Tesela

A new Virtual Observatory tool to determine blank fields

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The need of observing blank fields

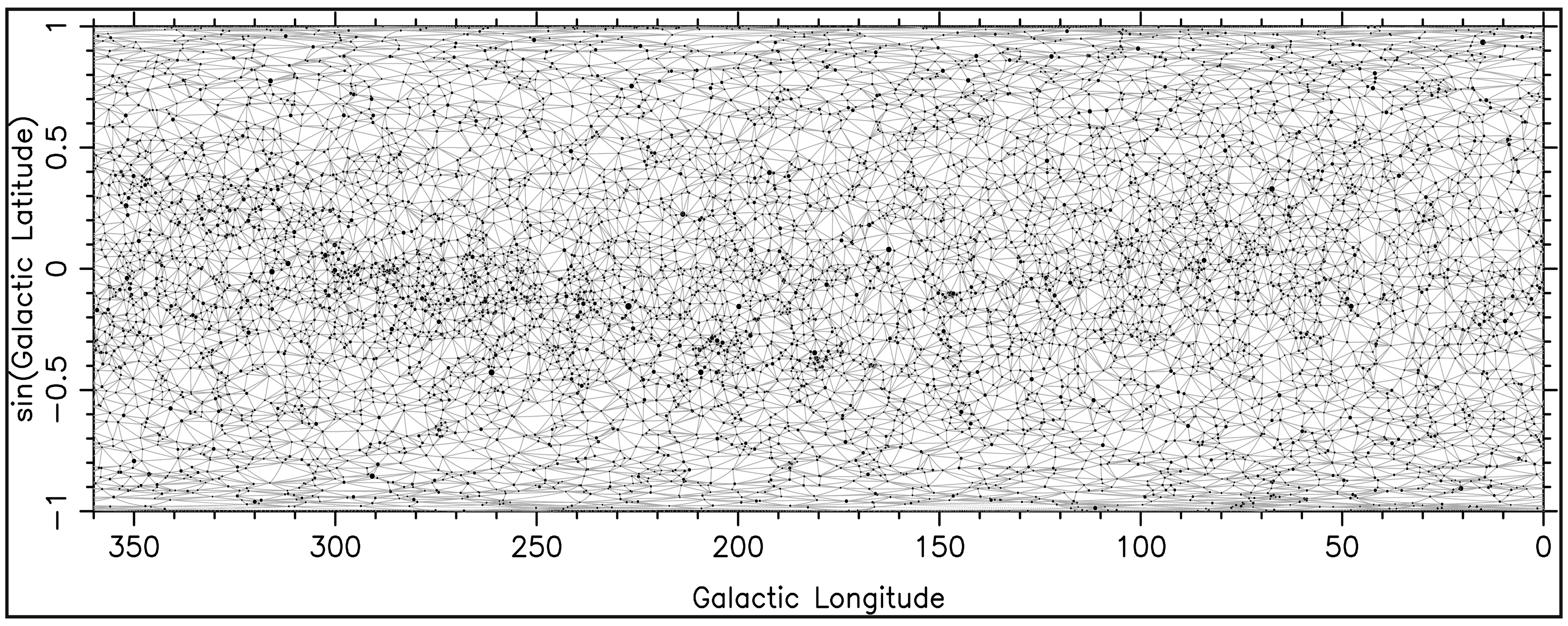
Many times astronomical observations demands the pointing of a telescope to **blank fields**, sky regions devoid of bright objects, in particular bright stars down to a given magnitude. This is particularly true when one tries to obtain calibration frames for flatfielding, or when the sky subtraction requires the observation of auxiliary images nearby the science targets because the objects are extended.

With the advent of instruments with increasing field of view, the problem of avoiding bright objects in the images is getting more difficult. The situation is also starting to be important in spectroscopic observations, since integral field units with high multiplexing capabilities (and thus, increasingly larger field of view) are expected to be the most common instrumentation in ground-based observatories.

