A Brainlike Sensing Monitoring Improvement Illustration

The following case study illustrates how Brainlike sensing technology can improve monitoring performance. The Figure 1 plot shows energy usage levels measured every 15 minutes over a three month period. The plot is one of over 40 measurements that were recorded concurrently at the same period. Figure 1 is typical of monitored activity data in that baseline values gradually change over time, as is plain to see.

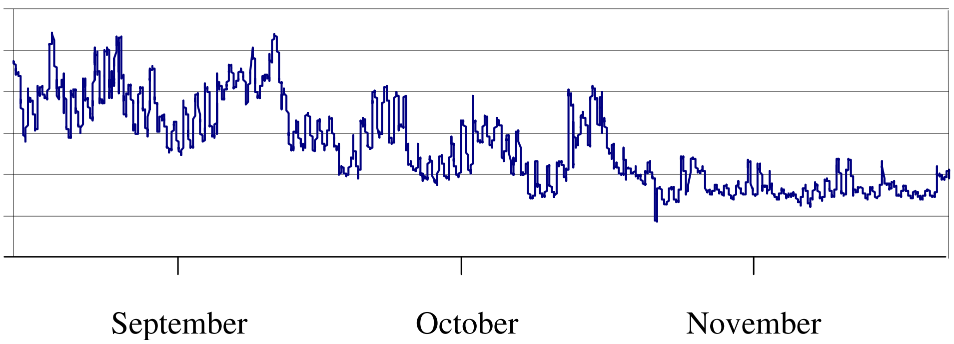

Figure 1. A Typical Plot of Monitored Activity over Time

> **<u>Market driven need</u>. A critical need is emerging in the monitoring marketplace for Brainlike sensing technology. In analogy to its biological counterpart, Brainlike sensing features the capacity to learn automatically, continuously, and quickly. Also in analogy, Brainlike sensing delivers benefits in the form of increased monitoring precision and automation.**

Data plots like that in Figure 1 demonstrate the need for adaptive monitoring. Without adaptive monitoring, alarm cutoff values must be fixed. If they're fixed at relatively insensitive levels such as the maximum and minimum values in Figure 1, then very few false alarms will occur. However, subtle problems that develop slowly or are indicated by only slight deviations from expected values will be missed most of the time. On the other hand, if alarm cutoff values are set to more sensitive levels, many false alarms will occur. Thus, the changing baselines in Figure 1 pose a basic, pervasive, and important monitoring and analysis problem.

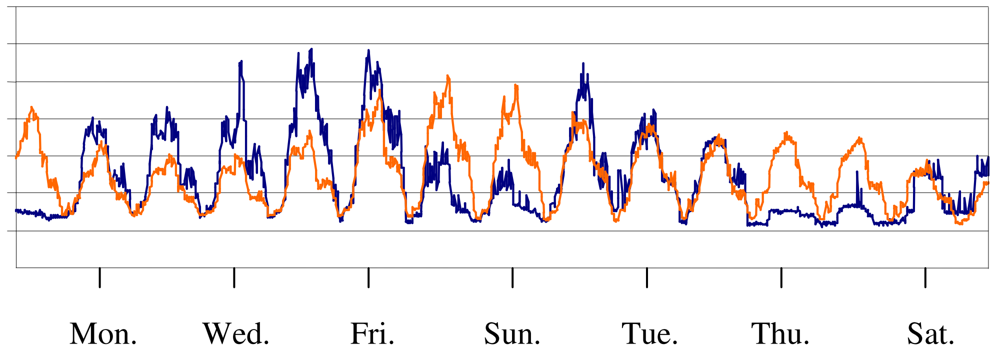

Figure 2. A Monitoring Baseline Resulting From Simple Concurrent Learning

Figure 2 shows how a simple form of concurrent learning can add monitoring value. The figure shows data, in blue, spanning only two weeks instead of the three-month span shown in Figure 1. The figure also shows a baseline for monitoring, shown in orange, which is obtained in the following way. For every 15-minute monitoring point at any given time, a baseline for comparison is computed as a function of the average among the values for the same time during the last few days. When expected values are computed in this way, actual values can be compared to them in order to determine unexpected events. As a result, alarm thresholds can be made more precise and a higher signal-to-noise ratio can be obtained than by using fixed thresholds.

Measurable added value. Case studies have repeatedly shown that Brainlike sensing yields over three times the sensitivity and early warning of the best available alternatives. As a result, added Brainlike sensing value is easy to measure in settings where false alarm costs and missed opportunity costs can be quantified. Further added value can be tied to reduced operating costs through Brainlike automation.

