APPLICATIONS OF WHITE-LIGHT OPTICAL DENSITY ENCODING TECHNIQUE IN MEDICINE

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ABSTRACT

This paper will briefly outline the principle and approaches of the Optical Density Encoding Technique. The main advantages of this technique will be emphasized.The results of the medical applications of this technique, such as: False-coloring of black and white imagery taken through Optical Microscope, Ultrasonoscope type B, Transmissive Electronical Microscope (T E M), Scanning Electronical Microscope (S E M), and Computerized Tomograph (C T) are reported.

KEY WORDS: Image Analysis, Image Interpretation, Image Processing, Optical, Superimposition.

1. INTRODUCTION

This paper is a sister paper of the Optical Density Encoding Techniques [1]. It is mainly devoted to the medical applications. We are not going to present the basic principle and approaches here again. We will just give an outline of them in section 2. The advantages of this technique are:

1) High sensitivity for distinguishing faint density differences in a black and white imagery by different false-colors;

2) Ability of 2-D parallel processing;

3) Huge capacity of information;

4) Low price of the equipment;

5) Easy operation.

The main advantages of this technique are that it can distinguish faint density differences in the order of magnitude of wave length and the cost for establishing such a device is quite low, because the optical interference and diffraction principles have been applied in this technology. If there are some imagery which are difficult for processing with other methods in order to be able to distinguish the targets required, the technique introduced may solve your problems.

2. BASIC PRINCIPLE AND APPROACHES

These will be outlined in steps. The main points of this technology are:

1) Superimposing the Ronchi Grating to the original black and white imagery for making this Grating modulated or encoded by the original imagery;

2) Bleaching this encoded imagery for getting a Transparent Phase Grating;

3) Decoding it through filtering in a white-light information processing equipment. A saturated, bright, and abundant false-color image will be obtained.

During decoding in the white-light information processing equipment each wave length in the white light will be diffracted and interfered to get the image with each wave length, and the images with different wave lengths will be superimposed to get the false-color imagery. When filtering we can interrupt the other orders of the diffraction spectrum and only let the zero order or the first order to pass through in order to get the false-color imagery.

The colors in the false-color imagery are complementary for the zero order and the first order. For the best use of the light energy, we usually only choose Lower orders.

In addition, in the white-light information processing equipment, the 4f system is uasually used. In order to get the enlarged false-color pictures directly, we have designed a white-light ZOOM processor (WLZP) [1] which can adjust the enlargement of the false-color images easily, and the length of the room used can be reduced accordingly. By the way, all of our false-color images were obtained by this WLZP.

3. REPORT ON MEDICAL APPLICATIONS

In medical applications the imagery of the specimens used in different instruments are usually with single wave length (e.g. black and white). It does not like the MSS Landsat Data with multiple spectrum bands. Therefore, the false-color imagery can only be produced by a single black and white imagery. The Optical Density Encoding Technique is one of the methods for false-coloring of the black and white imagery. In this paper we will only show the results in medical applications. We have processed 7 samples with single wave length (black and white) imagery through 5 different instruments in different applications.

3.1 False-coloring of a T E M Imagery

This imagery is offered by the Central Laboratory in the Academy of Medical Science of Hubei Province, Wuhan, China. The Target was a small white mouse's kidney cell. After false-coloring we have got the following results:

3.1.1 The colors of two kinds of the Chromatins in this cell are completely different and are easy to be distinguished;

3.1.2 Each membrane of the Chondriosome in the cell plasmin can be seen more clearly;

3.1.3 The similar density of the Chondriosome in the black and white imagery were in different colors. This phenomenon meant that when a certain plasmin or an organ within a cell had got some small changes which was not enough to be distinguished by the density differences in the black and white imagery, but after false-coloring it is possible to reveal the difference with different colors in the false-color imagery. Therefore, this technology can be an useful referential means for detecting and diagnosing some diseases.

