

The Effect of Faulty Local Detectors on a Detection Network

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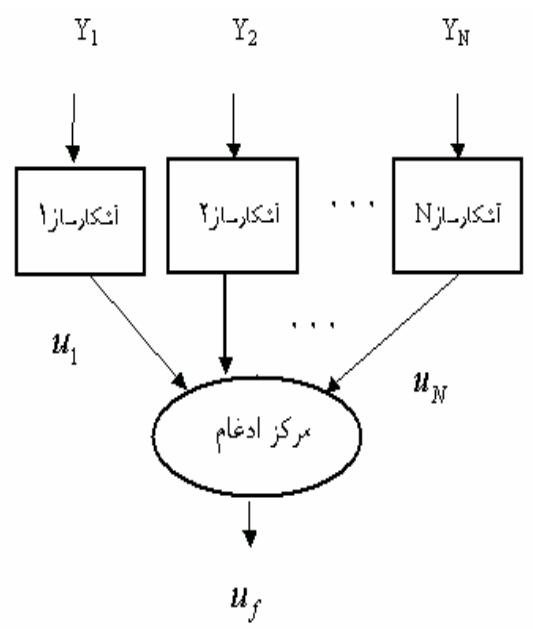
Abstract

Distributed detection theory has received increasing attention recently. Deployment of multiple sensors for signal detection results in improved detection performance and increased reliability. In a detection network, each local sensor decides locally whether a signal is detected or not. The local decisions are sent to the fusion center, where the final decision is made. In this paper, a theoretic approach is considered to data fusion when one of the sensors is faulty. If the fusion center does not have any knowledge of this fault, the performance of the system is different than its nominal performance. The changes in the error probabilities depend on the type of the fault and on the threshold value of the fusion center test. We derived some expressions for the changes in the values of error probabilities. For some type of faults, the system false alarm probability increases significantly, whereas for some other faults, the system detection probability decreases significantly. To illustrate the results, a numerical example is also given.

Key words: Detection networks, Fusion center, Fault, Performance.

$$\delta_f : D \rightarrow \{0,1\}$$

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(.)

(H_1)

(H_0)

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$$D_0 \quad D \quad \delta_f$$

$$U \in D_0 \quad u_f = 0 \quad D_1$$

$$P_d \quad P_f \quad U \in D_1 \quad u_f = 1$$

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$$p_d = p(u_f = 1 | H_1) = P(D_1 | H_1) \quad ()$$

$$p_f = p(u_f = 0 | H_0) = P(D_0 | H_0) \quad ()$$

N

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$$D \quad k$$

$$D_{11} \quad D_{01} \quad D_{10} \quad D_{00}$$

$$:$$

$$Y_i$$

$$u_i \quad i$$

$$u_i = 1$$

$$u_f \cdot u_i = 0$$

$$D_{ij} = \{U \in D_j; u_k = i\} \quad i, j = 0, 1 \quad ()$$

D

$$U = (u_1, u_2, \dots, u_N)$$

U

$$D_{01} \cup D_{11} = D_1, \quad D_{00} \cup D_{10} = D_0$$

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$$p_{d0} = p_d - p(D_{110}|H_0) \quad (1)$$

$$D_{ijm} = \{U \in D_{ij} : \text{if } u_k \neq i \text{ then } u_f = m\} \quad i, j, m = 0, 1 \quad (2)$$

$$p_{f1} = p(D_{001}|H_0) - p_f \quad (3)$$

$$p_{d1} = p(D_{001}|H_1) - p_d \quad (4)$$

$$P \quad (5)$$

$$P \quad 1 - P \quad (6)$$

$$P \quad (7)$$

$$P \quad (8)$$

$$p_{dp} = p_f + p(D_{001}|H_0) - P \times [p(D_{110}|H_0) + p(D_{001}|H_0)] \quad (9)$$

$$p_{dp} = p_d + p(D_{001}|H_1) - P \times [p(D_{110}|H_1) + p(D_{001}|H_1)] \quad (10)$$

$$p_f = p(D_{01}|H_0) + p(D_{11}|H_0) \quad (11)$$

$$p_d = p(D_{01}|H_1) + p(D_{11}|H_1) \quad (12)$$

$$p_{fp} = p_f + p(D_{01}|H_0) - P \times [p(D_{110}|H_0) + p(D_{001}|H_0)] \quad (13)$$

$$p_{dp} = p_d + p(D_{01}|H_1) - P \times [p(D_{110}|H_1) + p(D_{001}|H_1)] \quad (14)$$

