Improving IV&V Techniques Through the Analysis of Anomalies

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http://menzies.us/pdf/sas07brief.pdf

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Problem

*Flying Safely to 2020 and beyond means attacking **relentlessly** all three levels of the risk iceberg!*

- Brian O'Connor March 20, 2003

- **Mishap recommendations**
- **Problem solutions**
- **IFA fixes**

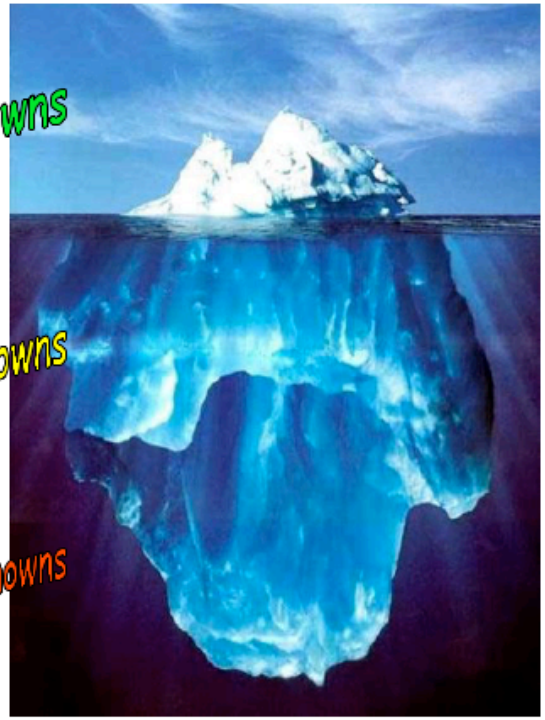
Known Knowns

- **FMEA/Hazard controls**
- **Close call recommendations**

Known Unknowns

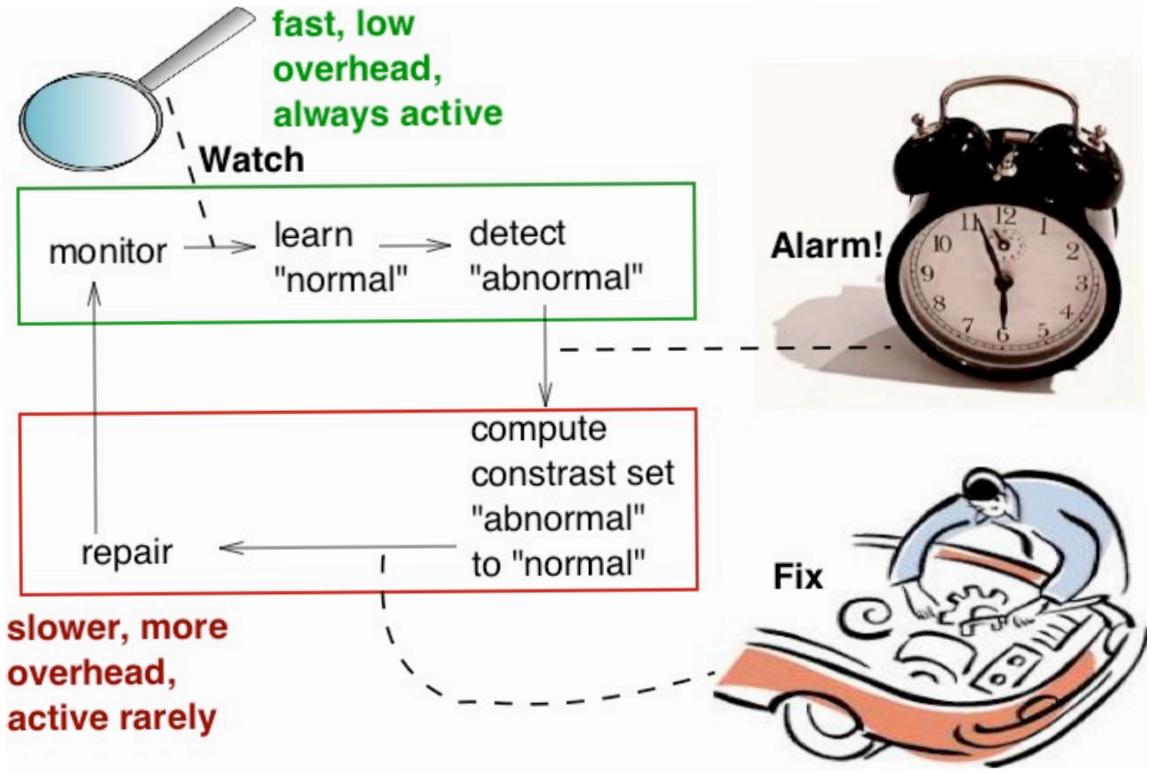
- **Ignored close calls?**
- **Old cert, new environment?**
- **Inadvertent excursions out of cert/family?**
- **Hardware talking…nobody listening?**