Figure 3 shows how "brain like" concurrent learning can add significantly more monitoring value. Along with the same actual data as in Figure 2 shown in blue, the figure shows in red a much more precise baseline for monitoring, which is obtained in the following way. For every 15-minute monitoring point at any given time, its baseline for comparison is computed as a prediction function, which is automatically computed and updated at every time point. These expected values are predictable in two different ways. First, each value is predictable from all the others because they are all correlated. Second, each of the current values are predictable from recently measured values because they are also auto-correlated. Because these measurements are so much more predictable, they add much more monitoring value as the following two figures show.

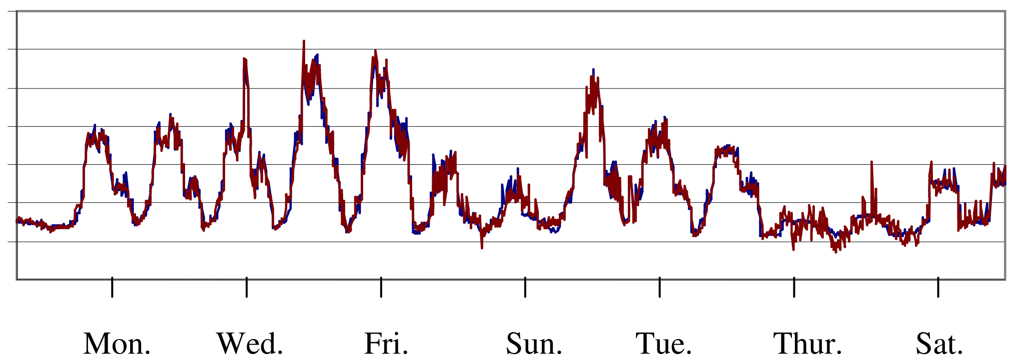

Figure 3. A Monitoring Baseline Resulting from "Brain Like" Concurrent Learning

Figure 4 shows tolerance bands in orange, based on the baselines that were created in Figure 1. The widths of these baselines were set in a way that produced an acceptably small number of false alarms for the entire three month period. Figure 4 also shows, in magenta, the way a typical costly incident might be expected to develop. For example, this development resembles the way that memory leaks might develop in faulty software applications running on a server, over a period of two hours or so. As Figure 4 shows, the tolerance bands for monitoring are not narrow enough to flag the developing problem before it turns into a costly incident.

