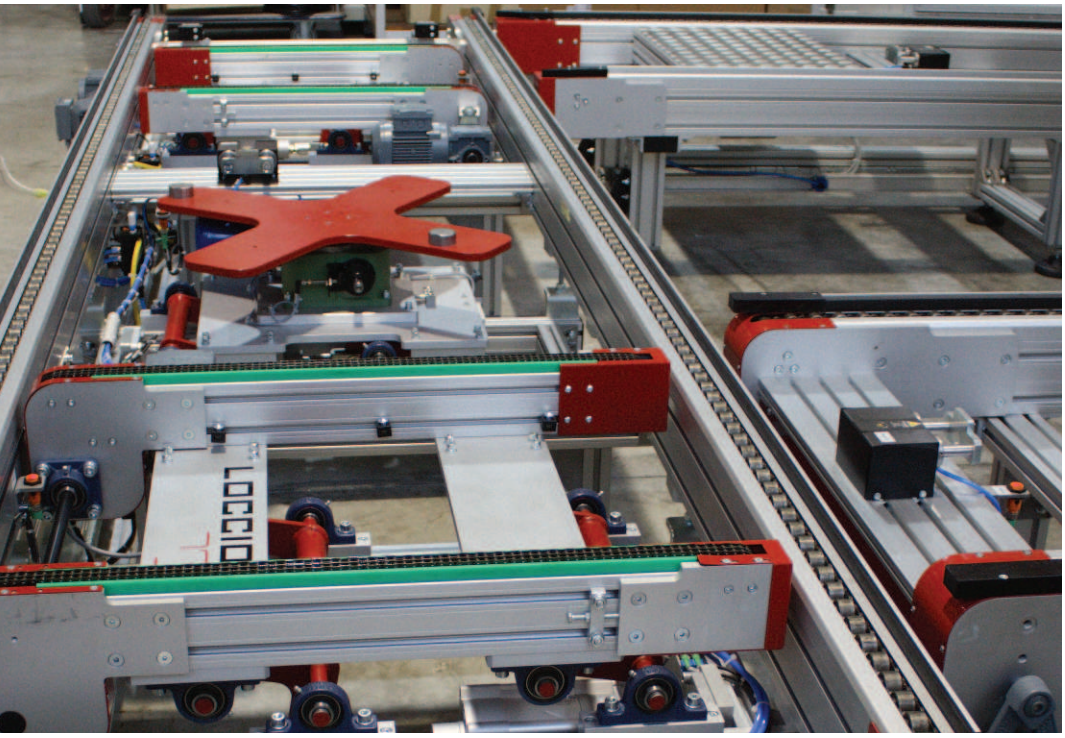
Grace

inteGration of pRocess and quAlity Control using multi-agEnt technology



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**.

Self-adapting test plans

Self-creation and self-updating of test plans in automatic quality control

Quality in manufacturing is formally defined as a set of properties and characteristics which the product has to have in order to satisfy requirements. In this sense, **Quality Control denotes conformity to specifications.**

An Automatic Quality Control (AQC) system needs a *test plan*, which is basically a software tool defining the measurement task to be performed as well as the optimal criteria for the decision about the quality of the product under test. The editing of the test plan is a very long and difficult task because it requires a deep knowledge of both the product under test and the measurement system. For this reason it is normally performed by skilled personnel who are responsible for the quality management. Moreover, the variability of products being tested (see figure 1 as an example), due to different and new production models, different and new components, implies the need to have flexible and upgradeable test plans, so that they need to be constantly updated.

Test plans updating is usually carried out by human operators. Within the Grace project an **innovative approach for self-creation and self-updating of test plans using only the knowledge gained from the production** is presented. **The approach makes use of pieces of information collected along the production line through the Multi Agent System (MAS) architecture** developed within the Grace project.

Updating a test plans

An AQC system is basically a two level system (Figure 2):

> The **measurement system** denotes the hardware and software components able to acquire a physical quantity,

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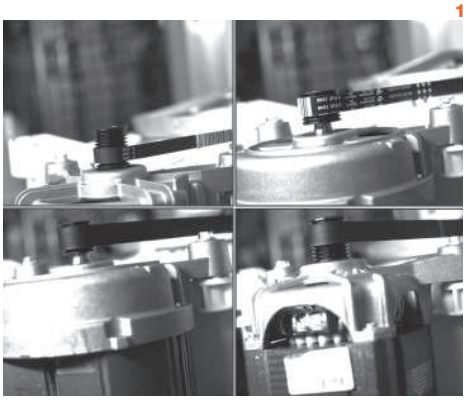

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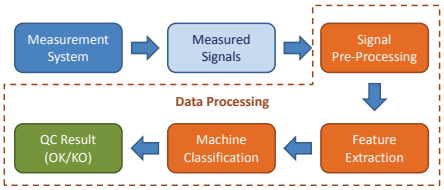

such as sensors and transducers, the data acquisition electronic and data processing software. Its output is the Measured Signal (numerical representation of the physical quantity object of the measurement) and its objective is to minimize the measurement uncertainty.

