Automated Feature Selection Methodology for Reconfigurable Automated Visual Inspection Systems

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Presentation Outline

- Problem Definition
- Objectives of Research
- General Approach
- The Feature Selection Problem
- Results
- Conclusions and Future Research

Problem Definition

- **The lack of flexibility, combined with the rapid introduction and retirement of electronic products, has deterred equipment manufacturers from investing in the development of AVI systems more convenient for process improvement.**

Motivation for Research

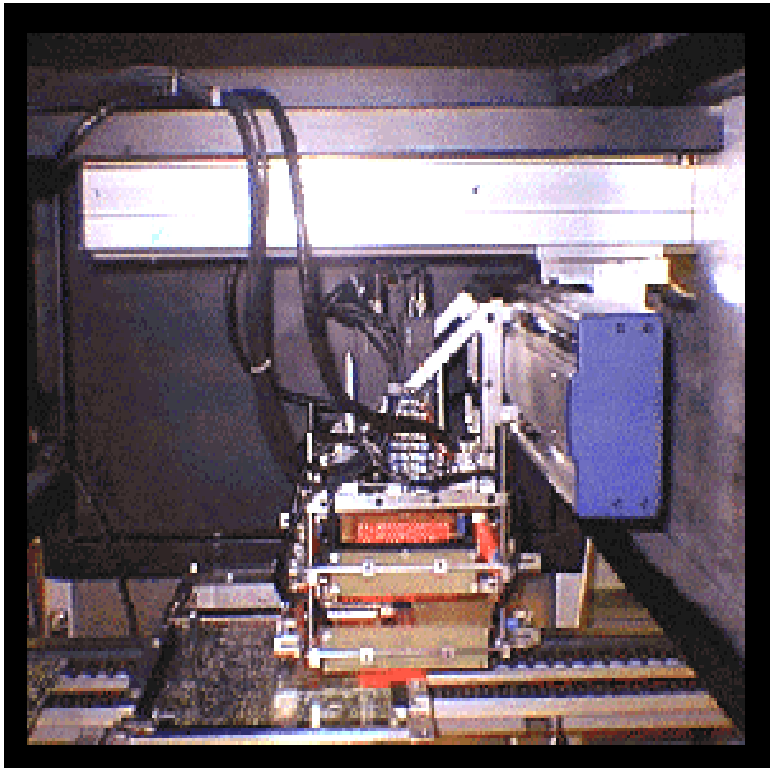
Current State

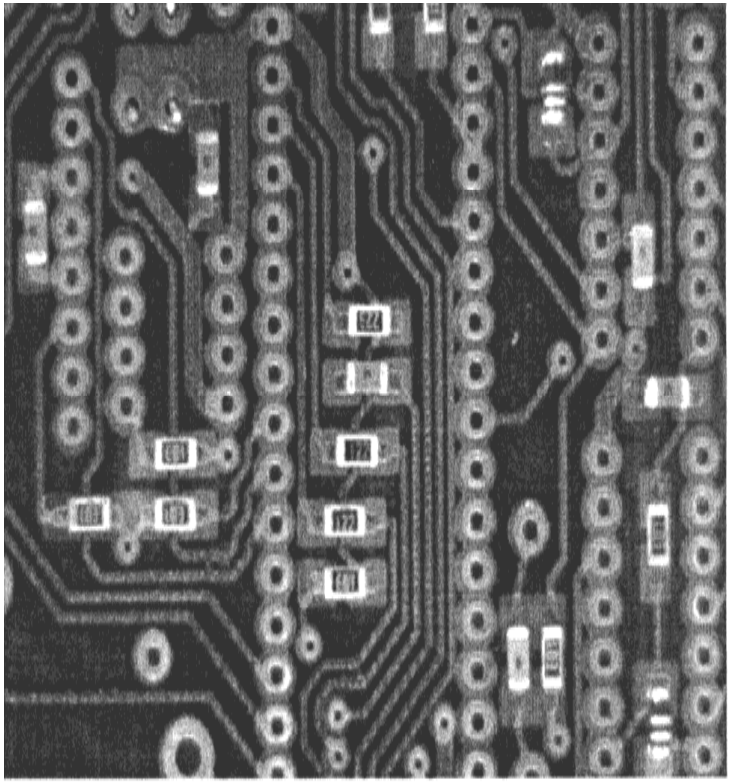
- Designed for Mass Production
- Fixed Production Schedules
- Dedicated Lines (Single or Limited Mix of Products)
- Quality Monitoring by Human Inspection
- Manufacturing Quality Control Systems Designed and Operated Independently of Each Other

