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Contributions to the processing of the signals received from the optical sensors

ABSTRACT

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It is impossible to mimic the human ability to see by the means of an artificial system, as the human eye excellently perceives the colours and can distinguish a wide range of nuances. The light plays an essential part in the colours' perception. Light is reflected, refracted, diffracted and it dissipates when it touches the objects. Every object has a particular shape, colour, and reflects light upon it, but the human eye only perceives the reflected light; the rest of the light being absorbed by the object, causing it to heat up. The role of the human eye is to capture the light. The visual information is then transmitted to the optical nerve, after having been processed by the retina, and then it reaches certain brain areas where the colour sensations are created.

The digital cameras try to copy the process of sight and are meant to represent as accurately as possible the realities that the human eye perceives, but its accuracy and resolution are limited.

The present thesis proposes the study, the soft implementation, the compatibilization, and the optimization of the connections formed between the various optical, analogical and digital phenomena, which represent the basis of the image acquisition sensor's functions in a digital camera pipeline.

The image acquisition sensor converts the light in to digital signal, than using digital colour processing techniques the image is obtained, compressed and saved in a

digital format. Throughout this thesis we intend to globally present by the means of image simulation, the light conversion in to digital signals and the colour corrections taking place when an image is passed through an image acquisition sensor inside a digital camera pipeline.

This thesis proposes the study of those aspects connected to how the human eye sees and how the camera perceives the light. In order to perform illumination the light spectrum of various light sources, the sensitivity of the cones within the human eye and the reflection of the visualized object are calculated. They are used in an image processing algorithm dedicated to estimate the illumination by the means of spectral images, which measure the object's reflection from 10 to 10 nanometres in the visible spectrum and have a data representation 256x256x31. For this reason a conversion to the standard 256x256x3 format is required, being performed by a seven steps algorithm. The digital processing of the colours is carried out starting from the digital processor situated at the CCD sensor's output. The important aspects related to the colour processing are: the improvement of the interpolation and the colours' calibration where is made a compatibilization between how the eye sees and the way the monitor can render the colours.

Furthermore, the thesis puts forward the study to the functional simulations of the photographic objectives. For this purpose we began with the study of the diffraction phenomenon; this phenomenon being the basis of the optical filters and the optical systems' design. We treat: the ideal optical systems and filters, as well as optical aberrations, the optimization of the lenses' surfaces and real optical systems. The functionality of certain photographic objectives is presented along with the simulations equations for: a singlet, a doublet, a triplet and the light fall-off.

Another thesis aims is to study the aspects connected to the structure and the functionality of the CCD sensor. This sensor is meant to convert light in to digital signal and it consists of three components: optical, analogical and digital. The research focused on each of these aspects is presented in Chapter 5. The digital part is represented by the analog to digital converter, followed by the digital colours processing blocks. The optical transfer function of the sensor is calculated and implemented for the optical part. For the analogical part the inferential physical model of the semiconductor is presented.

According to these, the dynamic range and the integration time are inferred from. The image quality can be improved using appropriate dynamic range and integration times. By eliminating the fixed pattern noise the quality of the image is considerably improved. This thesis does not deal with temporary noises.

The contributions to the development of the research in the field of the image processing inside the digital camera pipeline are:

- the simulation of the image illuminations and the high dynamics range images;
- the simulation of the photographic objective functionality form the resolution point of view;
- the optical transfer function, the high dynamic range and the removal of the fixed pattern noise from a CCD sensor;
- the colours processing techniques taking place in the digital camera pipeline and the monitors.

Removing all these deficiencies when all the image acquisition system's blocks work together, is a difficult problem and difficult to achieve. Such an alternative has been proposed in Chapter 6 considering the results presented comparatively in figures 6.5 a) and c).

The annexes section contains some significant code samples that have been taken from the applications presented in the thesis. We present the matrix illumination model, the colour processing techniques like contrast and luminosity. For the optical part we present the optical amplitude filters'algorithm. Also we present the CCD's modulation transfer function and the light fall off law as Matlab® functions. All the simulations presented in this thesis are based on interconnected Matlab® functions. When work together all those functions simulate the digital camera pipeline functionality.

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