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PAM

NEW APPROACH TO

CONDITION MONITORING

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Introduction

- Existing Methods of condition monitoring and fault detection fall into 3 categories:

  * Model based fault detection methods.
  * Fuzzy/neural/expert system type methods.
  * Model free, algorithmic data driven methods.

- Neural network type techniques are particularly good for non-linear systems and when little information is available.

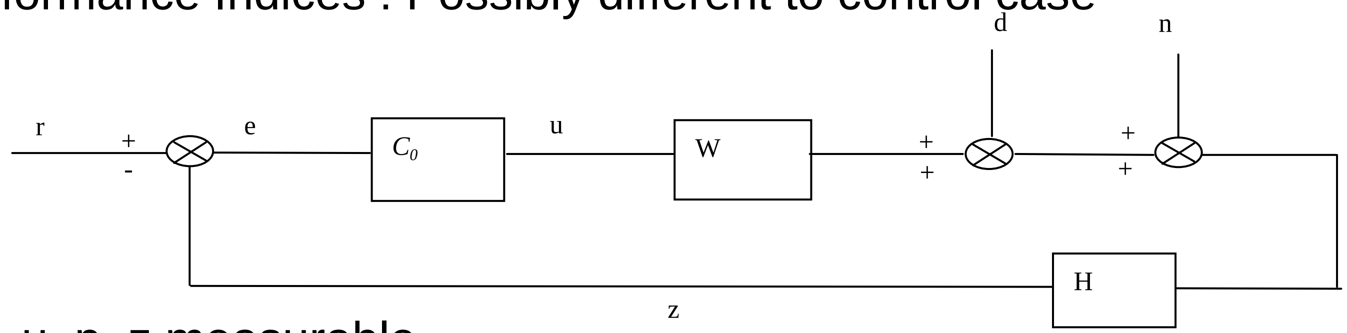
- Model based methods can often give good discrimination between faults but require very detailed models.

- Statistical process control is a good technical and management tool but is not linked to optimisation.

- Aim is to introduce a new class of condition monitoring and fault detection algorithm.
- Builds upon success in the performance assessment and benchmarking community.
- Can be model free data driven or utilise models in more sophisticated algorithms.
- When models are used they do not need to be of the same accuracy or complexity as model based fault detection techniques.
- These developments fit in nicely with new advances in intelligent sensors and in wireless communication devices.

Condition Monitoring

Performance Indices : Possibly different to control case



e, r, u, p, z measurable

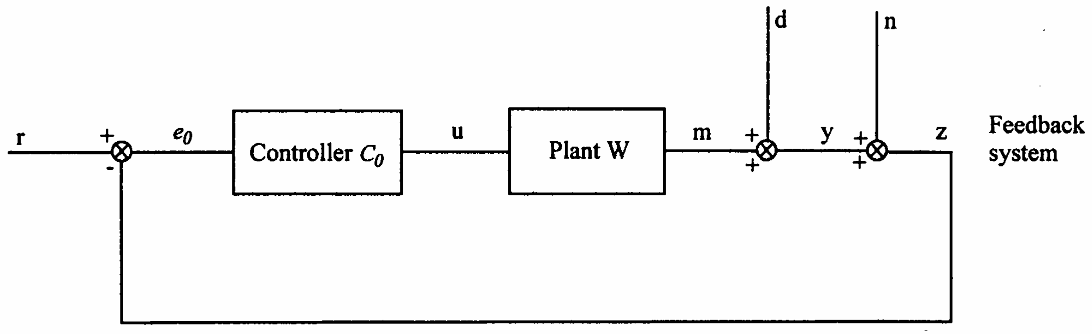
Question - What is the most sensitive performance measure that can be defined for a given control loop that can detect changes in:

(a) Sensors
(b) Actuators
(c) Disturbances
(d) Noise
(e) Plant dynamics
(f) Measurement system dynamics

Aims of the New Data Driven Reduced Complexity Condition Monitoring Devices

- Should be able to use model data or not, depending upon availability.
- Need to be links to optimisation so that good performance can also be recognised.
- Should include design tuning variables to enable fault discrimination to occur.
- From a user perspective should be simply to understand and to interpret results.
- Need to be easily extendable to nonlinear, uncertain and multivariable systems.