Current Trends

- Miniaturization of Components
- Increased Speed of Assembly
- Increased Capital Investment
- Reduction of Work-in-Process (WIP)
- Reduction of Production Batch Sizes
- Global Competition and Time-Based Competition

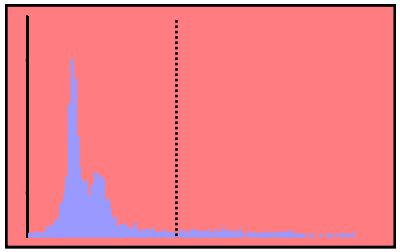
Inspection Module (2-D System)



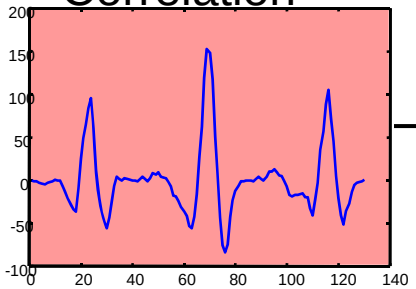


Vector Classification

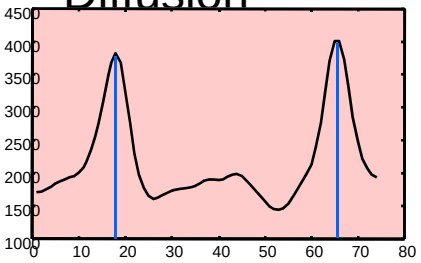
Energy



Correlation



Diffusion



$$R_1 : -\frac{1}{2}\mathbf{x}'\left(\Sigma_1^{-1} - \Sigma_2^{-1}\right)\mathbf{x} + \left(\mu_1'\Sigma_1^{-1} - \mu_2'\Sigma_2^{-1}\right)\mathbf{x} - k \geq c$$

$$R_2 : -\frac{1}{2}\mathbf{x}'\left(\Sigma_1^{-1} - \Sigma_2^{-1}\right)\mathbf{x} + \left(\mu_1'\Sigma_1^{-1} - \mu_2'\Sigma_2^{-1}\right)\mathbf{x} - k < c$$

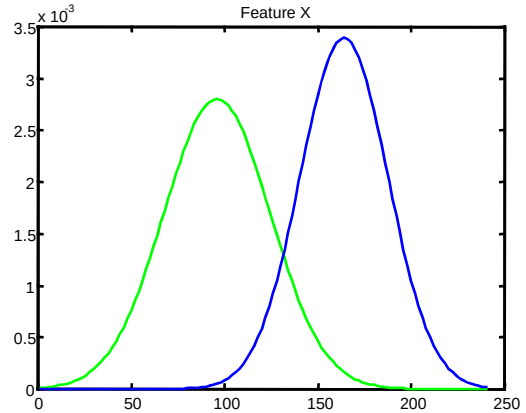
$$k = \frac{1}{2}\ln\left(\frac{|\Sigma_1|}{|\Sigma_2|}\right) + \frac{1}{2}\left(\mu_1'\Sigma_1^{-1}\mu_1 - \mu_2'\Sigma_2^{-1}\mu_2\right)$$

$$c = \ln\left[\left(\frac{c(1|2)}{c(2|1)}\right)\left(\frac{p_2}{p_1}\right)\right]$$

