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TRIANGULATION OF AURORAL PHENOMENA: NEW APPROACH TO DETERMINATION OF SPATIAL BRIGHTNESS DISTRIBUTION

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Abstract. We present preliminary results of using new software for triangulation of auroral and another optical phenomena in the atmosphere based on a new approach of determination of brightness distribution. The main idea was to exclude transitory stages of processing auroral data, such as determination of distortion curve of TV camera. This was made using the method of Gurau network. Finally, to determine auroral forms at particular height we used orthogonal colors to paint auroral images transformed to geographical grid. Those auroral forms, which fit to proposed altitude, get the white color.

Introduction

Previous classic papers devoted to the problem of triangulation of auroral phenomena [Kaila, 1981] were called for solution of two main problems: 1) determination of altitudes of any auroral form and 2) mapping of auroral forms to geographic grid. This was successfully fulfilled and was confirmed by further measurements of auroral and artificial optical phenomena in the atmosphere [Kaila, 1987; Tagirov, 1993; Tagirov et al, 1999]. The methodology of processing of initial ground based optical data consisted, in principle, in transition from three-dimensional problem to single dimensional one. This was done by calculating of distortion factors such as camera distortion curve, inclination of optical instrument regarding to zenith direction and errors of camera orientation. In spite of very weak computer abilities at that time the accuracy of measurements was very high. We propose a new approach for solution of triangulation problem basing mainly on more powerful computer technique, which is able to solve the problem more directly excluding transitory stages of processing of auroral data. This is most important at processing of TV auroral data and precise comparing of auroral data with satellite and balloon measurements.

Data processing and triangulation

Very often it is usual for auroral TV data that they have specific distortion factors, which makes the classic approach to triangulation of aurora unacceptable. These distortions are connected with non-linearity and central asymmetry of geometric distortions caused by non-linearity of TV raster and usage of image intensifiers.

Let's divide the problem of triangulation in two independent ones: 1) normalization of geometry of video data (two- dimensional) and triangulation (three-dimensional).

For solution of the first problem we propose to use filling of camera field of view (FoV) by most bright stars. It is always possible and in each TV frame during clear sky period one can easily identify at least 30-40 stars. The quantity of stars can be multiplied if the same stars will be measured with most appropriate interval 2-3 hours during the night. As a result one will have two sets of stars coordinates: the first set represents "distorted" i.e. measured positions of stars directly from TV frame, whereas the second one is the set of coordinates of the same stars taken from Astronomical Annual. So having such two sets of data one can measure correction vector reducing actual star coordinates to geographical coordinates of its image at proposed altitude of an aurora. Considering the stars as knots of triangle Gurau network one can get function of so called Gurau painting, which in our case will be correction vector field normalizing initial video data (Fig.1). Using this vector field we unfold the auroral images obtained from different points of observations into geographical projection and thus get their joint mapping to geographical grid.

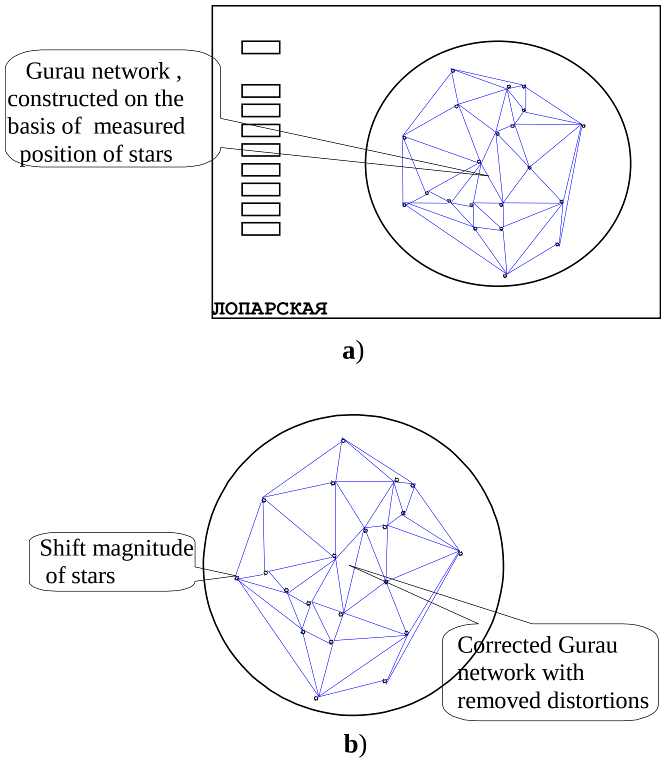

Fig.1.a) Schematic picture of initial all-sky TV camera screen; b) corrected TV image by removing distortions on the basis of stars background.