Unknown Unknowns

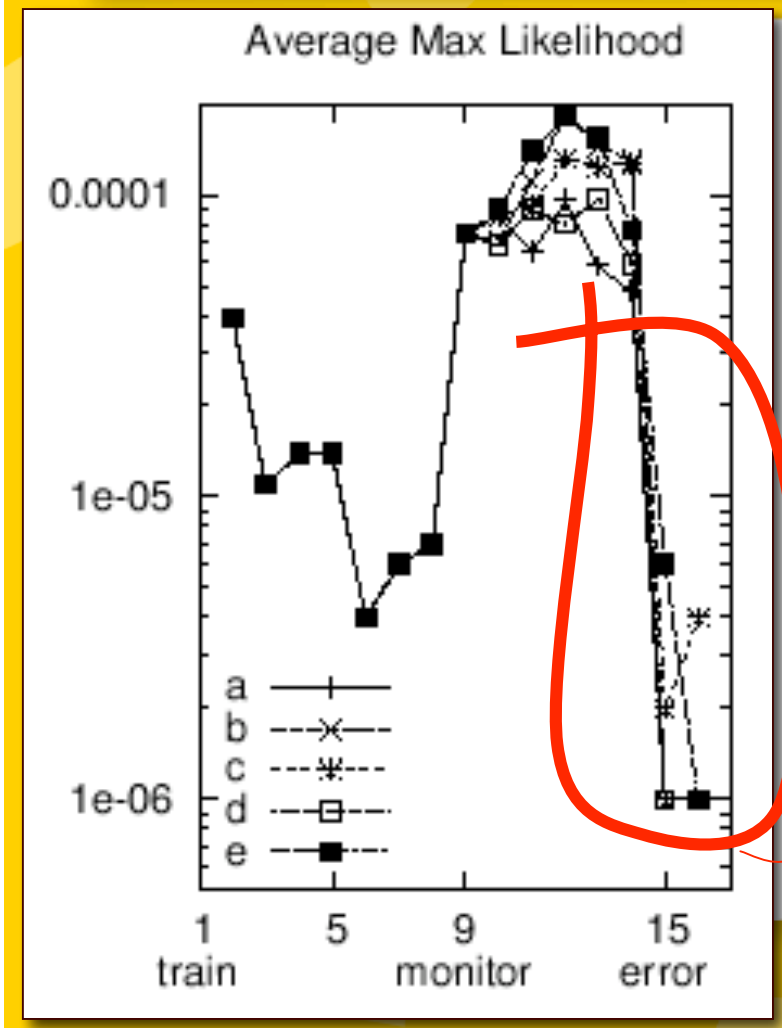


But how to know what we don't know?

Approach


fast, low
overhead,
always active
Watch
monitor
learn
"normal"
detect
"abnormal"
Alarm!
compute
constrast set
"abnormal"
to "normal"
repair
Fix
slower, more
overhead,
active rarely

Approach (details): count, alert, fix



Count: stuff seen in past
Alert: if new counts different
Fix: find delta new to old
- Very, very fast

An incremental discretizer + a Bayes classifier where all inputs are all mono-classified