Condition Monitoring Metric Strategy



- Condition Monitoring Metric = $E\{(H_{m1}e)(t)^2 + (H_{m2}u)(t)^2 + (H_{m3}y)(t)^2\}$
- For plant actuator failure $W \rightarrow W.\delta W_1$ and $u \rightarrow u + c_1$ where c_1 is a coloured noise signal.
- The change in the CMM may be computed for given weightings given δW_1 and c_1 .
- The δW_1 can be presented probabilistically and signal c_1 can be represents stochastically.
- Problem is to choose weightings to maximise change due to fault.

CONDITION MONITORING COST INDICES

- **A weighted sum of output, control, error signals can provide a new cost indices**
- **The definitions of weightings which make these indices sensitive to faults, degradation or failure requires new design procedures.**
- **The idea is to choose weightings which penalise fault conditions but which provide low costs during normal operation.**

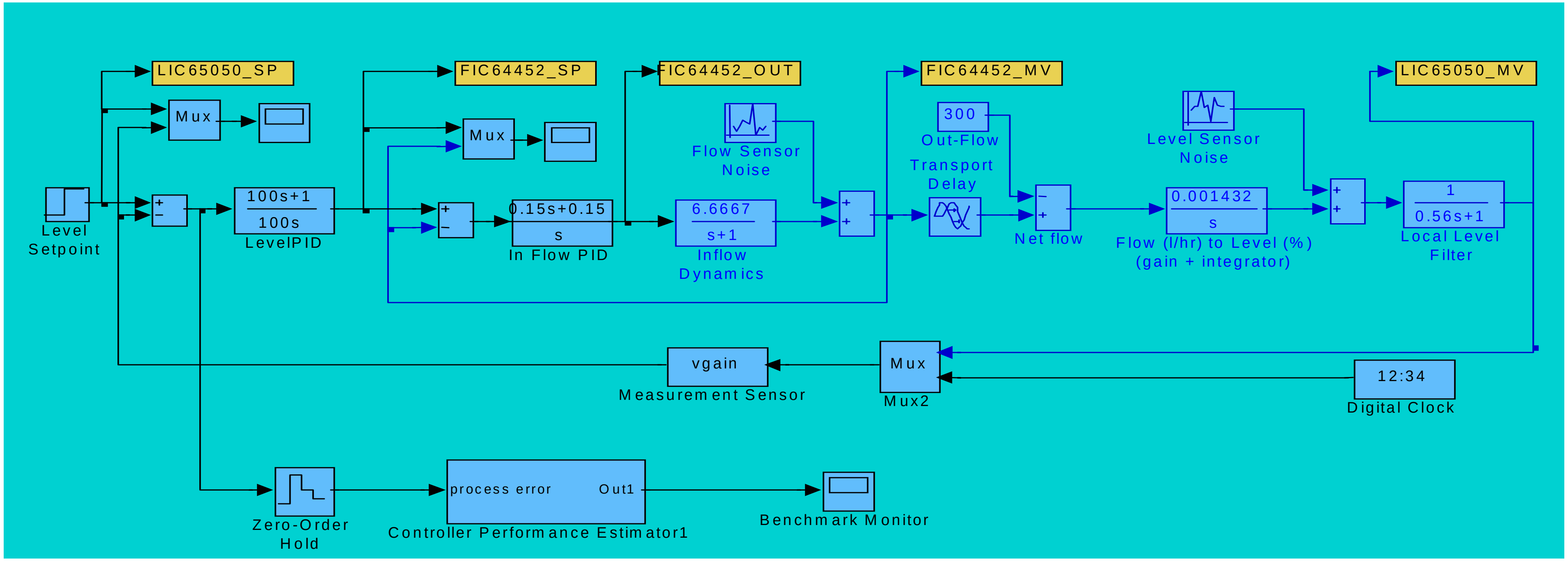
DEALING WITH NONLINEARITIES

- **Systems that operate at different nonlinear operating points give rise to condition monitoring indices which can be averages across set of plant models.**

- **This is an alternative to storing the condition monitoring indices at each operating point and finding schedule based differences.**