This work describes a method that helps to determine the availability of blank fields in any region of the celestial sphere. The method is based on the use of the Delaunay triangulation, and generates blank field catalogues to varying limiting magnitudes. In order to facilitate the use of these catalogues, we have created TESELA, a new Virtual Observatory tool accessible through the WEB, which provides a simple interface that allows the user to retrieve the list of blank fields available near a given location in the celestial sphere. Interested readers can find a full description of this work in Cardiel et al. (2011, MNRAS, in press).

Using the Delaunay Triangulation to tessellate the sky

In this work we have applied the Delaunay triangulation to the Tycho-2 stellar catalogue. Tycho-2 contains astrometric and photometric information for the 2.5 million brightest stars in the sky, and it is complete up to magnitude V=11.5 mag. Photometric data consists in two pass-bands (B_T and V_T, close to Johnson B and V; Perryman et al. 1997).



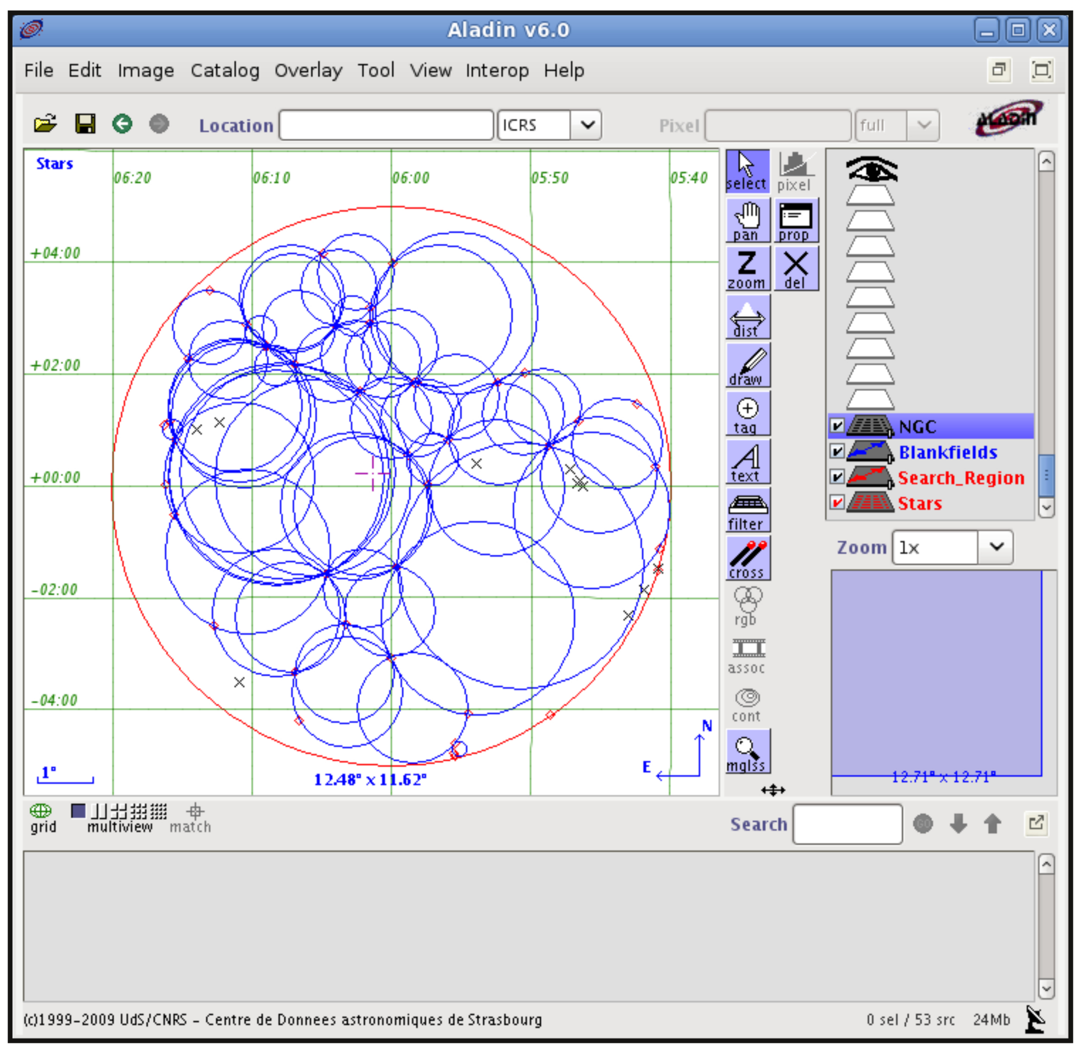
For illustration, in the above image we represent all the stars down to 6.5 mag in the whole celestial sphere (using a Lambert projection with galactic coordinates), and the resulting triangulation. In this particular example, we considered more than 8350 stars, leading to more than 16700 triangles, i.e., blank fields.

