Study on the Optimization of Selection from Primary-standby Digital Tracking Receivers

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Abstract. The selection of the primary-standby DTR (digital tracking receivers), usually depends on the indicators of the system. But this cannot avoid instability of the whole tracking system in satellite communication. For this, new method of quantitative analysis is used in this paper. By using the principle of optimization and variance, the optimal state of evaluation is determined. Actual data proved that the new optimized methods provide accurate evidence for primary-standby digital tracking receivers.

Introduction

DTRs are usually work in a primary-standby mode. When both under normal operating conditions, the ACU (antenna control unit) will receive oscillator locked signal of DTRs, and DTRs' lock signals, which used as a judgment to select a primary one and a standby one from the two DTRs. In practical use, such signals for judgments are usually locked, but the whole tracking link still appears unstable. The reason is that the ACU only judge for the basic qualitative aspects of DTRs, without deep quantitative indicators, such as the stability of AGC (Automatic Gain Control) level and SNR (Signal to Noise Ratio) level, which indicate the status and response capacity to the existing beacon signal quality of DTRs.

Through the research, it can be concluded that the selection of performance measures and the determination of index weights (usually depends on the model of sorting) are the focus of scholars at present. Based on lots of research and use for reference, this paper uses time series [1, 2, 3], linear programming, the principle of variance of probability and statistics [4], to construct an evaluation model of DTR based on optimal variance. As to prove the model, two DTRs are used as samples for analysis.

Optimal Selection Model Based on Variance

Optimization theory is mainly used for optimal solutions of a class of problems in mathematics. It provides an effective method for determining the index weight value. In General, analysis on optimal combination determining weights method is in group decision model, which with k evaluation objectives, m evaluation indicators, and n decision-making factors in, to give the results of weight values for a final coordinated in the single model [5-6].

Because the type of DTRs is the same, comparison of two DTRs about AGC and SNR indicators should have some similarities. And the output and input signals are linear in some measures [7]. Therefore, the optimal combination determining weights method can be used to identify optimal weighting coefficient values of AGC and SNR of the DTRs. Then, using this value weighting coefficient based on variance, a DTR in best condition could be determined.

Set the equations of state for each receiver as:

$$u(n) = \lambda * a(n) + \varphi * s(n) \quad (n = 1, 2, 3, \ldots, m) \tag{1}$$

Among them, a(n) stands for level trend over time about AGC of a DTR, s(n) stands for value trends over time about SNR of a DTR, λ, φ is a coefficient in combination, n is the sample of time

series. In order to facilitate the processing, it can set $\lambda, \varphi \geq 0$ and $\lambda + \varphi = 1$ to satisfies the normalization constraint condition. At this point, the key to determine the optimal state of DTRs changes to how to determine the coefficients value of λ and φ. According to probability theory, mathematical expectation of available DTRs (average) as formula (2).

$$\bar{u} = \frac{1}{m} \sum_{k=1}^{m} u(k) = \frac{1}{m} \sum_{k=1}^{m} [\lambda * a(k) + \varphi * s(k)]$$
(2)

Generally speaking, the larger expectation values of the DTR, the better, within the scope of characteristics. And the more beneficial for systems that require stability. Further to calculate the variance of formula (1) as follows:

$$D = \frac{1}{m} \sum_{k=1}^{m} [u(k) - \bar{u}]^2 = \frac{1}{m} (\sum_{k=1}^{m} u^2(k) - \sum_{k=1}^{m} \bar{u}^2) = \frac{1}{m} \sum_{k=1}^{m} u^2(k) - \bar{u}^2)$$

$$= \frac{1}{m} \sum_{k=1}^{m} [\lambda * a(k) + \varphi * s(k)]^2 - \left\{ \frac{1}{m} \sum_{k=1}^{m} [\lambda * a(k) + \varphi * s(k)] \right\}^2$$
(3)

Variance D is a measure of deviation between the observed value with expected value (mean)[8]. The smaller variance is, the better status of a DTR. In order to reflect the actual working situation of a DTR more objectively, variance D should be as small as possible. Also it needs to meet the constraints of $\lambda + \varphi = 1$ and $\lambda, \varphi \geq 0$. To get the minimum variance D, that is equivalent to solving the following optimization problem:

$$\min D = \min \left\{ \frac{1}{m} \sum_{k=1}^{m} [\lambda * a(k) + \varphi * s(k)]^2 - \left(\frac{1}{m} \sum_{k=1}^{m} [\lambda * a(k) + \varphi * s(k)] \right)^2 \right\}$$

$$\text{s.t. } \lambda + \varphi = 1, \lambda \geq 0, \varphi \geq 0$$
(4)

Formula (4) listed in the optimization model can be solved by programming. It is assumed that the optimal solution is obtained as the λ^*, φ^*, the optimal equation of state for DTR as:

$$u^*(n) = \lambda^* * a(n) + \varphi^* * s(n) \quad (n=1, 2, 3, \ldots, m)$$
(5)

Example Analysis

In order to verify the optimization model for DTRs proposed in this paper, monitoring values of working parameters of DTRs are chose from a system. On the basis, both advantages and disadvantages were given by comparing the variance through calculation.

