An Optimal Design of Array Configuration of KARST for SKA

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Abstract KARST, Chinese version of the SKA, consists of about 30 individual FAST type elements, each roughly 200 m in diameter, in the karst region of Guizhou province. One method which can pick 30 sites from hundreds of candidates to get the best uv coverage is briefly described here.

1 Introduction

The SKA, the Square Kilometer Array, as a major next generation radio telescope has an effective collecting area of 1 square kilometers dividing into number of elements (Peter 2000). The array configuration is closely related to the uv coverage quality of the future SKA. For two dimensional arrays, there is no corresponding exact solution, and it is quite complex and difficult even to specify an optimization criterion (Bunton 1999). Thus, a careful consideration takes on a particular importance. Currently, numerous groups in different countries are involved into this simulating investigation, which includes the number of stations, the layout at various scales, and geographic and cost constraints. Various sample configurations have been put forward and analyzed, for example, asymmetric array, several armed spiral forms for SKA (Bunton 2000), a doughnut shape and maximally filled array for Allen Telescope Array (ATA) (Bock 2000) etc.. L. Kogan proposed one method to minimize side lobes in a region around the primary beam by the specific array element shift, which, however has some restrictions in general use (Kogan 1997).

The FAST, Five hundred meters Aperture Spherical radio Telescope, is a Chinese effort to the international cooperation as a pilot of the SKA (Nan & Peng 2000). A number of likely karst depressions in south of Guizhou province have been found and studied (Nan et al. 1995). Fig.1 shows 288 suitable telescope locations in Pingtang county. Among the statistical data, 30 best sites should be chosen as a synthesis array. One possible layout has been investigated that the sites were obtained randomly in terms of some rules without optimization (Tian et al. 1995).

2 The Approach to the Problem

2.1 Basic method

Basically, the routine of using minimum redundancy is to abandon redundant antennas in terms of the uv coverage quality. As we know, among uv points of instantaneous snapshot observations, the uv points which are close to other points could be dropped without losing much information.

We could select the locations according to their contribution to the uniformity of uv coverage. Suppose there are N elements in the array, then for the element m, the minimum distance between its every relevant uv point and other uv points could be calculated. Thus, the sum of $(N-1)$ minimum distance of every relevant uv point of one site could be determined by the following equation

$$TotalMinDis(m) = \sum_{n=1}^{N-1} MinDis(m,n)\,. \tag{1}$$

Comparing the value of $TotalMinDis(m)$ of all elements, we can obtain the smallest one which means it has less contribution and could be abandoned. Thus, $(N-1)$ elements have been left, return back to the beginning, calculate and compare again, get rid of others till the number of the rest is what we want.

2.2 Weighted coverage scale method

The basic method described above is to make the uv coverage as uniform as possible. It does not work in any cases due to different scientific requirements. Thus the basic criterion can be modified by multiplying different weight functions for other uses. For example, to get more information of an extended source, it is necessary to make the center of uv tracks more condensed. At this point, $MinDis(m,n)$ of each element can be adjusted as the following equation

$$MinDis(m,n)_f = MinDis(m,n) \times \exp(-\frac{r^2}{D^2}) \tag{2}$$

where $exp(-\frac{r^2}{D^2})$ is a Gauss taper function, r is the distance between one uv point and the origin in the uv image, and D is a constant which could be set according to different requirements.

3 Results

We wrote several tasks in Octave which provide the optimization of minimum distance for the given number of elements. Fig.1 shows the element selection by the basic method. The instantaneous snapshot observations of all candidate locations and 30 selected sites to a source with longitude 60 degree and latitude 60 degree at 18 cm wavelength are demonstrated in Fig.2 and Fig.3 respectively. Apparently, the uv coverage of 30 sites basically cover all the informaion of the source with the most uniformity.

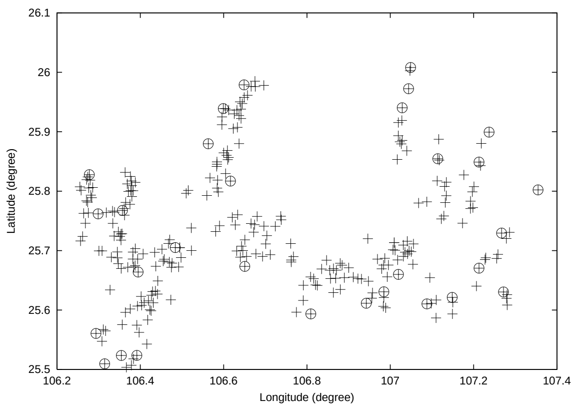

Fig. 1 The sites distribution (cross: 288 candidates locations; circle: 30 picked sites)

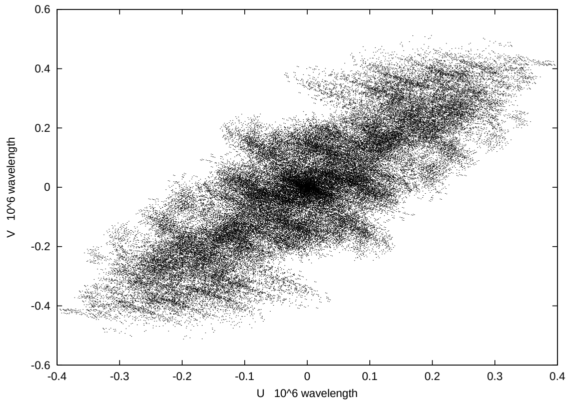

Fig. 2 An instantaneous snapshot observation by 288 candidates

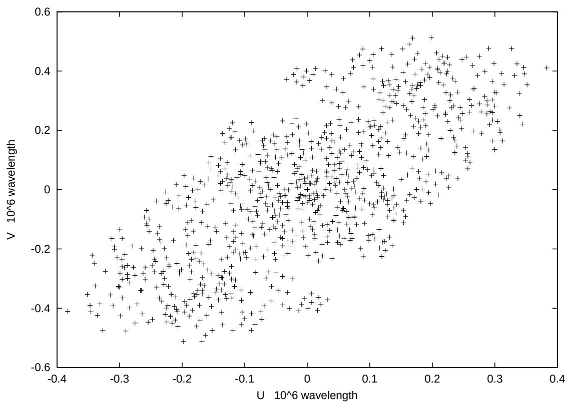

Fig. 3 An Instantaneous Snapshot Observation by 30 Selected Telescope Sites

4 Remarks

We provide one more choice for designing 2-dimensional arrays. It produces uniform uv coverage. The advantage to this idea is that the site selection criterion is not constant, and could be changed by taper function to fulfill different scientific objectives.

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