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# A Novel Data Hiding Algorithm for High Dynamic Range Images

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## *ABSTRACT*

***In this paper, we propose a novel data hiding algorithm for high dynamic range (HDR) images encoded by the Open EXR file format. The proposed algorithm exploits each of three 10-bit mantissa fields as an embedding unit in order to conceal k bits of a secret message using an optimal base which produces the least pixel variation. An aggressive bit encoding and decomposition scheme is recommended, which offers a high probability to convey (k+1) bits without increasing pixel variation caused by message concealment. In addition, we present a bit inversion embedding strategy to further increase the capacities when the probability of appearance of secret bit "1" is greater than 0.5. Furthermore, we introduce an adaptive data hiding approach for concealing more secret messages in pixels with low luminance, exploiting the features of the human visual system to achieve luminance-aware adaptive data hiding. The stage HDR images produced by our algorithm coincide with the high dynamic range image file format, causing no suspicion from malicious eavesdroppers. The generated stage HDR images and their tone-mapped low dynamic range (LDR) images reveal no perceptual differences when subjected to quantitative testing by Visual Difference Predictor. Our algorithm can resist steganalytic attacks from the HDR and LDR RS and SPAM steganalyzers. We present the first data hiding algorithm for OpenEXR HDR images offering a high embedding rate and producing high visual quality of the stego images. Our algorithm outperforms the current state-of-the-art works.***

***Key points:*** ***Index Terms—high dynamic range images, data hiding, OpenEXR, adaptive, optimal base, Visual Difference Predictor***

## INTRODUCTION

Data hiding, also known as data embedding, is a method of using digital media to conceal critical messages. In general, the object in which secret messages are intended to be embedded is referred to as the cover medium, and the objectin which the messages are concealed is called the stego medium. An image data hiding technique is usually evaluated in terms of the embedding capacity, also known as the payload, and the quality of the stego image [1]. On one hand, data hiding algorithms should maximize the quantity of messages that can be conveyed. Offering a large payload plays an important role for applications such as the annotation of images. On the other hand, the data hiding algorithms should minimize the embedding distortion, producing a high quality stego image to resist steganalytic attacks, which attempt to detect the presence of hidden messages. A data hiding algorithm which can provide a plausible stego image with a sufficient and secure payload raises no suspicion to a malicious eavesdropper and thus is suitable for applications such as covert communication. In recent years, interest in high dynamic range (HDR) [2] images has increased dramatically. The dynamic range of a scene is the contrast ratio between its brightest and darkest parts. HDR images represent a large range of luminance using floating-point numbers. This is in contrast to low dynamic range (LDR) [3] images which represent a limited range of luminance using integers.

A set of advanced image techniques allowing a far greater dynamic range of exposures than normal digital

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image techniques has been investigated herein. The scenario behind these techniques involves accurately representing the wide range of intensity levels found in real scenes, ranging from direct sunlight to deepest shadows, in order to exhibit the accurate fidelity of a real scene. There are three main HDR image formats. The first is the RGBE format, which adopts 32 bits per pixel to represent both luminance and chromatic information. The second is the uncompressed LogLuv TIFF format, which uses 48 bits for one pixel. The third is the OpenEXR format, which 2Page | 2also employs 48 bits for a pixel to represent a dynamic range of luminance and chromatic information. Over the past few years, the OpenEXR format, developed by Industrial Light & Magic (ILM), has become an industry standard for HDR image formats due to its flexible and expandable structure. This format is considered the de facto standard in the movie industry. For example, it was adopted by Hollywood film editors and special effects directors to produce the film Harry Potter and the Sorcerer's Stone. The OpenEXR format covers the entire visible color gamut and the full range of perceivable luminance, thus providing optimal visual fidelity on a variety of output devices. Because of their great potential, HDR images encoded by the OpenEXR format are expected to replace LDR images, and will serve as one of the new image standards in the future [4-7].

A number of data hiding algorithms have adopted LDR images, such as binary, grayscale, or color images, to conceal secret messages. Watermarking algorithms, which emerged as an enabling technology to protect the intellectual property of digital contents, were investigated for HDR images. The current state-of-the-art HDR watermarking works can be referred to in recent papers. Along with the wide availability of the distribution channels for providing applications such as video-on-demand and multimedia social networks, digital watermarking techniques aimed at preventing copyright violations for distribution channels have become more important than ever. Unfortunately, research in HDR data hiding has not kept pace with advances made in HDR images, despite the fact that they provide great potential to become the leading image standard. To the best of the authors' knowledge, research into data hiding algorithms for HDR images has been very limited.

These algorithms fall within two basic categories. The first type is intended to yield high capacity data hiding. These algorithms convey a large number of secret messages at the cost of producing a stego image with large distortion. They are current state-of-the-art algorithms, providing an embedding rate of at least 5 bits per pixel. The second type of algorithm is intended to yield high image quality of data hiding. These algorithms specifically exploit the RGBE HDR encoding format to conceal a small quantity of messages; unfortunately, the capacity offered by these algorithms is limited to less than 0.5 bits per pixel. They are also referred to as distortion-free algorithms because any distortion produced after the secret message embedding is so insignificant that the stego image generated after the tone-mapping operation is identical to the cover tone-mapped image. Since the capacity offered by these distortion-free algorithms is limited, it becomes difficult for them to support applications that require large capacity. Developing an HDR data hiding algorithm is a distinct challenge. Unlike the fixed range of luminance for an LDR image, each HDR image has a very different luminance range [6].