$$p_{f0} = p(D_{01}|H_0) + p(D_{101}|H_0) + p(D_{111}|H_0) \quad (15)$$

$$= p(D_{01}|H_0) + p(D_{11}|H_0) - p(D_{110}|H_0) \quad (16)$$

$$= p_f - p(D_{110}|H_0) \quad (17)$$

$$p_{f0} = p(D_{01}|H_0) + p(D_{101}|H_0) + p(D_{111}|H_0) \quad (18)$$

$$= p(D_{01}|H_0) + p(D_{11}|H_0) - p(D_{110}|H_0) \quad (19)$$

$$= p_f - p(D_{110}|H_0) \quad (20)$$

$$\begin{aligned}
 H_1 & \quad \quad \quad N & \quad \quad \quad : & \quad \quad \quad P_{fps} \\
 & \quad \quad \quad [\] & \quad \quad \quad H_0 & \quad \quad \quad p_{fps} = (1-S)p_f + (S)p_f + (S)p(D_{001}|H_0) \\
 & \quad \quad \quad : & \quad \quad \quad (\) & \quad \quad \quad (\) & \quad \quad \quad - (SP)[p(D_{110}|H_0) + p(D_{001}|H_0)] \\
 p_f & = \sum_{i=n}^N \alpha^i (1-\alpha)^{N-i} & (\) & \quad \quad \quad = p_f - (SP)p(D_{110}|H_0) \\
 p_d & = \sum_{i=n}^N \beta^i (1-\beta)^{N-i} & (\) & \quad \quad \quad + S(1-P)p(D_{001}|H_0) & (\)
 \end{aligned}$$

$$\begin{aligned}
 & \quad \quad \quad : & \quad \quad \quad p_{dps} = p_d - (SP)p(D_{110}|H_1) + S(1-P)p(D_{001}|H_1) \\
 & \quad \quad \quad k & \quad \quad \quad (\) \\
 & \quad \quad \quad : & \quad \quad \quad u_k = 0
 \end{aligned}$$

$$\begin{aligned}
 p(D_{110} | H_0) & = & \quad \quad \quad n & \quad \quad \quad u_k = 1 | H_0 & \quad \quad \quad D_{001} & \quad \quad \quad D_{110} \\
 & \quad \quad \quad p & \quad \quad \quad (\) & \quad \quad \quad (\) \\
 p_{f0} - p_f & = - \binom{N-1}{n-1} \alpha^n (1-\alpha)^{N-n} & (\)
 \end{aligned}$$

$$\begin{aligned}
 p_{f1} - p_f & = \binom{N-1}{n-1} \alpha^{n-1} (1-\alpha)^{N-n+1} & (\) & \quad \quad \quad \beta_i & \quad \quad \quad \alpha_i \\
 & \quad \quad \quad : & \quad \quad \quad i & \quad \quad \quad \alpha_i = \alpha, \beta_i = \beta \quad i = 1, \dots, N
 \end{aligned}$$

$$\begin{aligned}
 & \quad \quad \quad 1-P & \quad \quad \quad P & \quad \quad \quad [\] \\
 & \quad \quad \quad : & \quad \quad \quad (\) & \quad \quad \quad (\) & \quad \quad \quad u_f = \begin{cases} 1 & \text{if } i \geq n \\ 0 & \text{if } i < n \end{cases} & \quad \quad \quad (\) \\
 p_{fp} - p_f & = (1-P) \binom{N-1}{n-1} \alpha^{n-1} (1-\alpha)^{N-n+1} & \quad \quad \quad i & \quad \quad \quad \\
 & \quad \quad \quad - P \binom{N-1}{n-1} \alpha^n (1-\alpha)^{N-n} & \quad \quad \quad n & \quad \quad \quad .1 \leq n \leq N \\
 & \quad \quad \quad & \quad \quad \quad \frac{N}{2}
 \end{aligned}$$

$$H_0 \sim N(0,1)$$

$$H_1 \sim N(3,1)$$

$$= \binom{N-1}{n-1} \alpha^{n-1} (1-\alpha)^{N-n} (1-P-\alpha)$$

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 ()
 $p=0 \quad s=1$
 () ()
 $p=1 \quad s=1$

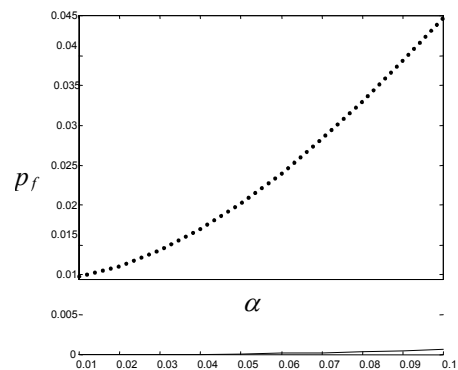
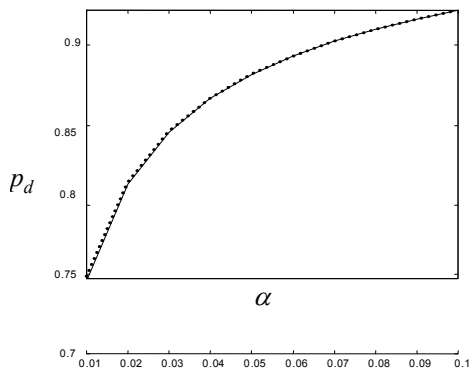
()
 S
 p
 $1-p$
 $p_{fps} - p_f = \binom{N-1}{n-1} \alpha^{n-1} (1-\alpha)^{N-n} S(1-P-\alpha)$
 ()
 $p_{dps} - p_d = \binom{N-1}{n-1} \beta^{n-1} (1-\beta)^{N-n} S(P+\beta-1)$
 ()
 $p=0.5 \quad s=1$
 $p=0.5 \quad s=0.5$