3.2 False-coloring of a S E M Imagery

This imagery was offered by the same organization mentioned above. The target was a cancer cell of a human stomach. After false-coloring we have got the following results:

3.2.1 Abundant false-colors were obtained for better interpretation;

3.2.2 The outline of the cell was clearer;

3.2.3 The surface of the cell with radiated structure was much clearer;

3.2.4 The lesion lines in the cell surface can be seen more clearly.

3.3 False-coloring of a Optical Microscope Imagery

This imagery was offered by the Prevention and Protection department in the Academy of Medical Science of Hubei province, China. The target was a micro nucleus of a cell of the human Lymphatic Gland. After false-coloring we have got the following results:

3.3.1 It is much clearer that the colors of the main and micro nucleus drifted in the plasmin of the cell were identical;

3.3.2 The boundary lines of the main and micro nucleus in the cell were much clearer;

3.3.3 These results can confirm that we can enhance the interpretation ability for recognizing the structure of the micro nucleus in the human Lymphatic cell to a certain extent.

3.4 The same as in 3.3

The target was a nucleus Hernia in the human Lymphatic cell. After false-coloring we have got the folloewing results:

3.4.1 The false-color imagery has shown an another metamorphosis of a cell nucleus —— nucleus Hernia clearly;

3.4.2 It was much clearer that the formation of the nucleus Hernia was due to that the partial plasmin of the cell nucleus went outward from the membrane of the cell nucleus;

3.4.3 These results have confirmed us that the false-color imagery had more abundant color series; the information required could be emphasized and it is quite helpful for recognizing the formation of the micro nucleus in the human Lymphatic cells.

3.5 False-coloring of a Ultrasonoscope Imagery

This imagery was offered by the Tumour Research Institute in the Tumour Hospital of Hubei Province, Wuhan, China. The target was a abdominal cavity of a human. After false-coloring we have got the following results:

3.5.1 The cavity of the intestines could be seen more clearly;

3.5.2 The substance in the intestines was dislplayed more clearly;

3.5.3 The liver and the various layers of the belly walls were also displayed clearly.

3.6 The same as in 3.5

The target was a Myoma of a woman's Uterus. This has been proved by the clinical treatment in their hospital. After false-coloring we have got the following results:

3.6.1 We can distinguish the normal muscle of the uterus by the dark brown color;

3.6.2 We can distinguish the fibre tissue or small dead parts and glass-like focus by green or blue green;

3.6.3 We can distinguish the muscle fibre tissue in the edge of the Myoma by red color;

3.6.4 We can distinguish the center part of the Myoma by green;

3.6.5 These results has confirmed us that the cavity of the intestines; the different characteristic substances and the difference between the muscular and fibrous tissues in the Myoma of the Uterus can be easily distinguished.

All of these can show us that the potential capabilities of this technology are valuable.

3.7 False-coloring of a C T Imagery

This imagery was offered by the Radiation department in the Tong Ji Subordinate Hospital of the Tong Ji Medical University of Wuhan, Wuhan, China. The target was a Pituitary Adenoma of a huaman Brain. This has been proved by the clinical treatment in their hospital. After false-coloring we have got the following results:

3.7.1 We can easily distinguish the grey matter and white matter of a human brain;

3.7.2 We can easily distinguish the structure of the Ventricle walls of the brain;

3.7.3 It is possible to distinguish between the Ventricle walls and the Cerebrospinal fluid;

3.7.4 It is easier to distinguish the differences among the calcific ring around the Pituitary Adenoma, Adenoma tissue itself,the Ventricle and the surrounding brain tissues.

4. CONCLUSIONS

The advantages of the Optical Density Encoding Techniques have been briefly introduced. However, there are some inherent disadvantages in the single black and white imagery, such as:

1) Different objects may have the same density;

2) The same object may have different densities;

3) False-color imagery are different from natural color imagery and black and white imagery, therefore, the people who are familiar with the black and white imagery may not be familiar with the false-color imagery. The false-colors and the densities are related by its own function. It is impossible to assign them arbitrary.

Having got these ideas in mind, we can apply this technology, especially, in the field where the objects can not be well interpreted from the imagery processed by other methods. In addition, the main advantage of this technology is able to distinguish faint density difference. Therefore, this technology may be a new means for detecting the object which is very difficult with other means. It can be very useful in medical diagnosing, Biology, Genetics and any other subjects which need image information for detecting, interpreting and analyzing targets required. A broad application range and economical benefit can be expected.

We will show the false-color images during the presentation. We are willing to cooperate with the people who are interested in this technology in the medical field. We are sure that we can further improve it and make it easier to operate and get better results.

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