Track average max likelihood for data processing in "era"'s of X instances

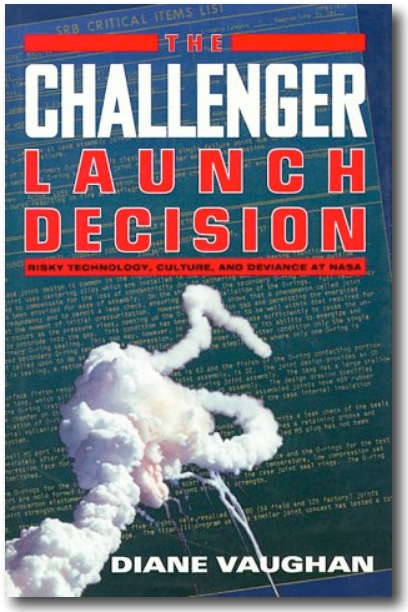
Contrast set learning

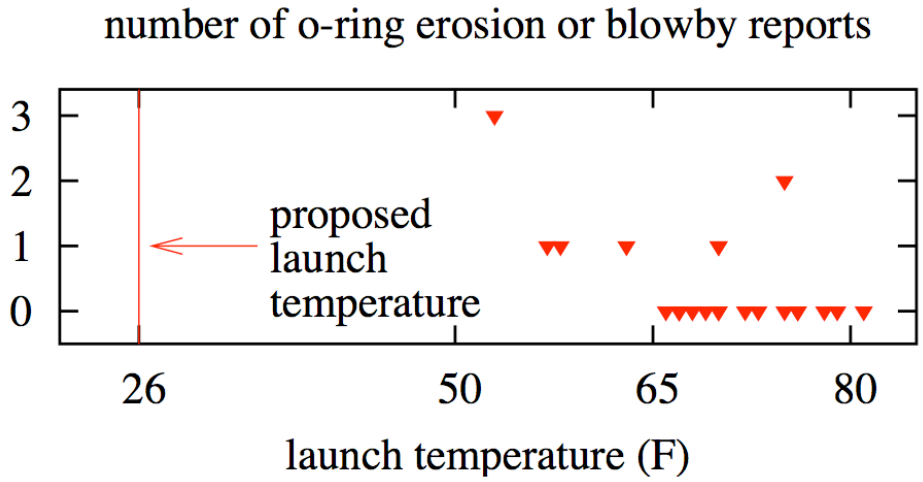
Linear time inference, Tiny memory footprint

- And, it works [Orrego, 2004]
  - F15 simulator data [courtesy B. Cukic]
  - Five flights: a,b,c,d,e
  - each with different off-nominal condition imposed at "time" 15
  - Off-nominal condition not present in prior data
  - In all cases, **massive change detected**

Relevance to NASA

- Recent examples of ignored anomalies
- Challenger launch decision



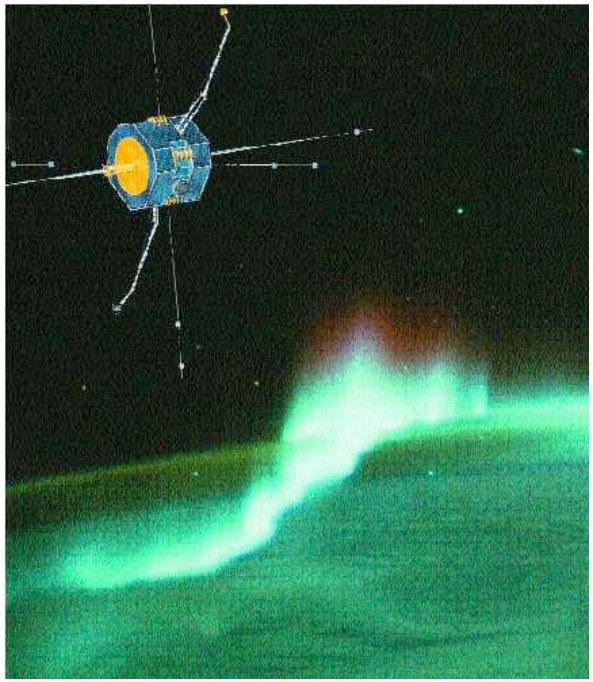


Relevance to NASA (2)

- More examples of ignored anomalies
- Columbia ice strike:
  - Size: 1200 in^3,
  - Speed: 477 mph (relative to vehicle)
- Certified as “safe” by the CRATER micro-meteorite model
  - A typical experiment in CRATER’s test database
    - Size: 3 in^3 piece of debris
    - Speed: under 150 mph.

Relevance to NASA (3)

- Fast-time vs slow-time monitoring + repair
- Fast time (milliseconds):
  - A generic IVHM, optimized for speed + memory.
  - On-board real-time advisor for ground control, crew
    - Explored elsewhere
- Slow time (days to months):
  - Monitoring software projects
  - E.g. IV&V's thin pipe of data to the project
    - Is anything going on in the project that they haven't told us yet?



Accomplishments

- Core algorithms
  - Much progress (good geek stuff)
- Fast-time:
  - ? Install into JSC's TRICK system
  - Distribute an intelligent advisor with that simulator
  - Explored elsewhere
- Slow-time:
  - To find anomalies in project data…
  - … we need to find project data.
  - This afternoon: We have good news and we have bad news
- Good news:
  - there exists at least 5 NASA data sources with strong quality indicators
- Bad news:
  - 4 / 5 are now inactive
  - Even those some of that data would be simple, cheap, t collect across the NASA enterprise
  - Q: why does NASA ignore valuable data sources about NASA software?
  - A: ?
- Good news:
  - 1 / 5 still active
  - Can build the anomaly detectors for NASA projects

Next Steps

- Two application areas:
  - Fast time: TRICK / JSC
  - Slow time:IV&V project monitoring
- To do
  - Hook algorithms into active data sources
  - Assess if we can detect anomalies
  - Assess if we can propose repairs