An HDR data hiding algorithm must cope with a different luminance range that provides high capability while keeping the distortion of the stego image as small as possible. In addition, the encoding format of the stego HDR image should be coincident with the original HDR image, arousing no suspicion from malicious eavesdroppers. Finally, when a cover and stego image are tone mapped for the purpose of visualization, the image quality should be visually plausible, and the difference between them should not be visible to a human observer. This paper presents a novel data hiding algorithm using optimal base, abbreviated as DHOB,

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which employs an optimal base to conceal a serial secret bit stream with least distortion in a high dynamic range image encoded by 48-bit OpenEXR file format. This type of HDR image consists of three 16-bit floating-point values in the red, green and blue channels, all of them being

## 2.LITERATURE REVIEW

Real-time high-quality video tone mapping is needed for many applications, such as digital viewfinders in cameras, display algorithms which adapt to ambient light, in-camera processing, rendering engines for video games and video post-processing. We propose a viable solution for these applications by designing a video tone mapping operator that controls the visibility of the noise, adapts to display and viewing environment, minimizes contrast distortions, preserves or enhances image details, and can be run in real-time on an incoming sequence without any pre-processing. To our knowledge, no existing solution offers all these features. Our novel contributions are: a fast procedure for computing local display-adaptive tone-curves which minimize contrast distortions, a fast method for detail enhancement free from ringing artifacts, and an integrated video tone-mapping solution combining all the above features

## 3.SYSTEM ANALYSIS

### 3.1 EXISTING SYSTEM

Cheng and Wang [20] pioneered in presenting an adaptive steganographic algorithm with authentication for an HDR image encoded by the RGBE format developed for radiance software [5]. The range of luminance intensity is decided by the 8-bit exponent field (E) for all three-color values in each pixel. Their algorithm took advantage of this to classify pixels into flat or boundary areas in order to convey different quantities of secret messages, thus achieving adaptive message embedding [8]. They employed a two-sided approach which considers an input pixel and its two neighboring pixels (upper and left) in order to estimate the number of adaptive bits to be embedded on this input pixel. This two-sided approach was extended to become an L-sided approach which considers three neighboring pixels than the 30 dB which are acceptable to human perception.

Li et al. [21] proposed a data hiding scheme for HDR images which improves the embedding capacity of Cheng and Wang's scheme. Instead of using HDR images encoded in 32-bit radiance RGBE coding, Li et al. used an HDR image encoded by a 48-bit TIFF format, where each channel has 16 bits, including a 1-bit sign field, a 5-bit exponent field, and a 10-bit mantissa field. The secret messages are embedded into the mantissa field, leaving the sign and exponent fields intact. Based on the optimal pixel adjustment process (OPAP) [8], they introduced three data hiding strategies which offer an exquisite balance between high embedding capacity and the quality of the tone-mapped stego images. Their algorithm adopted a pixel as an embedding unit and provided an average embedding rate of 26 bpps. The tone-mapped stego image has a PSNR value in the range of 30.47-37.00 dB. Li et al.'s algorithm outperforms Cheng and Wang's method in the embedding rate.

### 3.2 PROPOSED SYSTEM

In the proposed system, the system presents a bit inversion embedding strategy to further increase the capacities when the probability of appearance of secret bit "1" is greater than 0.5. Furthermore, we introduce an adaptive data hiding approach for concealing more secret messages in pixels with low luminance, exploiting the features of the human visual system to achieve luminance-aware adaptive data hiding [10].

The stego HDR images produced by our algorithm coincide with the high dynamic range image file format, causing no suspicion from malicious eavesdroppers. The generated stego HDR images and their tone-mapped low dynamic range (LDR) images reveal no perceptual differences when subjected to quantitative testing by Visual Difference Predictor. Our algorithm can resist steganalytic attacks from the HDR and LDR RS and

