Correction And Impact Analysis

of "Optimal Maintenance Strategies for Wind Turbine Systems Under Stochastic Weather Conditions," Published in IEEE TRANSACTIONS ON RELIABILITY, VOL. 59, NO. 2, pp. 393-404, JUNE 2010.

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First of all, we, the authors, apologize for having made this mistake. In the above-referenced paper, "Proposition 4" is not correct. Let π_i^2 and $(\pi P)_i$ denote the ith position of the row vector $\pi^2 (= \pi'(\pi))$ and πP, respectively. Then, we claimed

$$\sum_{i \geq j} \pi_i^2 \;=\; \sum_{i \geq j} \frac{(\pi P)_i}{R(\pi)} \leq \sum_{i \geq j} \frac{(\pi P)_i}{R(\hat{\pi})} \leq \sum_{i \geq j} \frac{(\hat{\pi} P)_i}{R(\hat{\pi})} = \sum_{i \geq j} \hat{\pi}_i^2,$$

where the summation was made up to m. In this proposition, we wanted to prove that $\pi'(\pi) \prec_{st} \pi'(\hat{\pi})$, which requires $\sum_{i \geq j}^{m} \pi_i^2 \leq \sum_{i \geq j}^{m} \hat{\pi}_i^2$. This in turn requires that $\sum_{i \geq j}^{m} \frac{(\pi P)_i}{R(\hat{\pi})} \leq \sum_{i \geq j}^{m} \frac{(\hat{\pi} P)_i}{R(\hat{\pi})}$ in place of the second inequality above. Unfortunately, this inequality does not always hold. The inequality does hold if i sums until $m+1$ rather than m, namely that $\sum_{i \geq j}^{m+1} \frac{(\pi P)_i}{R(\hat{\pi})} \leq \sum_{i \geq j}^{m+1} \frac{(\hat{\pi} P)_i}{R(\hat{\pi})}$ is true. That is how we made the mistake.

As a correction, the authors will treat "Proposition 4" as an assumption, and is restated as follows: *Suppose that P is IFR. Then we assume that if $\pi \preceq_{st} \hat{\pi}$, then $\pi'(\pi) \preceq_{st} \pi'(\hat{\pi})$.*

This assumption implies that the stochastic ordering of two states is maintained in the next period; that is, for two states $\pi \prec_{st} \hat{\pi}$, the next state of $\hat{\pi}$ is more deteriorated than the next state of π in a probabilistic sense. This assumption holds in many gradually aging systems, and thus, the results in this paper are applicable to many practical aging systems.

Impact Analysis: We analyze the technical impact of this correction on the result. We also perform a downstream analysis to examine how the correction affects the result of other papers that cited our paper.

1) Technical impact: Proposition 4 was used to derive the closed-form expressions related to the optimal policy. Having the closed-form expressions makes the final algorithm (presented