Parameters selection of the DTR. Usually, AGC in a DTR is automatically adapt to the range of received signal. It forms a stable range of output signal by internal gain of control method, to adapted signal demodulation in the follow up circuits [9]. This signal is a key demodulation part in the front-end of a DTR. And it's easy to reflect the quality of a DTR by numerical monitoring.

Another indicator of the quality is the SNR. This indicator determines the capability of a DTR about tracking beacon signal and identification [10]. It is a key specification to contact satellite specifications and performance parameters. It can reflect the whole communication performances of the tracking link.

Accordingly, two technical indicators of two DTRs' (A and B) were recorded, in accordance with the chronological order and monitoring data. As shown in Table 1.

Table 1 Technical monitoring data of DTRA-B

V_{A_AGC}	S_{A_SNR}	V_{B_AGC}	S_{B_SNR}
3.3	80.4	3.5	76.3
3.3	80.4	3.5	77.2
3.3	80.3	3.4	77.0
3.3	80.2	3.5	78.3
3.3	80.1	3.3	78.3
3.3	80.1	3.4	78.5
3.3	80.0	3.4	78.5
3.4	80.1	3.3	78.5
3.3	80.1	3.2	79.1
3.3	80.2	3.1	79.1
3.3	80.3	3.3	81.3
3.3	80.3	3.1	81.7
3.3	80.4	3.1	81.9
3.3	80.6	3.1	81.3
3.3	80.6	3.2	81.5

Data Processing. Table 1 shows that the AGC of two DTRs' range within 3.1~3.5V, and the variation range of SNR within 76.3~81.9dB. Both range are inconsistent, so it needs linear even up data with each other. The calculation goes on based on the optimal of variance.

A search function is written in Matlab, the AGC, SNR value even up is entered, and the coefficients λ^*, φ^* were got after performing the treatment ,which meet the requirements of normalization. Also the two minimum variance values of the parameter were calculated. All results are shown in Table 2.

Table 2 Optimal coefficient of variance of DTR A-B

λ_A^*	φ_A^*	D_{A_min}	λ_B^*	φ_B^*	D_{B_min}
0.13	0.87	0.02	0.32	0.68	0.56

Accordingly, the parameter values change with influence of different combinations coefficient of variance were drew as shown in Fig. 1 and Fig. 2.
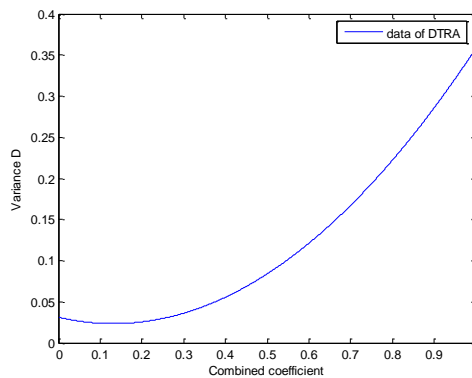

Figure 1. Chart of combinatorial coefficient under the influence of variance-DTRA
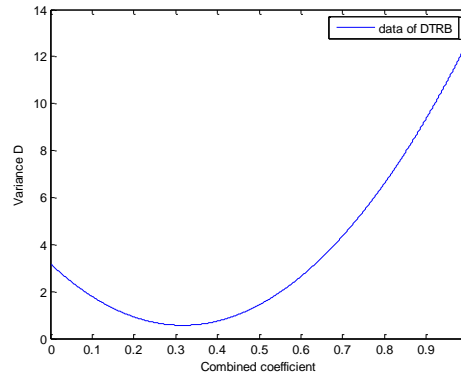
Figure 2. Chart of combinatorial coefficient under the influence of variance-DTRB

Analysis of Results. Through calculation of the optimal combination weights model, two minimum values were got as 0.02-0.56. Logically judgment can be got as 0.02<0.56. It can be drawn that DTRA is better than DTRB, and DTRA should be selected as the primary one in the ACU. From two charts of combinatorial coefficient under the influence of variance, it can be seen that, there is a certain degree of similarity within two DTRs, and obviously the results obtained through search algorithm are the best.

Although there are some limitations in the indicators used in the model as a whole system and establishment of the optimal combination of coefficients, also limited to the amount of data relationships, it should be further improved to make the whole judging process. The result of this judgment, to reflect the state of primary and standby DTRs, is consistent with its operational characteristics, so is effective in judgment. Therefore, the evaluation results for the Satellite communication are effective for the primary-standby switch in ACU.

Conclusions

This paper coordinates multiple parameters based on quantitative evaluation to optimum decisions for DTRs'. The model of optimum combination coefficients of variance based on of model for optimizing digital tracking the main work, taking into account both the qualitative indices and ones of the DTRs'. So that the evaluation value is much closer to the real state of DTRs'. In some circumstance, the model is also applies for the optimization problem of other similar primary-standby equipments. It's impossible to finish an assessment for equipment within qualitative indices only. So the state equation of equipments should be studied, to mine the parameter of working state on its principle. Then models with different parameters of equipment should be built to optimize the parameters of coefficient for combination. This will help to improve the whole reliability of equipments' state.

This paper only studied a model with two combination coefficients. It's a problem to establish appropriate models for different equipments with more operating parameters. By optimizing the method to determine the parameters of distribution coefficient, further study should be taken to enhance the optimal strategy.

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