Tesela

In order to provide an easy way to access the blank field catalogues, we have created Tesela, a tool developed by the Spanish Virtual Observatory and publicly available both via WEB and ConeSearch.

If you want to have a look to it, just try this QR code:

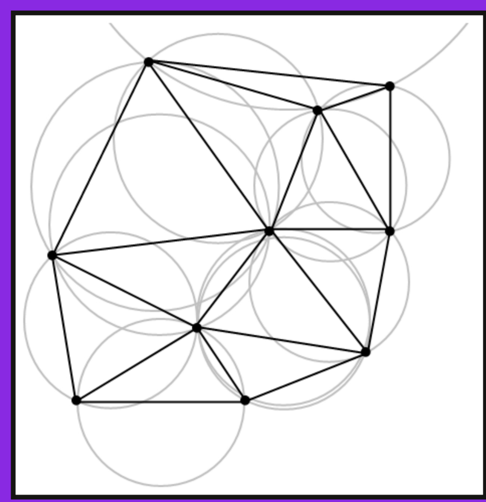
The tool consists of a database containing the Tycho-2 stars, the already computed blank fields regions, and an user-friendly interface for accessing the data. Tesela allows the users to perform a cone-search around any position in the sky. Through its search form users can select the threshold magnitude, the Tycho-2 filter to be used (B_T, V_T, or the combination of both), and define a minimum radius for the blank field regions.



Tesela also provides users with the possibility of visualizing the data, making use of the excellent VO tool Aladin (Bonnarel et al. 2000). In this way it is trivial to superimpose entries from astronomical catalogues or databases to the results provided by Tesela.

Description of the Delaunay Triangulation

The Delaunay triangulation (Delaunay 1934) lies in the subdivision of a geometric object into a set of simplices (the n-dimensional analogue of a triangle). In particular, for the Euclidean planar (2-dimensional) case, given a set of points, also called nodes, the Delaunay triangulation becomes a subdivision of the plane into triangles whose vertexes are nodes.

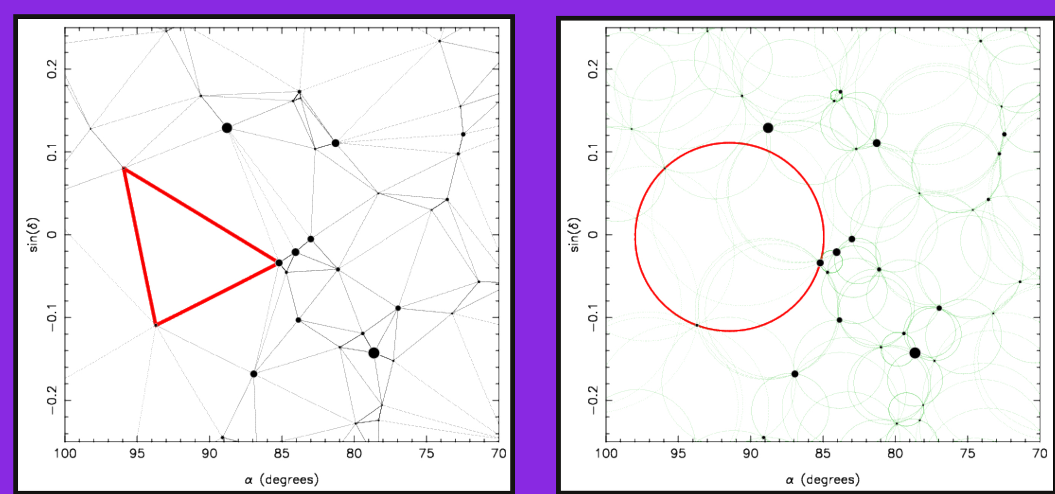


There is a property of the Delaunay triangulation, known as the **empty circumcircle interior property**, that, for our purposes, becomes extremely useful. This property indicates that all the circumcircles that can be drawn passing exactly through the three vertexes of all the triangles are empty, i.e., there are no nodes inside any of the computed circumcircles.

