Optimum Array Configuration to Improve the Null Steering Performance for CRPA Systems

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***Abstract* - This paper proposes the optimum array configuration that improves the null steering performance for controlled reception pattern antenna (CRPA) systems. The proposed array is composed of a center reference element and six auxiliary elements, and its array pattern is adaptively steered to mitigate the interference effect in conjunction with a constraint least-mean-square (LMS) algorithm. Then, the null steering performance of the proposed array is compared to that of a uniform circular array (UCA) having the same number of elements and the same aperture size, and the results demonstrate that the proposed array is suitable to be used for CRPA systems.**

***Index Terms* —GPS array, CRPA array, adaptive array, interference mitigation.**

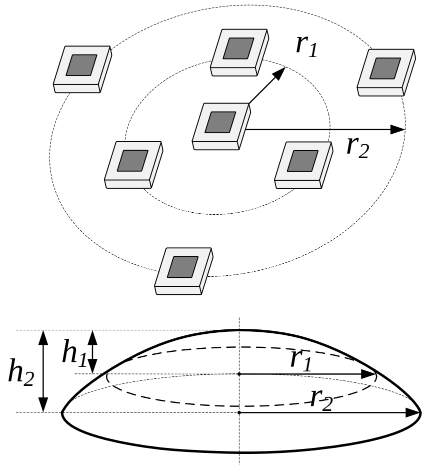
I. INTRODUCTION

A global positioning system (GPS) has been applying a controlled reception pattern antenna (CRPA) array to improve the navigation accuracy by mitigating the interference effect. The interference effect can be suppressed by an adaptive null steering operation that adjusts the direction of array pattern nulls toward interference sources in conjunction with a space-time adaptive processing (STAP) algorithm. For this operation, a uniform circular array (UCA) has been widely used because of its wide beam scanning coverage in both azimuth and elevation; however, its planar arrangement often claims low signal-to-interference-plus-noise ratio (SINR) [1] at low elevation. Although much effort has been made to achieve higher SINR values by developing optimum STAP algorithms [2] and improving radiation characteristics of individual array elements [3], there has not been an in-depth analysis of an optimum array configuration to improve the null steering performance.

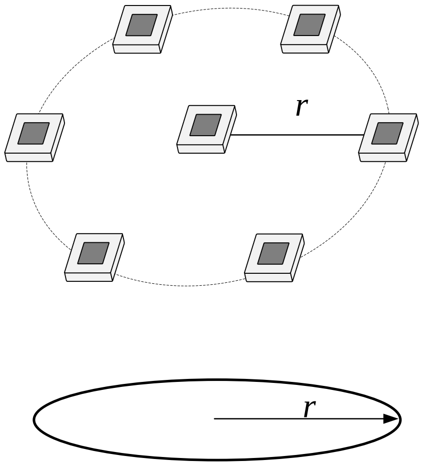
In this paper, we propose the optimum array configuration to improve the null steering performance for CRPA systems. In our approach, array patterns are calculated by using a microstrip patch antenna, proposed in [4], in conjunction with a constrained least mean square (LMS) algorithm, presented in [5]. The proposed array is composed of a single reference element with six auxiliary elements whose curvature and radius are optimized to improve the null steering performance in conjunction with a genetic algorithm (GA). Then, the proposed array is evaluated by comparing its null steering performance with a six-element UCA with a center reference element. The results demonstrate that proposed array improves the null steering performance by forming deeper and sharper nulls even for low-elevation interference sources.

II. PROPOSED ARRAY CONFIGURATION

Fig. 1(a) shows the proposed array configuration that consists of a single reference element at the center and six auxiliary elements arranged in two circular sub-arrays. These two sub-arrays are determined by the radii of r_1 and r_2 and the heights of h_1 and h_2, whose values are optimized by a genetic algorithm. In the GA process, the null steering performance



(a) Proposed array configuration

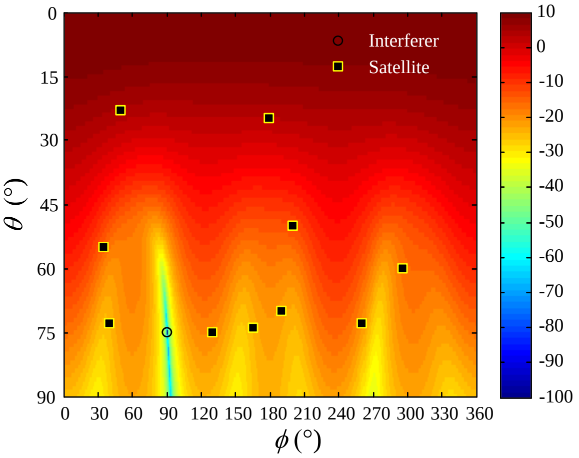


(b) UCA with a center reference element
Fig. 1. Proposed array configuration.

