An Adaptive Anomaly Detection Algorithm

Sylvia Halasz[1], Ph.D., Colin R. Goodall[1], Ph.D., Arnold Lent[1], Ph.D.,
John Allegra[2], M.D., Ph.D., Dennis Cochrane[2], M.D.

[1] AT&T Labs – Research.   [2] Emergency Medical Associates of New Jersey Research Foundation.

OBJECTIVE

Ideal anomaly detection algorithms should detect both sudden and gradual changes, while keeping the background false positive alert rate at a tolerable level. The algorithms should also be easy to use. Our objective was to develop an anomaly detection algorithm that adapts to the time series being analyzed and reduces false positive signals.

METHODS

We combined updated techniques from industrial quality control. We also account for day of week effects. The result is HWR, an exponentially weighted moving average (EWMA)-type adaptive algorithm with several parameters. The user has the option of setting these parameter values; however, satisfying the requirement of ease of use, the method works even if started with default parameter settings.

We tested the algorithm against the EARS Cusum methods C1, C2 and C3 and against Cusum 7, which alerts if one or more of C1 or C2 or C3 alert. The test data were time series of daily visits from two emergency departments (ED) for two syndromes: respiratory (RESP) and GI. We added in simulated outbreaks. We report here our results using outbreaks of four and six days durations. Maximum of the GI outbreaks is 9, for RESP it is 12 for ED1, 11 for ED2.

RESULTS

Comparison with C3 and Cusum 7 are shown on the graphs, where the red curve represents HWR, blue is C3, brown is Cusum 7. The table compares our results - with a given set of parameters - and C3 and Cusum 7 with the usual 2.0 cut-off for two EDs.
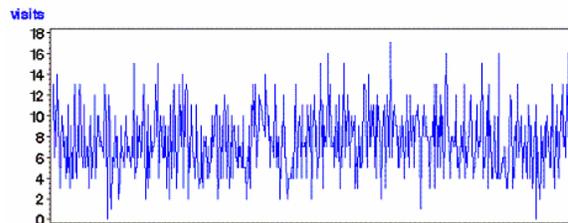

GI 4-DAY OUTBREAKS ROC COMPARISON (ED1)
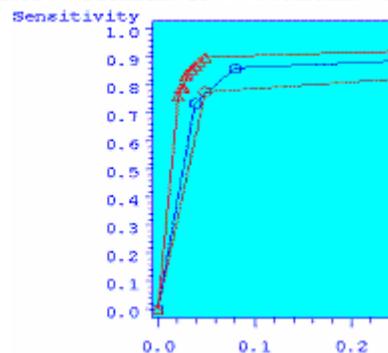
ORIGINAL RESP DAILY VISITS, ~19 MONTHS, ED1
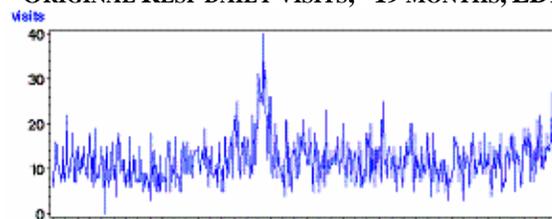
RESP 6-DAY OUTBREAKS ROC COMPARISON (ED1)
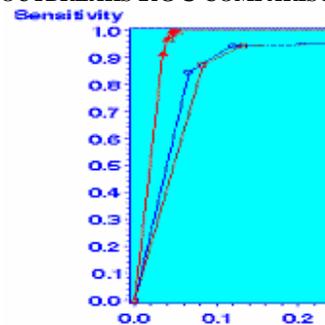
CONCLUSIONS

We have developed HWR, an EWMA-type algorithm with several parameters. With specificity at least that of C3 or Cusum 7, HWR has higher sensitivity, by up to 17%. Further research is needed to study the efficacy of this approach.

	E D	**HWR**		**C3**		**CUSUM 7**	
		SENSI-TIVITY	**SPECI-FICITY**	**SENSI-TIVITY**	**SPECI-FICITY**	**SENSI-TIVITY**	**SPECI-FICITY**
GI 4-DAY	1	90.1	95.1	73.6	96.1	77.8	95.1
	2	88.7	93.8	75.0	94.3	81.9	93.6
GI 6-DAY	1	95.8	95.2	91.7	96.3	93.0	95.3
	2	94.4	94.2	86.1	94.5	87.5	93.8
RESP 4-DAY	1	94.4	94.4	76.4	93.5	80.6	91.8
	2	94.4	93.4	76.4	94.9	80.6	93.8
RESP 6-DAY	1	100.0	94.6	84.7	93.4	87.5	91.7
	2	98.6	93.5	83.3	95.0	87.5	93.9

ORIGINAL GI DAILY VISITS, ~19 MONTHS, ED1