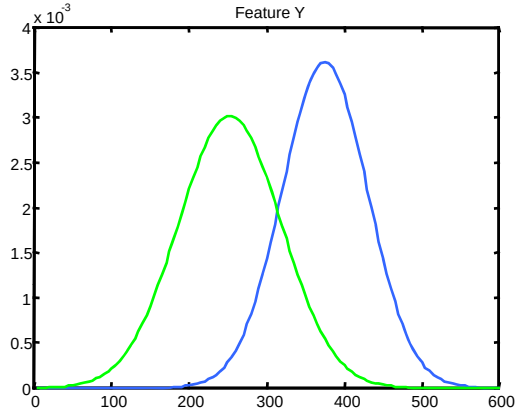
Result

Presence or absence of Component

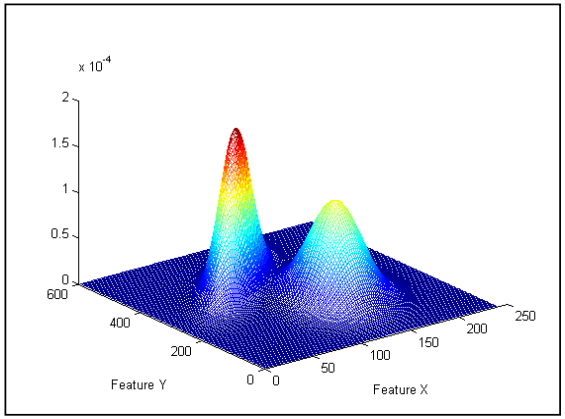
Multivariate Classification



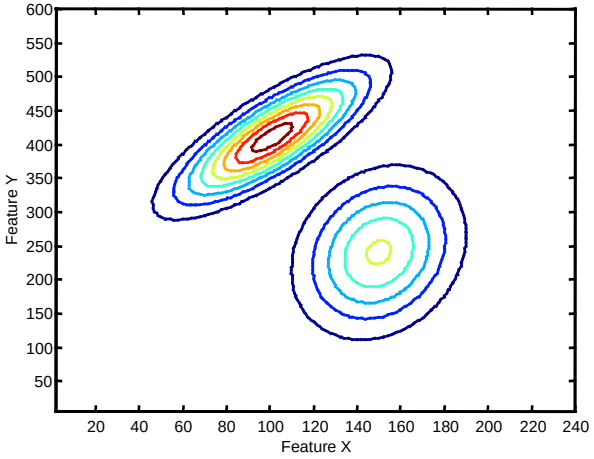
Histogram of Feature X



Histogram of Feature Y



Joint Features



Contours of Joint Features

Objective of Research

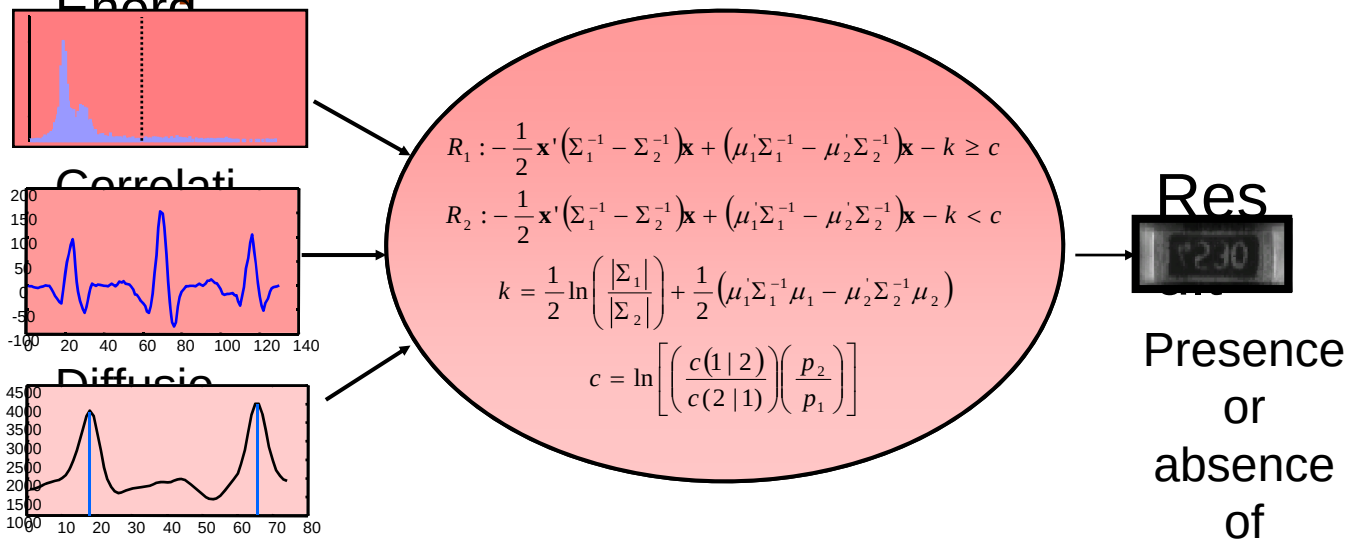
- **The development of a methodological framework that would make possible the automated development and reconfiguration of automated inspection Systems for surface mounted devices (SMDs)**

