machine vision applications, particularly for measurement and quality control, where image quality enhancement is necessary. **Image contrast, or any other image quality parameters, can be improved by adaptive illumination through spatial modulation of light intensity.** The idea is to replace a standard illuminator with a fully controllable one, so to have the possibility to change the illumination, in order to optimize image quality within a Region Of Interest (ROI). If this is done through an adaptive process, the system can compensate disturbances modifying lighting conditions of the test environment.
The spatially controllable illuminator is based on the projection of spatially modulated light distribution by a Digital Light Projector (DLP) that allows to project over the target object an arbitrary light distribution. DLPs are realized by MEMS active micromirrors; DLP technology allows projection of spatially controllable light distributions as well as to control light intensity and colour. The DLP is directly interfaced with a PC through a VGA port, allowing a full control of the projected light distribution.
Such an illuminator may be of interest especially on optically non-cooperative surfaces. With this term we intend surfaces in which the light is strongly absorbed or strongly reflected, so that the image exhibits poor contrast. Many objects of industrial interest indeed have finished surface which is dark or reflecting.

Contacts

Paolo Castellini
p.castellini@univpm.it

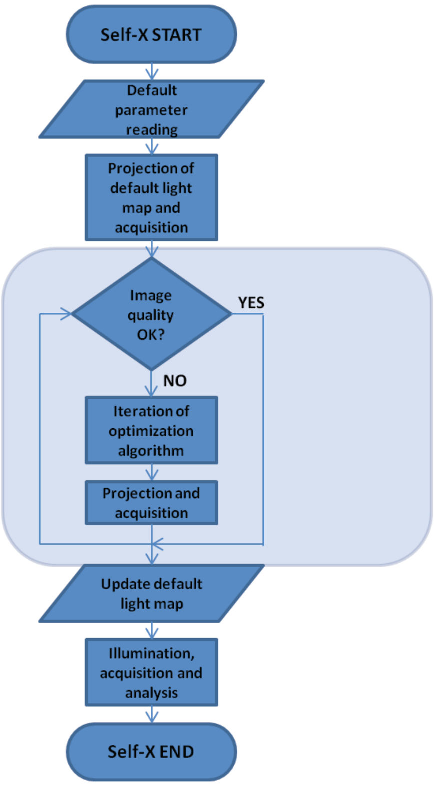
Lorenzo Stroppa
l.stroppa@univpm.it

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

2



2 Self-adaptation and self-optimization process for the illuminator

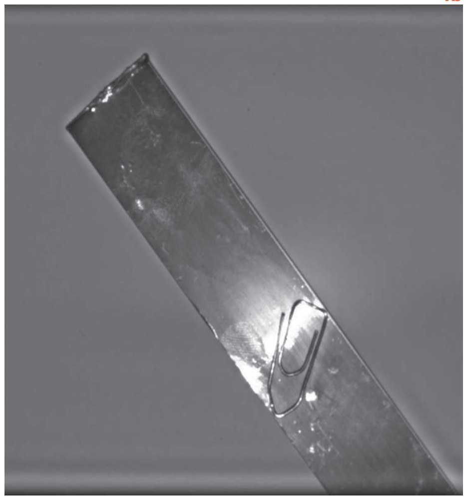
3 Controllable illumination of a WM part

4a-4b Experimental test: clip recognition over a reflecting surface

3

4a

4b



Dark surfaces often produce low contrast images, while reflecting surfaces may cause local image saturation, depending on light angle of incidence with respect to surface and camera. In these cases it can be difficult, if not impossible, to find an adequate light setting (in terms of intensity, colour, position, direction, etc.) that allows a satisfactory acquisition of the complete ROI on the target object. In fact illumination characteristics and camera setting can be only a compromise among the different needs of each portion of the scene.

Adaptive illumination with a spatially controllable illuminator can improve significantly image quality.

System layout

The spatially controllable illuminator is realized by a 3-LED DLP (commonly named a picoprojector). One main limit in using DLP technology for illumination is that DLP projects pulsating light at high frequency. Therefore the camera has to be triggered to properly synchronize to pulsating illumination, so to avoid image flickering and intensity changes in the acquired images. A specific camera sync device is therefore included in the prototype system. The prototype layout is described hereafter in figure 1; the illuminator is quasi-coaxial with the camera.

The self-adaptation procedure

Image quality can be affected by several causes: external illumination may vary, reflections may occur, etc. Therefore, self-adaptation can be used to significantly improve image quality by controlling spatial illumination.
Specific image quality estimators are available in literature and the optimization/adaption process can be driven by maximizing one of them, selected a priori (for example image contrast). The prototype developed implements a set of algorithms for computing image quality indicators.
The block diagram of figure 2 shows the strategies implemented to realize a self-adaptive spatially controllable illuminator.
Step 1: an optimized illumination distribution (optimized off-line from previous calculations) is projected on the target. Then an image is acquired and its quality is computed.
Step 2: if the quality of the image is not optimal, the illuminator light spatial distribution is adapted by using a dedicated optimization algorithm (Nelder-Mead downhill or genetic algorithms have been implemented and tested in the prototype). The new illumination is then used to update the default one in order to speed up the whole process.
The procedure is iterated until the desired image quality is achieved or until convergence to a local maximum of the image quality indicator has been obtained.

Results

The potential of the adaptive illuminator has been demonstrated to improve image quality of appliance parts in a vision quality control system.
Figure 3 illustrates the inspection of a black pipe with a metallic clamp. The image on the left shows the effect of illuminating the whole area with an intense and uniform illumination. If the controllable illuminator projects the lightning pattern represented in the central image, the resulting image is the one on the right, where the pipe is clearly more visible than in the original image. A quality indicator such as contrast clearly marks the improvement achieved.
Another example is in figure 4; a metallic clip over a highly reflecting surface becomes more visible when adapting the light spatial distribution so to minimize saturation and maximize visibility.
Therefore a spatially controllable illuminator can be used as part of a self-adaptive illumination system which could operate autonomously and maximize or minimize specific image quality indicators; this opens the possibility to develop an illumination device capable of compensating causes of disturbance in a variety of industrial cases.