(α)

($n=3$)

α

β

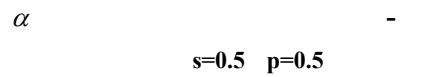
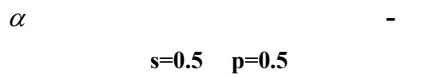
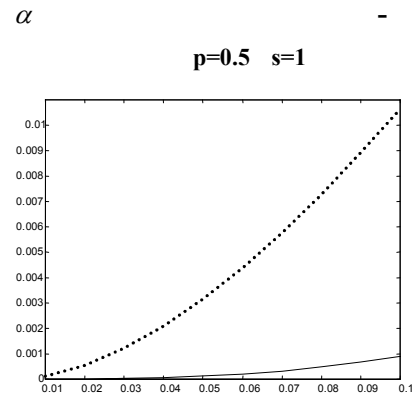
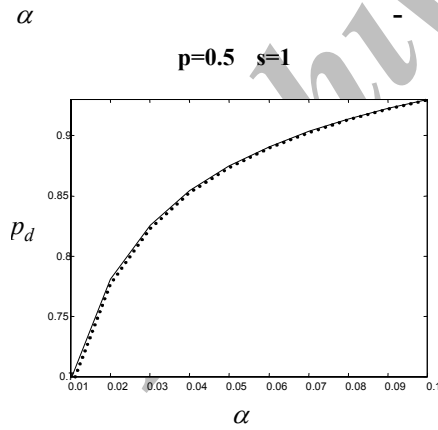
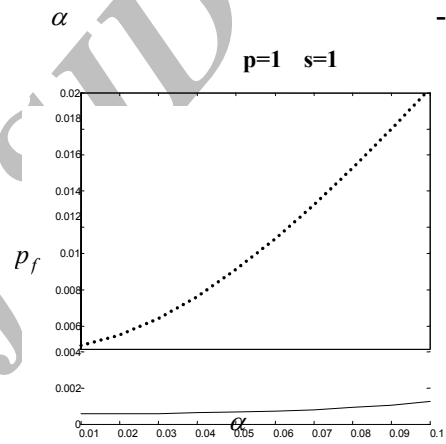
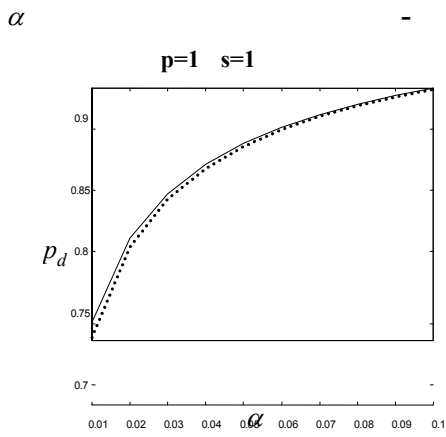
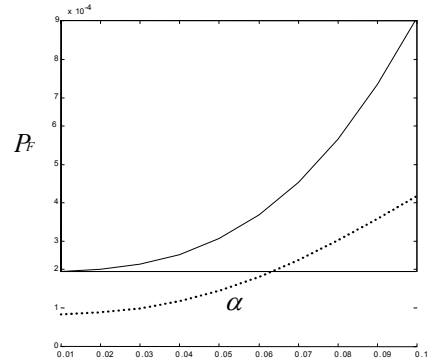
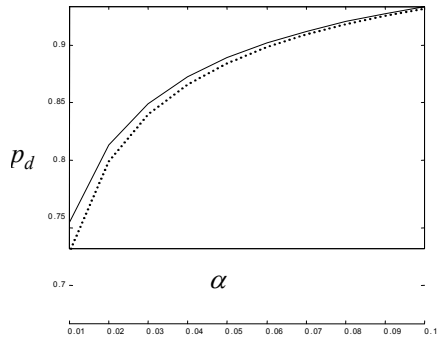


α

$p=0 \quad s=1$

α

$p=0 \quad s=1$



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