UNIVERSITY OF TEXAS SITE

FOR THE INDUSTRY UNIVERSITY COOPERATIVE RESEARCH CENTER ON

INTELLIGENT MAINTENANCE SYSTEMS

PROF. DRAGAN DJURDJANOVIC
PRESENTATION OUTLINE

» Introduction
» Projects
» Model of operation
CONDITION BASED MAINTENANCE (CBM) PARADIGM

Data → Information → Decisions

- Quantitative Health Assessment
- Condition Diagnosis
- Performance Prediction

Feature Space

- Normal Behavior
- Most Recent Behavior
- Faulty Behavior

Feature Space

- Normal Behavior
- Most Recent Behavior
- Faulty Behavior

Model of a Fault
Predicted Probability of Failure
Prediction Uncertainty
Predicted Health
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PROJECT 1: INFORMATION THEORETICAL APPROACH TO DIAGNOSTICS AND PROGNOSTICS

User interface

1) Model Based Diagnostics
   • Sensors measure
   • Physics models simulate
   • Tune parameters, simulations = measurements
   • Parameters ID faults

2) Assess Health: “fault noise”, Shannon’s thms

3) Prognosis: forecast parameters, simulate, assess health

FUNDAMENTALS basis of PHM SOFTWARE
PROJECT 2: DEGRADATION MONITORING & PREDICTION IN COMPLEX SYSTEMS WORKING UNDER VARIABLE OPERATING CONDITIONS

Data → Information → Decisions

Feature $f_1$ → Feature $f_2$

Performance Prediction

Normal Behavior

Prediction Uncertainty

Good $P=0.8$

So-so $P=0.1$

Bad $P=0.1$

Awfull $P=0$
PROJECT 2: DEGRADATION MONITORING & PREDICTION IN COMPLEX SYSTEMS WORKING UNDER VARIABLE OPERATING CONDITIONS

Data -> Information -> Decisions

Performance Prediction

<table>
<thead>
<tr>
<th>Feature f₁</th>
<th>Feature f₂</th>
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<tbody>
<tr>
<td>P=0.1</td>
<td>Good</td>
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<tr>
<td>P=0.1</td>
<td>So-so</td>
</tr>
<tr>
<td>P=0.1</td>
<td>Bad</td>
</tr>
<tr>
<td>P=0.7</td>
<td>Awfull</td>
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</tbody>
</table>
PROJECT 3: IMMUNITY INSPIRED APPROACHES TO DIAGNOSTICS & PROGNOSTICS

A typical automotive assembly system:
- Hundreds of stations
- Highly integrated system
- Every minute of downtime costs about $25 K
- Intermittent connection on the automation network caused 4.5 hours of downtime

Source: 2001 report from the U. of Michigan Center for Automotive Research (Courtesy of ETAS Inc.)
PROJECT 4: FAULT DETECTION AND DIAGNOSTICS IN SEMICONDUCTOR MANUFACTURING

» Reliance index formulation to quantify prediction model uncertainty
» Virtual metrology integration with existing run-to-run EWMA controllers in semiconductor manufacturing
» Development of new controller performance assessment methods for use in high-mix non-threaded manufacturing
» Develop optimum controller tuning methods based on CPA optimality criteria
» Implement and test online in an industrial setting
PROJECT 5: PREDICTIVE MAINTENANCE PARADIGMS IN MEDICINE

- **Symptomatic** versus **system-based** monitoring

**System** → **Output** → **System** → **Output**

**Utility:**
- Clinical review
- Tele-operated robots
- Rehabilitation
- Prosthetics

**Challenges:**
- Incomplete system information
- Inaccessibility of input
- Indirect measure of output
- Nonlinear input-output relationship

PROJECT 6: MAINTENANCE LOGISTICS

» Consider the new degradation dynamics models within maintenance planning and scheduling models
» Incorporate new models of degradation and maintenance into logistics models including spares stocking
» Expand the focus on maintenance to include multiple sites, multiple equipment, geographically dispersed install base
  ▪ Explicitly model spatial considerations (distances between maintenance personnel, tools and target systems)
» Consider the limited quantity and capacity of maintenance and repair resources

E.g. a wind farm with maintenance office, spare parts stock, service technicians, and wind turbines.
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NSF Industry-University Cooperative Research Center (I-UCRC) on Intelligent Maintenance Systems at the University of Texas

- Project 1
- Project 2
- Project 3
- Project 4
- Project 5
- Project 6

Opportunity

- $40K overhead-free yearly membership
- (Long Term Research, Shared Knowledge)

Risk

- Project 1 (Company 1)
- Project 2 (Company 2)
- Project 3 (Company 3)
- Project 4 (Company 4)

- Short courses using university infrastructure
- Company-specific short courses, focusing on case-studies
- Student internships focusing on implementation issues
- Joint publications with industrial sponsors

(COMPANY SPECIFIC PROJECTS)
Opportunities for Research in Predictive Maintenance at the University of Texas at Austin

- Critical mass of faculty performing research in condition monitoring and prediction (data driven and physics based), with numerous applications, including semiconductor industry, mechanical, biological, electro-mechanical systems.
- Critical mass of faculty performing research in system-level decision-making and operations research, with applications including semiconductor operations, nuclear engineering, service logistics etc.

- Inexpensive access to highly talented and motivated students and researchers
- Ability to use at discretion up to 10% of the capabilities of one of the most powerful publicly available computing facilities
- Faculty and students with positive experiences in university-industry collaboration
- Strong industrial base in the vicinity
- Additional funds from the NSF ($50,000/yr)
THANK YOU