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"Alternative" Astronomical FITS imaging

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Abstract. Some important information on images of radio sources, such as radio flux and the noise of the map, is not easily accessible by astronomers other than radio astronomers, unless they are familiar with the Astronomical Image Processing Software. In the current work, we present a method of data hiding inside the radio map, which can be preserved under transformations, such as change of format from FITS to other lossless image formats.

1. Introduction

In Radioastronomy data reduction of extended radio sources is achieved using the Astronomical Image Processing Software, commonly known as AIPS. AIPS saves the manipulated file of the astronomical source in FITS (Flexible Image Transport System) file format. It uses a set of tables to save the most important information deduced while calibrating, cleaning and imaging the radio data as well as the whole history of the data reduction. These tables are saved in the FITS file. Some basic information, such as the telescope used, the date of the observations, is saved in the header of this file using keywords. The final FITS file is easy to handle within AIPS. An astronomer of another discipline however, not familiar with the copious data reduction in AIPS and who would, for example, like to know the radio flux of the source or the root mean square (rms) of the map is unable to work alone further. Considering this difficulty, we propose a data embedding algorithm in order to save additional information into the FITS map. Data hiding is a well known computer research field, aiming at embedding information into a digital file, not into the header, but in a way that no human observer notices the existence of such additional information [1]. Data hiding finds applications in authentication, tamper-proofing, copyright protection, secret communication and other [2].

In this study we propose a new application of steganography, able to preserve the hidden information even after a file format conversion. This information can be extracted from the FITS map and also from the image pixels when FITS is converted into TIFF image format. TIFF supports high dynamic range images. Such application that converts FITS to TIFF image format is ESA/ESO/NASA FITS Liberator 3 [1], a standalone application released in October 2010.

[1] http://www.spacetelescope.org/projects/fits_liberator/

2. Procedure

The proposed scheme consists of the embedding, format conversion and the extractor parts. The latter reads the hidden information. The input is the original FITS image and the message, which is the information to be embedded. The output is the extracted message that is the information we extract from the TIFF image. The proposed data hiding algorithm is based on the discrete Walsh-Hadamard Transform (WHT), where selected WHT coefficients are changed according to the embedded bits. The WHT is a non-sinusoidal, orthogonal transformation that decomposes a signal into a set of orthogonal, rectangular waveforms called Walsh functions [3]. During embedding, the original image is divided into 4×4 non-overlapping blocks and WHT is applied to every block of the image. The last diagonal element of WHT coefficients' matrix is read together with the message bit. One message bit is embedded into every 4×4 image block. *'1'* is represented by a positive WHT coefficient, and *'0'* by a negative one. If this is not the case, then the coefficient's sign is changed and its value is shifted by a constant value d, which is experimentally chosen. The stego-FITS produced image is saved and converted into 16-bit TIFF format, using ESA/ESO/NASA FITS Liberator 3. Then the stego-TIFF image is entered in the extractor, which reads the WHT coefficients of the stego-TIFF and extracts the message bits, namely *'1'*, if the coefficient is positive and *'0'* otherwise [4].

3. Results and Discussion

Test results were implemented into Matlab 2010 release, using the 16-bit double precision floating point real numbers' map of the radio source Cygnus A extracted from the NASA Extragalactic Data Base (NED). The message size for embedding was 42976 bits, equal to the image's capacity. Capacity is the maximum amount of data that can be embedded into the image map. The constant value d, according to which the WHT coefficient is shifted, was experimentally chosen to be 0.0001. The proposed embedding algorithm is proved to be robust to FITS Liberator conversion into 16-bit depth, by only using the linear stretch function with white and black levels equal to the maximum and minimum values of the produced stego-fits image. Consequently, the complete dynamic range of the FITS image is exported into the TIFF image and further image editing can be made with any image editing tool, supporting 16-bit TIFF format. Our results show that the embedding procedure produces no visual artifacts, which means that the image statistics remain unchanged and the good quality of the image is retained.

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