> **The data processing level** denotes the whole set of software tools that having as an input the measured signal provides as an output the diagnostic result of the Quality Control (QC) task with an adequate level of confidence.

A test plan defines the optimal workflow of operations, the optimal measurement system parameters and the optimal data processing algorithms, given a specific product model and environmental conditions during production. **The creation or updating of a test plan**, done either automatically or by a human operator, **can be thought as an optimization problem to be carried out off-line** because it uses information already collected on a certain number of items belonging to the same specific model.

Let us suppose the same AQC system must be used in a real washing machine (WM) production line to control, for example, the presence/absence of the belt and to measure its thickness. A typical production line produces different and always new models of washing machines, where different sets sub components can be assembled together in the final appliance. This implies that a different test plan for each one of those models must be created, containing the optimal system parameters, data processing and classification criteria.

1 Example of model variability in production line for a vision control station: images taken from an AQC vision system installed on a washing unit production line

2 Functional structure of an automatic quality control (AQC) system

3 High level flowgraph diagram of the self- creation and self-updating of test plans approach

Self-adapting test plans in production line

Since the creation and updating of test is a very time consuming and fatiguing activity, **a new methodology for the self-creation and self-updating of test plans is being developed in the Grace project, aiming at providing a support or an alternative to the skilled human operator**.

A high level flowgraph diagram of the proposed methodology is shown in figure 3. When a **brand new test plan** must be created for a specific new product model (left branch of the flowgraph), the basic idea is to use a test plan template for each QC task. This template contains all the “fixed” information, like the QC task objective, the kind of measure to be performed, the higher level workflow of operations and all the other measurement system and data processing parameters which only depend on the specific QC task, but not on the specific product model.
Starting from this template, all the available a priori knowledge is collected from the MAS (that is the local knowledge of the AQC system and the global knowledge on the whole production environment from the MAS) and additional knowledge is collected as more and more QC tests on the same product model become available. All this acquired knowledge is then used to estimate the optimal values of the other test plan parameters depending on the specific product model, by using self-adapting and self-learning procedures.
The situation is somehow similar for what concerns the **self-adaptation of already exiting test plans** (right branch of the flowgraph in figure 3), but in this case a test plan already configured and in execution is present already; therefore, the aim here is to **monitor over time that the AQC system keeps working close to the “optimal” parameter configuration**. To the purpose, as a new QC test is carried out on a specific item, the optimal test

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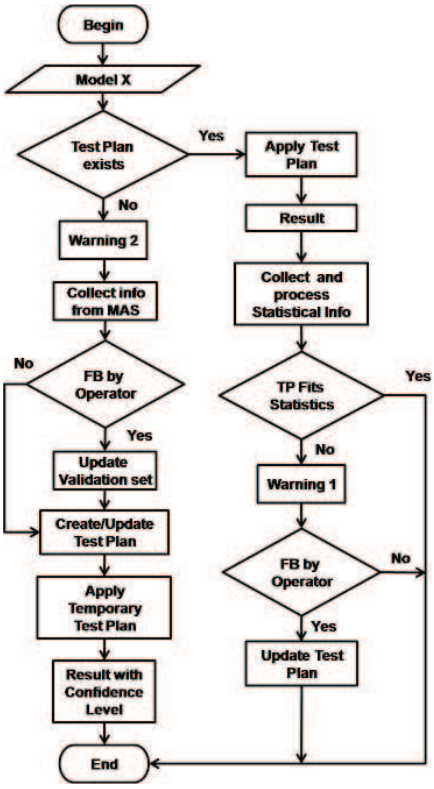

plan parameter configuration is calculated and made available to the operator. If a relevant difference is determined between the two parameter configurations -e.g.: in the value of a threshold - a warning can be sent automatically to the operator.
The final decision whether to use the self-generated and self-adapted test plans can be left to a skilled operator, but in every case the proposed methodology allows the operators saving time in the creation and updating of test plans.
The proposed procedure for self-adaptation/self-creation of test plans will be implemented as a distributed application in the Multi Agent System architecture that is being developed for the final demonstrator of the Grace project and will run in a real production scenario.