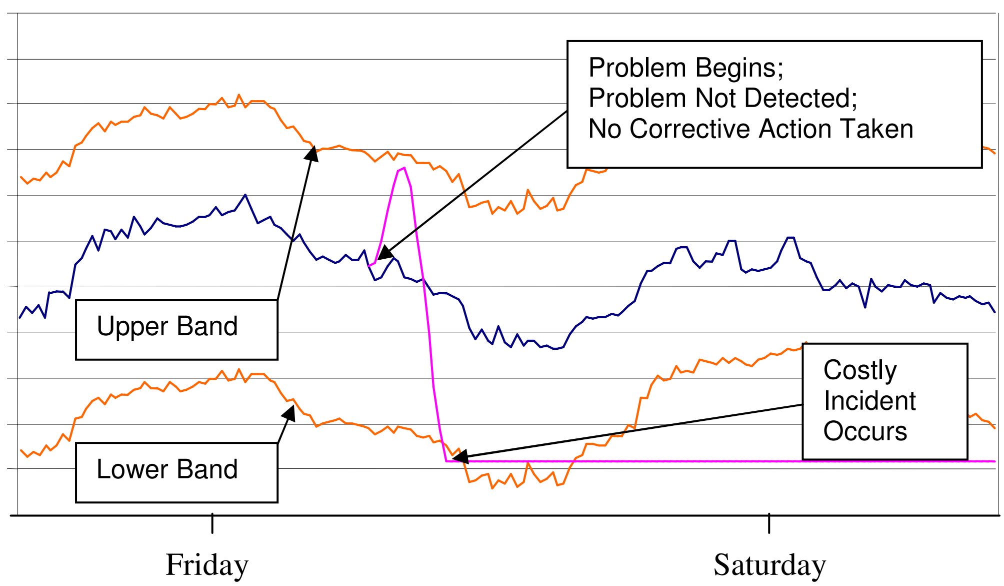

Figure 4. Incident Non-Detection During Simple Concurrent Learning

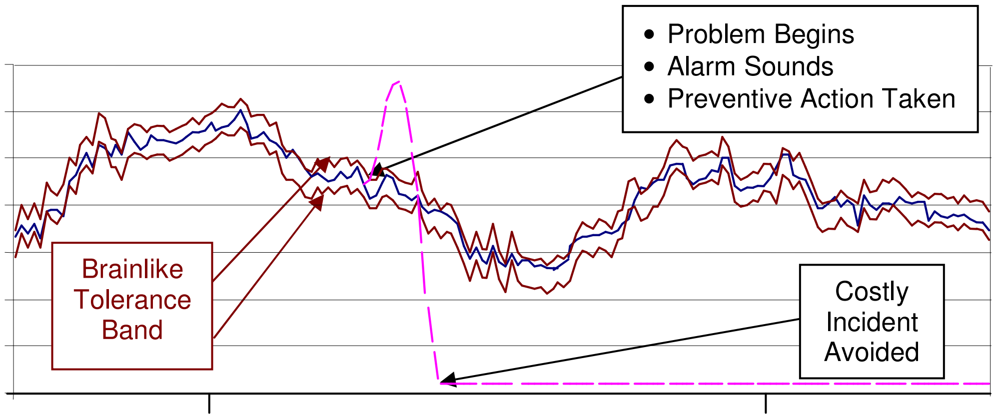

Figure 5. Incident Detection During "Brain Like" Learning

Figure 5 shows tolerance bands in red, based on the "brain like" baselines that were created in Figure 1. As in the Figure 4 case, the widths of these baselines were set in a way that produced an acceptably small number of false alarms for the entire three month period. Figure 5 also shows, in magenta, the same developing costly incident that was shown in Figure 4. In this case, however, the tolerance bands are sufficiently narrow to detect the costly incident.

This case study is one of many in which Brainlike sensing technology added value has been repeatedly demonstrated. While the cases study focuses on Brainlike sensing value at a decision-making level, Brainlike sensing value is underscored by a variety of related and recognized defense needs [1-19], its more broadly demonstrated added value [20-21], and its technological maturity [20-24].

<u>Technology features and benefits</u>. The distinctive feature of Brainlike technology is fully automated learning during information processing. Unlike artificial neural networks, statistical analysis, and rules-based analysis, this technology adapts automatically and continuously. It also doesn't require historical data. Brainlike technology is scalable, because it's fast, automatic, and compact; it's robust because it learns continuously; and it's precise because it learns each expected value as a function of all other current and recent values.

References

1. "The Brainlike Opportunity," Brainlike, Inc., Report #M-03-R-09-02.
2. D. Cochran, "A Less Complex Defense," *Darpa Magazine,* July 30, 2002.
3. E. Martinez, "Chips that can Think," *Darpa Magazine,* July 30, 2002.
4. L. Corey, "Advanced RF Sensors," *Darpa Magazine,* July 30, 2002.
5. B. Leheny, "It's a Small, Small World," *Darpa Magazine,* July 30, 2002.
6. D.W. Gage, "Making Robots Smarter," *Darpa Magazine,* July 30, 2002.

7. S.G. Wax, "Exploiting Nature through Materials and Design," *Darpa Magazine,* July 30, 2002.
8. R.P. Wishner, "Exploiting Information," *Darpa Magazine,* July 30, 2002.
9. J. Poindexter, "Information Please," *Darpa Magazine,* July 30, 2002..
10. J. Freebersyer, "Expanding the Outer limits," *Darpa Magazine,* July 30, 2002.
11. A.K. Ghosh, "House of Cards," *Darpa Magazine,* July 30, 2002.
12. T. Altshuler, "Heal Thyself," *Darpa Magazine,* July 30, 2002.
13. R. Brachman, "Cognitive Computing," *Darpa Magazine,* July 30, 2002.
14. J. Voorhees. "The Limits on Wireless Security: 802:11 in early 2002," SANS Institute (http://rr.sans.org/wireless/limits.php), January 30, 2002.
15. E. Amorso, Intrusion Detection: An Introduction to Internet Surveillance, Correlation, Trace Back, Traps, and Response." by Edward Amoroso Intrusion.Net Books, 1999.
16. A. Shkel. Micromachined gyroscopes: Challenges, design solutions, and opportunities. 2001 SPIE Annual International Symposium on Smart Structures and Materials, March, 2001.
17. R. Pool, "If It Ain't Broke, Fix It," *Technology Revie*w, September 2001.
18. "The Brainlike Niche," Brainlike, Inc., Report #M-04-R-09-02.
19. "Brainlike Homeland Security Relevance," Brainlike, Inc., Report #M-07-R-09-02.
20. "Brainlike Enabling Technology Basics," Brainlike, Inc., Report #T-05-R-09-02.
21. "A Brainlike Technology Seminar," Brainlike, Inc., Report #T-06-R-09-02.
22. R.J. Jannarone, *Concurrent Learning and Information Processing: A Neuro-computing System that Learns* during *Monitoring, Forecasting, and Control.* Chapman & Hall, New York, 1997.
23. R.J. Jannarone, *Concurrent Learning and Performance Information Processing System*, U.S. patent #5,835,902, 1998.
24. "Assessing Brainlike Partnering Suitability," Brainlike, Inc., Report #M-07-R-09-02.