A Jack of All Trades

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Application 1: Controlling Mass Transit Systems
Numerous optimization problems arise in the area of advanced automatic train control

- On a daily basis, the control system experiences approximately 20 delays of 5 or more minutes
- Decrease in travel time will reduce number of needed trains, thereby saving $2M per car
- **Short Term** - improve passenger comfort for the Bay Area Rapid Transit (BART) District
- **Long Term** - minimize energy consumption
Our enhanced control objective is to smooth interference during acceleration

• while
  – adhering to the schedule,
  – maintaining the worst case stopping distance,
  – making required station stops,
  – travelling at safe speeds, and
  – braking into a station at a controlled rate.

\[
\min_{x} \quad f(x) \\
\text{s. t.} \quad h(x) = 0, \\
\quad g(x) \geq 0
\]
What tools are needed to solve this problem?

- **Disciplines**
  - Physics
  - Numerical Analysis
  - Operations Research

- **Programming**
  - C++ (for UNIX systems)
  - Java

- **Software Tools**
  - Matlab
  - Excel

- **Soft skills learned**
  - Teamwork
  - Client Interactions

Items in orange font indicate my knowledgebase at the start of the project.
Application 2:
Detecting protein phosphorylation sites
Why is phosphorylation important?

- Controls DNA repair
- Regulates metabolism
- Can prevent diseases
What was the research question?

- **Problem Statement**
  - Given a set of known phosphorylated sites, can we use machine learning techniques to accurately detect the sites?

- **Approach**
  - Apply neural networks, Hidden Markov Models, etc.
  - Use majority vote to identify a site
  - Compare accuracy of individual methods and majority vote
Integration of existing tools was the heart of this project

- Disciplines
  - Data mining
- Programming Languages
  - CSH
  - Perl
  - Python

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Application 3: Stocking Shelves
How to stock shelves?

- **Key Questions**
  - How much to buy?
  - When to buy?
- **Driving metrics**
  - Customer wait time
  - Inventory investment
  - Workload
- **Items with sporadic demand are hard to manage.**
  - The past may not be a perfect barometer for the future
What is Sporadic Demand?

Frequent demands, quantities vary moderately

Infrequent demands, quantities vary greatly (not always low quantities!)
What tools are needed to solve this problem?

- **Disciplines**
  - Statistics
  - Inventory control

- **Programming**
  - Visual Studio C++

- **Database Tools**
  - FoxPro
  - Microsoft Access

- **Soft skills learned**
  - Project management

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Who is LMI?

• Formerly known as Logistics Management Institute
• A not-for-profit government consulting company
• Headquarters in Northern, VA
• We are hiring!
  – Computer scientist/mathematician posting