logi.DIAG

Test Driven Automation and Condition Monitoring

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20 Jahre Erfahrung in der Automatisierung

logi.DIAG: Focusing on Industrial Automation

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- **Automation** is the use of control systems (such as numerical control, programmable logic control, and other industrial control systems), in concert with other applications of information technology (such as computer-aided technologies [CAD, CAM, CAx]), to control industrial machinery and processes, reducing the need for human intervention.[1] In the scope of industrialization, automation is a step beyond mechanization. Whereas *mechanization* provided human operators with machinery to assist them with the physical requirements of work, *automation* greatly reduces the need for human *sensory* and *mental* requirements as well. Processes and systems can also be automated.

http://en.wikipedia.org/wiki/Automated

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Motivation - Automation

Increasing Requirements

↓

Ever-increasing Complexity

↓

Larger and more complex software

Two Approaches for one Solution

- Test-Driven Automation
  - To assist during design & development of automation solutions
- Condition Monitoring
  - To identify upcoming system failure at an early stage

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logi.DIAG: Test Driven Automation

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- Reusing concepts from business IT for automation systems development
  - Test Driven Development Process
  - Testable Application Architecture
  - Testing Practices like Unit-Tests
- Integration with process supporting tools like
  - Lifecycle-Management Tools (Requirement-, Test-, Issue-, Configurationmanagement)
  - Tools for Automated Testing

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logi.DIAG: Condition Monitoring

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- Identify a failure before it occurs, e.g.,
  - Monitor the sound of a motor's bearing and warn if the motor "sounds like becoming defective"
- Current approaches are very simple
  - Monitoring of single (or a few) sensor values
  - Compute some characteristic data/value (e.g. using an FFT)
  - See if characteristic data/value fits into an acceptance region
  - Issue an error
- Benefits
  - Maintenance intervals can be scheduled according to machine condition, not just every *n* months
  - Spare parts can be ordered in advance and do not have to be put on stock
  - Downtime can be minimized (minimum loss of production)

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logi.DIAG: Condition Monitoring

- Connection of Automation and Condition Monitoring
  - Integration of diagnosis into automation application architecture
  - Utilize diagnosis interfaces used for unit-testing to supply condition monitoring applications with process related data
- Development of Data-Mining Algorithms for Real-Time Data Processing
- Add statistical methods to the simple algorithms currently used in condition monitoring systems
  - Also allows to “collect data” over a rather long period of time without extensive need of resources
  - Can extend Condition Monitoring from single compontens (e.g. monitoring a drive’s bearings) to larger parts of automation solutions (e.g., machine or even complete production line/plant)