The method proposes using of painting of the images obtained from different observational points into orthogonal colors. In fact the usage of orthogonal colors, which being superimposed to each other give white color, easily allow understand what auroral form has been located at proposed altitude. They will be white in the final image. Auroral forms, which were located higher or lower than proposed altitude, will be painted into corresponding orthogonal colors.

Consequence of particular stages of processing and triangulation procedure is presented in Fig.2. The upper pair of images (a and b) shows the initial auroral images taken at he same moment from two auroral observatories Loparskaya and Lovozero separated by distance of about 100 km. The difference of the forms of images obtained by different cameras is evident. Note also that whereas N-S directions are similar (North is at the top of the images), the E-W directions are opposite (West is at the right side of the all-sky image of Loparskaya camera and it is very convenient when one works with maps of stars sky). The middle pair of images in Fig.2 (c, d) represents improved and correctly oriented all-sky TV camera images from both stations. They were made by Gurau method mentioned above of improving various distortions of auroral TV images.

Next stage is shown in Fig.2,e and it represents superimposed Merkator projections of both images. Superposition was made corresponding to geographical locations of both stations. Here the auroral height was proposed 100 km. Really each image was painted in orthogonal colors (unfortunately it is impossible to show it in this issue). The image from Loparskaya was red and from Lovozero was green.

Fig.2,f presents the final result of triangulation mapped on the geographic grid and coastline of Kola Peninsula. By light line crossing the images we indicated the path of FAST satellite foot point. The dotted oval indicates total FoV of Loparskaya all-sky TV camera. The edges of the images both along longitude and latitude were determined at 10º above horizon for both stations.

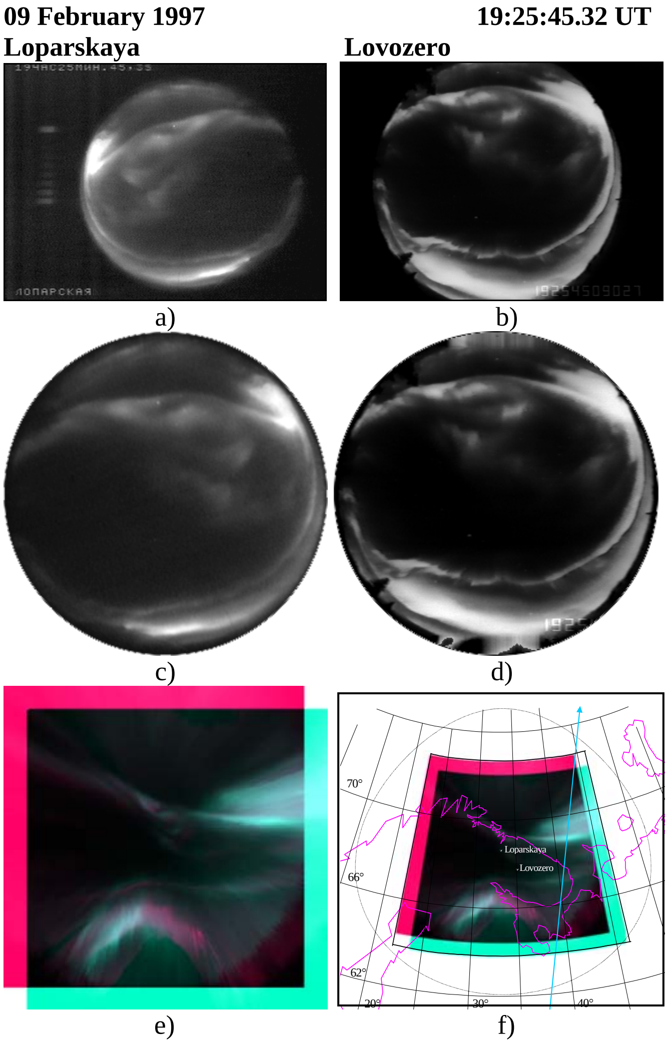

Fig.2. Sequential stages of image processing and further triangulation of auroral forms. Upper pair of images (a and b) shows the initial auroral images taken at the same moment from two auroral observatories Loparskaya and Lovozero separated by distance of about 100 km. N-S directions are similar in both images (North is at the top at the top of them), E-W directions are opposite in each image (West is at the right side of the all-sky image of Loparskaya camera). The middle pair of images (c and d) shows improved and correctly oriented all-sky TV camera images from both stations (see the text). Fig.2,e presents superposition of Merkator projections of the images from both stations. Transfer of these projections to the map of Kola Peninsula is shown in Fig.2,f. (see the text).

Summary

So the proposed method of triangulation of auroral forms and another optical atmospheric phenomena can briefly formulated as follows. The first stage is direct geometrical correction. The second stage is projection to geographic grid or to Merkator net of corrected optical data from different stations in orthogonal colors with height variations thus obtaining an altitude of different forms at particular moments. We propose that well organized interface will permit to quickly determine the height of any auroral form or atmospheric optical formation with perfect accuracy and time resolution.

References

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