EXPERT SYSTEM FOR FLEXIBLE MANUFACTURING SYSTEM

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Agenda

- Thesis Objective & Scope.
- Motivation.
- Why Flexible Manufacturing System?
- QCES Parameters & Assumptions.
- QCES: A Framework for KB-DSS.
- Why Control Chart Patterns?
- Control Charts Patterns Identification Techniques.
- Pattern Identification Attributes (Features).
- The Computer Program (Analytical Part).
- QCES Rule-Base Building.
- CASE STUDIES.

Thesis Objective & Scope

The main purpose of the current research work is to propose a conceptual framework for an online real time quality control system matching with the features and requirements of the recent advances in manufacturing systems, especially Flexible Manufacturing Systems (FMS). According to the proposed framework, an online expert quality control system (EQCS) is developed and implemented.
Motivation

- To date, quality control methods remain underutilized.
- Expertise is needed in quality control.
- Application of Expert System (ES) in quality control activities is important in FMS.
- Most of the research efforts focus on obtaining good rules to help construct good quality control diagnostic system.
- Most of the recent research suggests a framework of ES to develop statistical process control applications.

Motivation (Cont.)

- Most applications of ES in manufacturing concluded that the ES technology allows for implementation of sophisticated and efficient process control systems.
- The new philosophy of manufacturing control became in demand when FMSs were installed.
- All researchers that discussed pattern recognition concentrated on only six patterns: systematic, trends (upward & downward), stratification, cyclic, and natural pattern.

Why Flexible Manufacturing System?

- Produce Different Products in Small Batches
- Fully Automated System
- Costly
- Utilize Advanced Technology
**QCES Parameters & Assumptions**

- QCES is concerned with the analysis of control charts for variables (X-bar and R charts).
- QCES is based on the 3 sigma limits.
- Interpretation in QCES depends on the AT&T rules and on the identification of the chart pattern.
- QCES identified the last six patterns as unknown.
- Attribute-value triple mode was used to represent the knowledge base of the ES part.
- Production rule was used to build the rule base.

**QCES: A Framework for KB-DSS**

**Why Control Chart Patterns?**

- Non-random patterns in control charts signal the presence of special or assignable causes even if all points fall within the control limits.

- Correct interpretation of patterns helps the quality professional in identifying assignable causes; Western and Electric Company stated fourteen unnatural patterns of control charts and the common causes of each pattern.
Control Charts Patterns Identification Techniques

- Work on patterns identification in quality control charts have taken four main directions:
  - Expert System. (QE Interpretation)
  - Computer Vision. (QE Interpretation)
  - Neural Network. (Time & Effort)
  - Feature-Based Method. (More Accurate)

- Feature-based method is the most accurate. Pham and Wani (1997) stated that this has 99% accuracy for pattern recognition.

Control Chart Pattern Identification procedure

- Investigate the Patterns and Extract the Features
- Build a Database
- Convert these Data into a Decision Tree
- Develop Computer Program
- Verify the Results

Pattern Identification Attributes (Features)

- Test of normality
- Slope
- Moving Average
- Xi Xi+1 and Xi+1 Xi+2 for all samples
- 9 points Consecutive above CL or lower CL
- 9 points Consecutive below CL + σ
- 8 of points Lie on warring Limits Zone
- Points > 5 σ + CL
- 15 Points consecutive in Zone C
The Computer Program (Analytical Part)

- A computer program was developed based on the VB language; the program includes the following activities:
  - Computation of the quality control chart characteristics (X-bar and R charts).
  - Plotting the quality control charts.
  - Computation of the process capability.
  - Interpretation of the quality control charts by applying AT&T rules first and then applying pattern identification procedure.
  - Identification of the process status i.e. in or out of control & why?
QCES Rule-Base Building

- Collect data (assignable causes) related to the unusual patterns
- Construct an attribute value table
- Develop a rule-base
- Develop computer program
- Verify rule-base

CASE STUDIES

- Three case studies were considered to verify the proposed EQCS framework:
  - Case Study I (From Statistical Quality Control Hand Book)
  - Case Study II (Conventional M/C)
  - Case Study III (FMS)

CASE STUDY I (SQC Handbook)

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CASE STUDY I
(Computer Implementation)

CASE STUDY I
(Consultation Session)

CASE STUDY II
(Conventional M/ C)
CASE STUDY II
(Computer Implementation)

CASE STUDY II
(Consultation Session)

CASE STUDY III
(FMS)
CASE STUDY III
(Computer Implementation)

CASE STUDY III
(Consultation Session)

DISCUSSION

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DISCUSSION (Cont.)

- Three case studies were used for verification.
- In Case Study II, the causes of out-of-control were identified as follows: rotation of fixture, tool in need of sharpening, wear of tool, use of defective raw materials, and machine in need of repair.
- There is no significant difference in the results of the characteristics of the control charts.
- The normality test was also performed to verify the EQCS decisions.

Conclusion

- In this research, a quality control expert system (QCES) framework was developed. This framework integrates statistical quality control system with expert system (Hybrid DSS). The proposed framework:
  - Allows for the identification of instability patterns of control charts.
  - Helps to develop an on-line statistical quality control and process diagnostic system for FMS.
  - Makes on-line quality control and adaptive sampling plans more effective in FMS.
- Was applied and verified in three different case studies.

Thank You