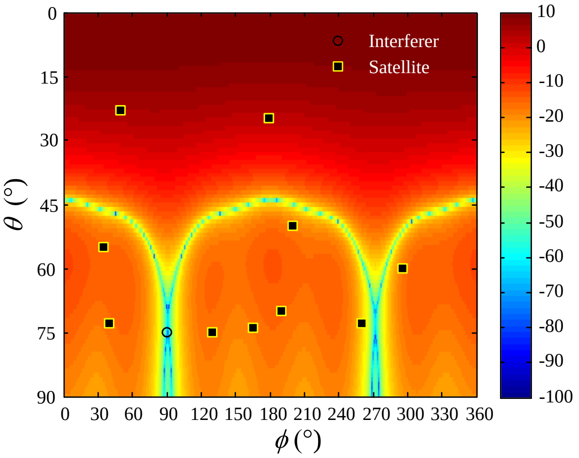
is evaluated by null depth and width of array patterns that are updated by the constraint LMS algorithm. It is assumed that the average power of incoming GPS L1 signals from ten satellites is about −130 dBm, and the noise floor of the system is −104.5 dBm. It is also assumed that an interference signal has a frequency range from 1.45 to 1.65 GHz with its peak power of −50 dBm at the array aperture. The optimized values for r_1 and r_2 are 45.2 mm and 115.2 mm, and those for h_1 and h_2 are 4.0 mm and 26.9 mm, respectively. The suitability of the proposed array is then evaluated by comparing its null steering performance with the six-element UCA shown in Fig. 1(b).

III. NULL STEERING PERFORMANCE

Fig. 2 shows a comparison of null steering patterns when an interference source is located at ϕ = 150° and θ_{EL} = 15°. As can be seen in the figures, the proposed array steered a deep and sharp null at the interference direction; however, the UCA configuration formed a wide and continuous null at around θ = 60°. This improvement can also be found in Fig. 3 that shows ϕ-scan patterns at θ_{EL} = 15°. The pattern null width of the proposed configuration is improved from 34.2° to 14.8°, and the pattern null depth is improved by 1.3 dB compared to the UCA configuration, which results in the improved average null depth of 1.1 dB for the interference sources located at ϕ = 0°, 30°,…, and 330°.



(a) Proposed array configuration



(b) UCA with a center reference element

Fig.2. Null depth variation according to LMS nulling iterations.

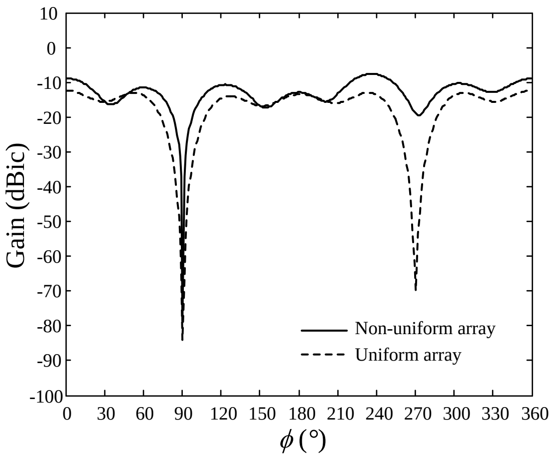


Fig.3. Null depth variation according to LMS nulling iterations.

IV. CONCLUSION

We have investigated the optimum array configuration that improves the null steering performance for CRPA systems. The proposed array is composed of a center reference element and six auxiliary elements, and its array pattern was adaptively steered to mitigate the interference effect in conjunction with the constraint LMS algorithm. The results demonstrated that the pattern null depth and width of the proposed array were improved by 1.1 dB and 19.4°, respectively, for low-elevation interference sources.

ACKNOWLEDGMENT

This research was supported by the MSIP (Ministry of Science, ICT&Future Planning), Korea, under the ITRC (Information Technology Research Center) support program (NIPA-2014-H0301-14-1005) supervised by the NIPA (National IT Industry Promotion Agency).

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