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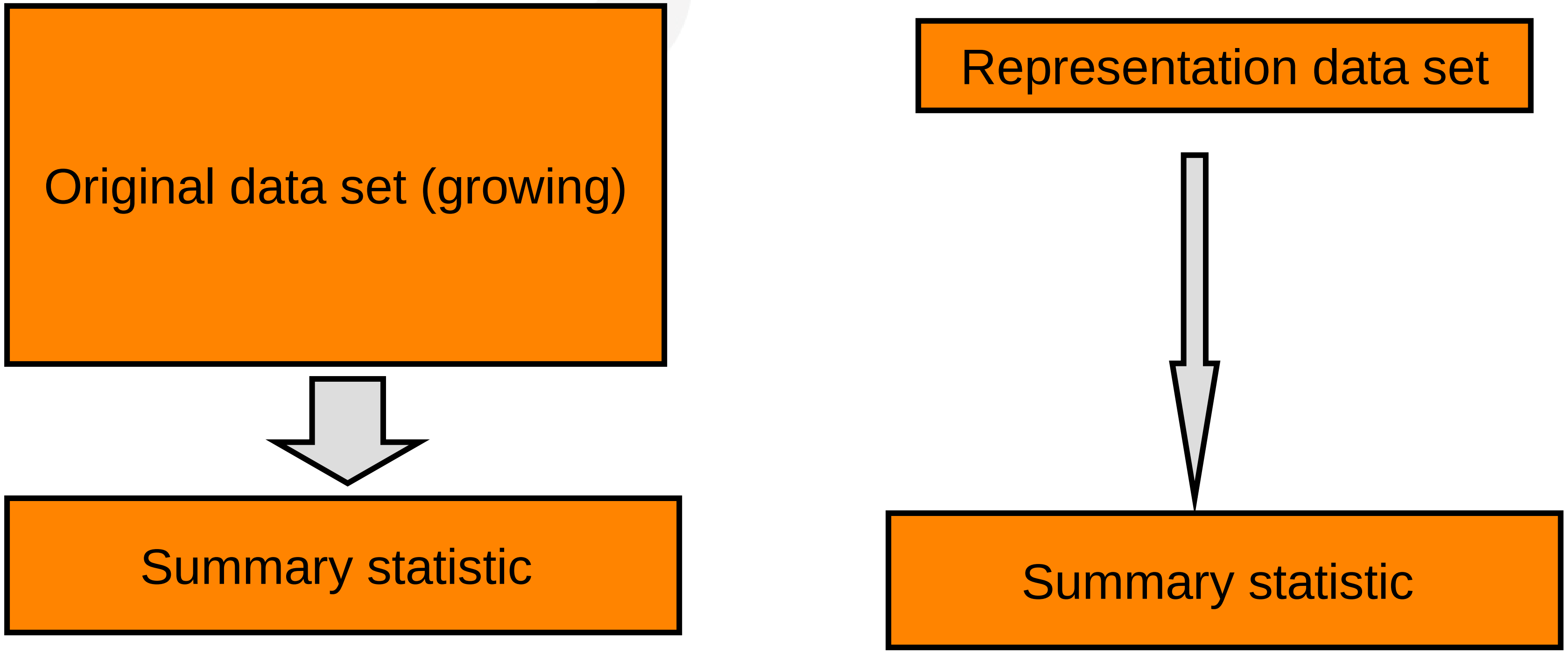
logi.DIAG: Efficient data monitoring

- Condition monitoring:
  Storing statistical data should be efficient timewise and spacewise
  - We represent data by a set of representatives of a fixed size
  - Instead of computing summary statistics with the original (large) data set which is constantly growing we compute the statistic using the "empirical statistics" with the representation data set
  - Data are collected continuously, and when a given number of new data is available, the representation data set is updated
  - Method is "universal" we do not restrict the set of available statistical methods by "condensing" the data

logi.DIAG: Efficient data monitoring



logi.DIAG: Efficient data monitoring

logi.cals by kirchner SOFT

- Algorithm (Chambers et al)
  - For the set of representatives compute the interpolating distribution function (representatives are used as quantile points)
  - For the data set to be used for adjustment compute the (discontinuous) empirical distribution function
  - Compute the mixture distribution of these two distributions. Weights in the mixture are accumulated number of points and size of the new data set
  - Compute quantiles of mixture distribution and use these as the new representation data set
  - This algorithm does NOT allow generalization to multivariate distributions easily.

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logi.DIAG: Efficient data monitoring

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- Multidimensional algorithm
  - Compute principal component directions for the data
  - Compute projections of the data sets on the components
  - Perform one-dimensional Chambers algorithm for each projection
  - Combine updated projected representatives to new set of representatives

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logi.DIAG: Efficient data monitoring

- Showcase application: coffee machine
  - We compute the sound spectrum of the noise
  - We want give a warning if coffee will run out soon
  - Spectrum has characteristic behavior for fineness of grinding
  - Spectrum is noticeably different when coffee will run out
- Implementation
  - Compute average energy in selected spectral segments in real time
  - Do multidimensional plot (lattice plot) with marked regions for different states of the machine

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Showcase Application: Coffee Machine

logi.DIAG: Issues with R Implementation

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- Algorithms are run on automation systems
  - Slow CPU (even 16-bit CPUs with < 10MHz)
  - Few memory (beginning with 2KB RAM+Flash up to ~ 1MB)
  - No math processor
  - Real-time operating systems
- Reimplementation required
  - Porting from R to C
  - Using as few R packages (and functions) as possible
  - Tuning for memory and operations (floating point?)

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Thank you for your interest

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