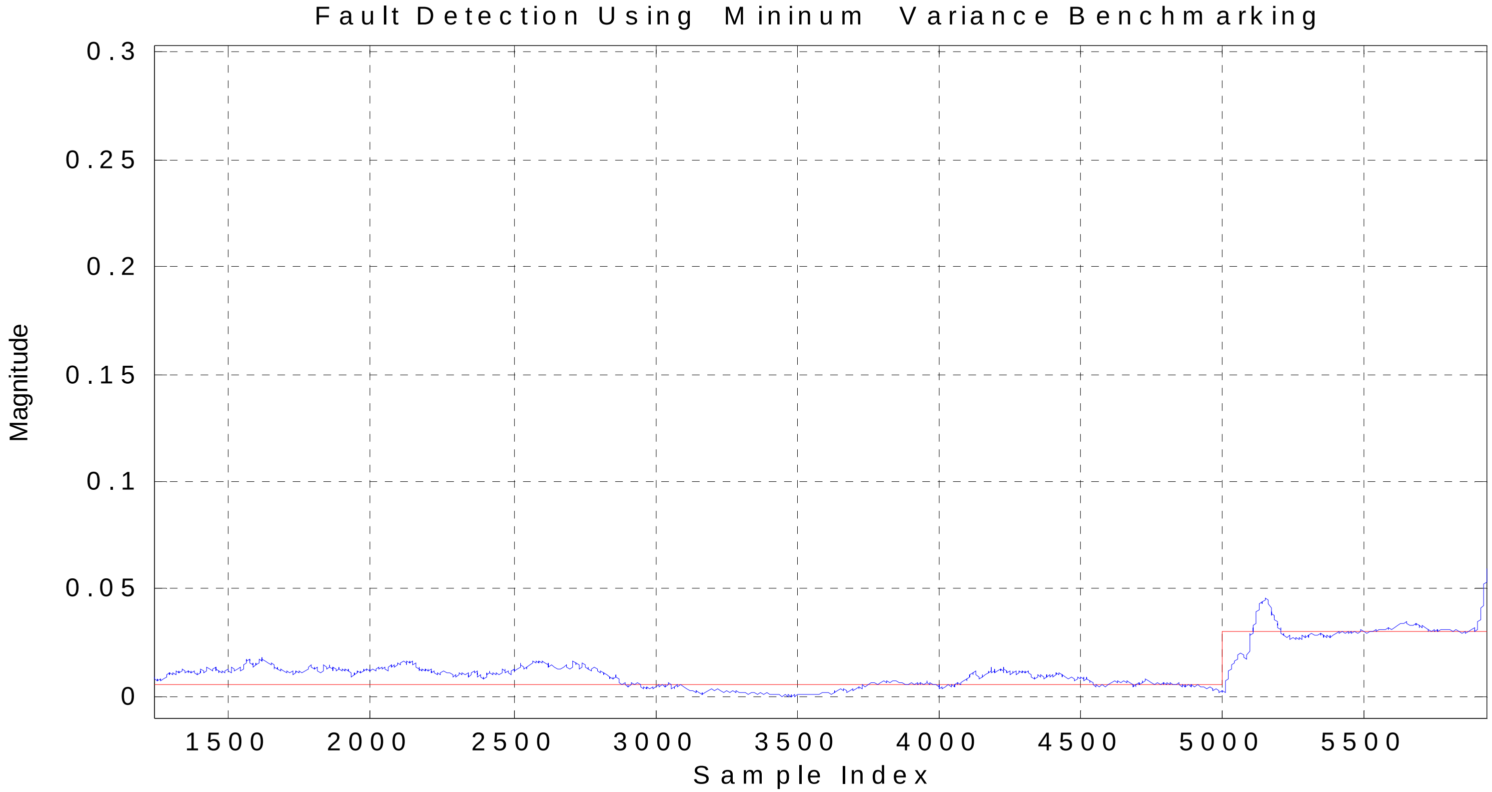
- **Least squares theory which underpins approach can also be modified to take into account non-linearities in system based upon non-linear estimation techniques.**

Fault Detection in a Distillation Column



- **PID cascade Control system**
- **90 sec transport delay**
- **2rd Order Transfer function Model**
- **Simulink Model Validated against real plant data**

Fault Detection in a Distillation Column



- **Baseline benchmark Index .005**
- **Measurement Sensor gain change from 1 to 1.02**
- **System Benchmark Index .03**

Conclusions

- **Theory of method for fault detection established**
- **Development for Fault isolation on going.**
- **Technique provides dual benefits**
  - **Performance Benchmarking**
  - **Fault detection**
- **Research required to deal with uncertainties and improve robustness.**