Goals of Research

- **Development of an algorithmic approach for the inclusion-exclusion of features into the classification vector**
- **Development of an algorithmic approach for the independent and multivariate optimization of the parameters of the feature extraction algorithms.**
- **Valuation-categorization of the sensitivity of the resulting inspection algorithms .**

Methodology

- **We are using a vector classification approach in conjunction with a hierarchical classification, to obtain the framework that will make possible the automated generation of inspection routines for SMD components.**



Envisioned Framework

- Pon el diagrama

Envisioned Framework for Autoreconfigurable Inspection Systems

In order to achieve the objective of developing self-reconfigurable AVI systems, we decompose the overall problem into simpler sub-problems or modules.

- The Feature Generation Module (FGM)
- The Feature Selection Module (FSM)
- The Decision Engine Module (DEM)
- The Performance Assessment Module (PAM)
- The Refinement and Improvement Module (RIM)

Envisioned Framework for Autoreconfigurable Inspection Systems

The Refinement and Improvement Module

The objective of this module is to enhance the performance of the inspection algorithms through the use of statistical tools.

Some areas of research are:

- **Feature Construction**
- Clusters Formation
- Multi-Feature Parameters Re-Optimization
- Data Transformation to Near Normality

Feature Selection

- The approach will consist on using the stochastic representation for the exact distribution of the Quadratic Discriminant Function (QDF) to estimate the MER.

- The proposed methodology will:
  - Minimize the MER of the final subset of features selected based in the MER and
  - avoid the computational problems due to the crossvalidation or simulation.

Envisioned Framework for Autoreconfigurable Inspection Systems

Feature Construction

- Feature construction is a process that discovers missing information about the relationships between features and augments the space of features by inferring or creating additional features (Liu *et al.,* 2003).

- In general, this process consists in applying a set of constructive statistical methodologies $\{m_1, m_2, \ldots, m_n\}$ based on the knowledge generated during the training period by the pre-existing features $\{f_1, f_2, \ldots, f_m\}$ of the inspection algorithm, resulting in the construction of one or more new features $\{f'_1, f'_2, \ldots, f'_N\}$ intended to be used to improve the current inspection algorithm.

- Having analyzed the literature on this topic and concluded that the previous methodologies are not really for the construction of features but for the transformation of the existing features, a novel approach is proposed.

- This approach consists of using a proactive-design point of view to solve this problem.

- This approach can be successful because the problematic of construction of features can be seen as a design problem, since it is necessary to identify the characteristics of the new features to improve the performance of the classifier.

QMM Conclusions

Preliminary Conclusions

- QMM will allow the rapid detection of a shifts in the process parameters
- MEWMA out performed Hotelling and CUSUM in detecting large shifts in the process mean
- Hotelling provides less false alarms than MEWMA and CUSUM

Current Activities

- Full implementation of QMM
- Test MEWMA under a non-constant interval sampling
- Testing of the system in the factory floor
- Development of interface with inspection allocation and diagnostics modules