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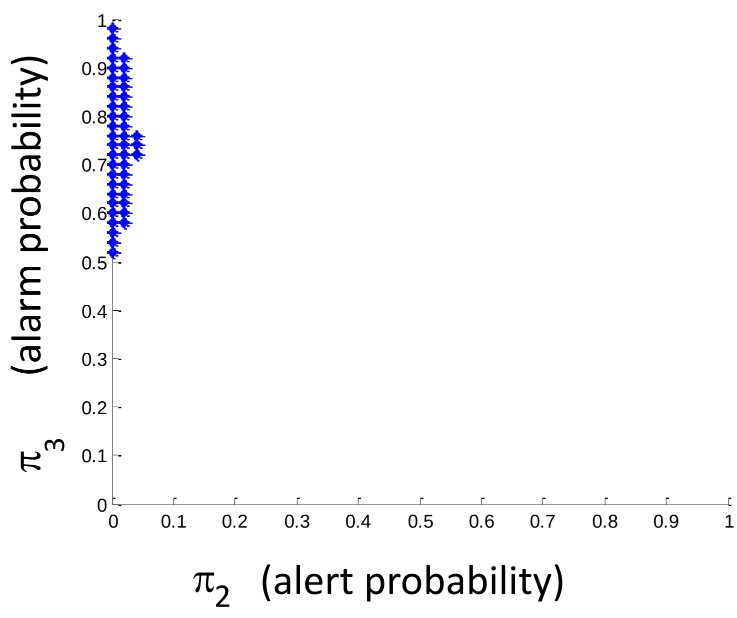
in Section V) more time efficient in finding the optimal policy. So the issue is what impact Proposition 4 (now assumption) has on this result if it does not hold. Noting that the state whose sample path is in $\prec_{st}$-increasing order satisfies the assumption, consider the following example. For the transition matrix used in the paper, the dots in the figure below are the states whose sample paths are not in $\prec_{st}$-increasing order, while the remaining states corresponding to the white space are in $\prec_{st}$-increasing order. Apparently, the dotted states are a very small portion of the whole state space. For these states, pure recursive techniques discussed in Section III.B should be applied in finding the optimal policy, and for the remaining state space, the algorithm in Section V can still be used to determine the optimal policy. As such, the loss in computational efficiency is small. Not only this, the authors also think that the dotted states are unlikely to be observed in applications. Note that in these states, the alarm probability π_3 is high, but the alert probability π_2 is low. Since $\pi_1 + \pi_2 + \pi_3 = 1$ and based on the reading of π_2 and π_3, one can tell that π_2, the alert state probability, is smaller than π_1, the normal state probability. This means that one has a system whose state could look like $[0.4, 0, 0.6, 0]$. Such a state, although theoretical possible, does not look practically reasonable.



2) Downstream analysis: According to the Google scholar citation index, there are about 127 papers (as of August 15, 2017) that cited our IEEE Transactions on Reliability 2010 paper (referred to as 2010TR paper). When going through the reference list one by one on the Google

scholar page, we only found a total of 123 references (not 127), but two of the sources are redundant (the same paper), so that there are 122 distinct sources that cited our paper. We examine all of the papers/sources and categorized them into the following four categories:

- (a): Refer our paper in a who-did-what fashion, or a general reference.
- (b): Cite or use the formulation, example, results without using Proposition 4.
- (c): Directly use Proposition 4.
- (d): Not available to us (not available online or through the library service at the authors' respective institutes. Or written in different languages other than English/Chinese/Korean)

Among the papers, 103 papers are in Category (a), 7 papers in Category (b), and 9 papers are in Category (d). The contribution and results of the 110 papers in Categories (a) and (b) are not affected by our correction. Three papers [1]–[3] belong to Category (c). Consequently, these three papers should also treat and state Proposition 4 as an assumption. One paper [3] is a conference paper of our own (co-authored by the first and third authors of the 2010TR paper), extending the formulation and structural results of this 2010TR paper. For the other two papers [1], [2], we contacted the corresponding author of the respective paper, apologized and informed them our mistake and correction.

There are no papers that cited [3]. Six papers cited [1] and five papers cited [2]. We further analyze all the papers that cited [1] and [2] and found that none of the additional references used the Proposition 4 result. We informed the authors of [1], [2] about this finding, too.

REFERENCES

[1] H. Fan, Z. Xu, and S. Chen, "Optimally maintaining a multi-state system with limited imperfect preventive repairs," International Journal of Systems Science, vol. 46, no. 10, pp. 1729–1740, 2015.

[2] M. Chen, H. Fan, C. Hu, and D. Zhou, "Maintaining partially observed systems with imperfect observation and resource constraint," IEEE Transactions on Reliability, vol. 63, no. 4, pp. 881–890, 2014.

[3] E. Byon and Y. Ding, "Integrating simulation and optimization for wind farm operations under stochastic conditions," in Proceedings of the IIE Annual Conference. Institute of Industrial and Systems Engineers (IISE), 2011.

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