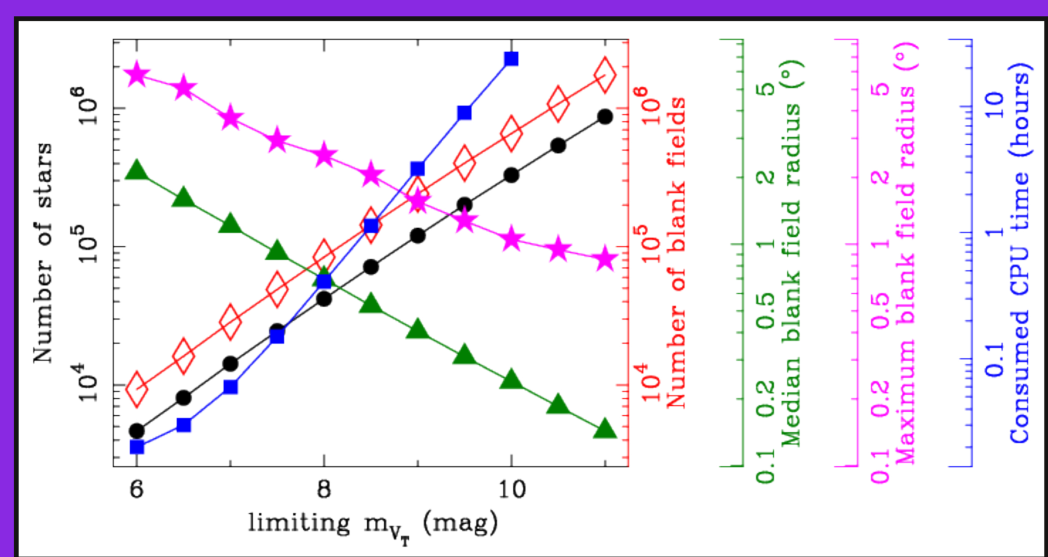
Since the Delaunay triangulation can be applied to the 2-dimensional surface of a 3-dimensional sphere, if one computes such triangulation using the coordinates of stars on the celestial sphere (down to a given threshold magnitude) as nodes, the above property will guarantee that there are no stars within the circumcircles associated to the derived triangles. In this way, the circumdiameter of every circumcircle determines the maximum field of view that can be employed in that region of the sky as blank field.

Computation of the Delaunay Triangulation

In order to proceed with the triangulation, we have made use of STRIPACK (Renka 1997), a Fortran~77 software package that employs an incremental algorithm to built the Delaunay triangulation of a set of points on the surface of the unit sphere. For the work presented here, we have modified the code in order to use double-precision floating arithmetic, which guarantees the proper computation of the triangulation when working with star separations approaching a few arcseconds.



The above images represent the sky region centered at the Orion constellation, considering all the stars brighter than m_V=4.5 mag. Left panel: The triangulation is carried out considering all the stars as nodes for the triangles, independently of their magnitude. A particular triangle is highlighted in red colour. Right panel: Circumcircles corresponding to all the triangles derived in the previous triangulation. The red circle indicates the circumcircle associated to the previously highlighted triangle. Note that the empty circumcircle interior property guarantees that there are no stars inside any of the displayed circumcircles.



Variation of relevant parameters during the tessellation as a function of the limiting magnitude of the considered stellar catalogue. Not surprisingly, these parameters exhibit a linear behavior in logarithmic scale, resulting from the exponential increase of the number of stars with m_V. Note also the decreasing blank field radius (both the median and the maximum) with m_V.

References

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