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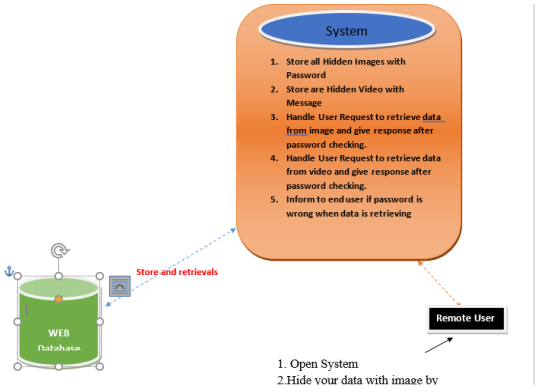
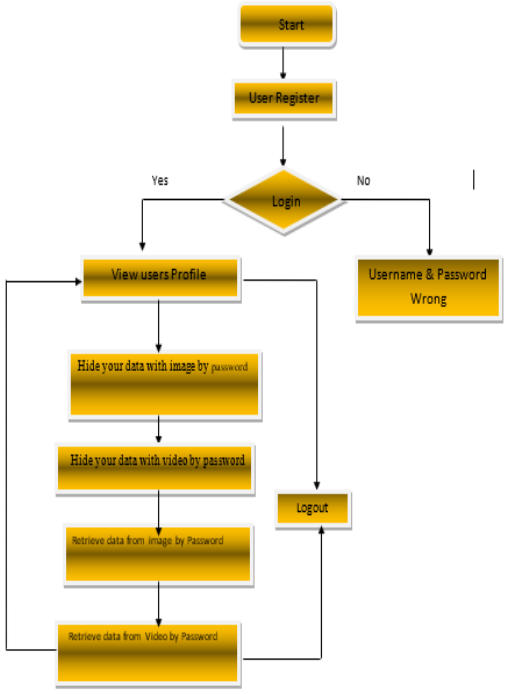
SPAM steganalyzers. We present the first data hiding algorithm for Open EXR HDR [9] images offering a high embedding rate and producing high visual quality of the stego images. Our algorithm outperforms the current state-of-the-art works.

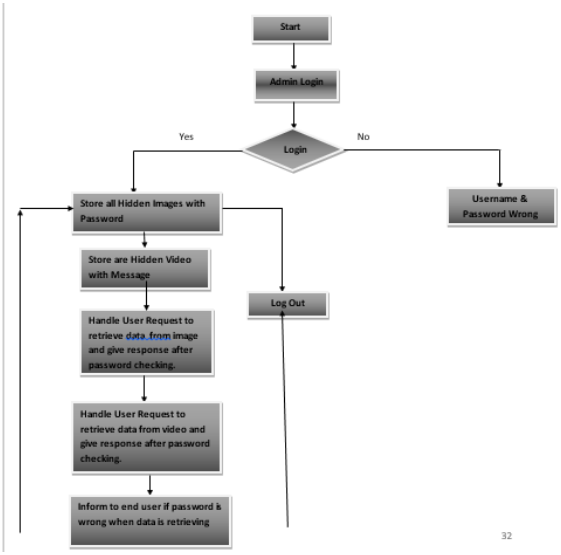
## Advantages:

- More security on data due to 64- bit data encryption techniques.
- There is no data leakage due to ABED Scheme

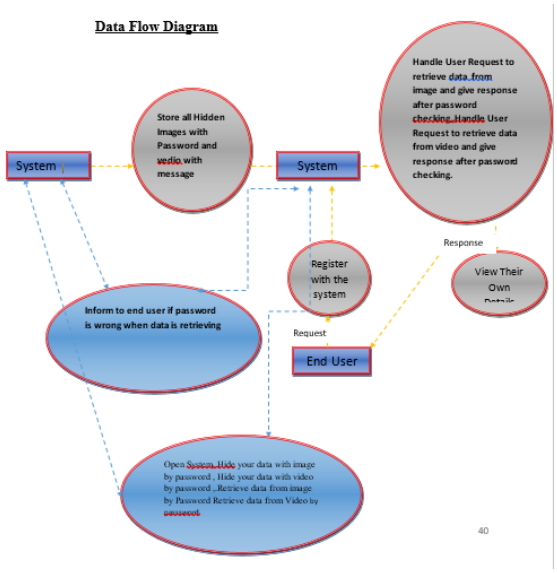
## ARCHITECTURE DIAGRAM



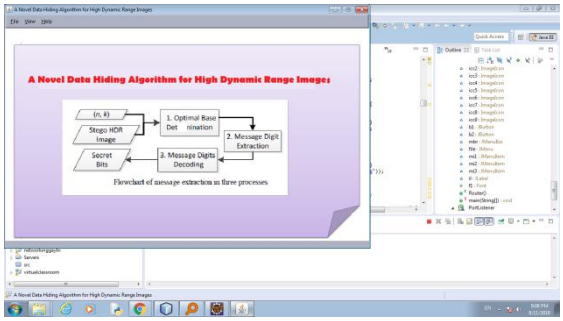




## DATA FLW DIAGRAM




## User login



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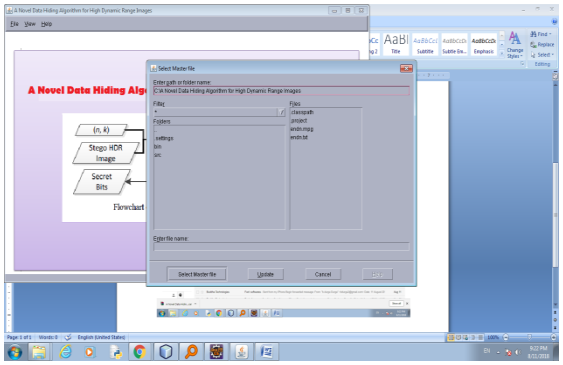
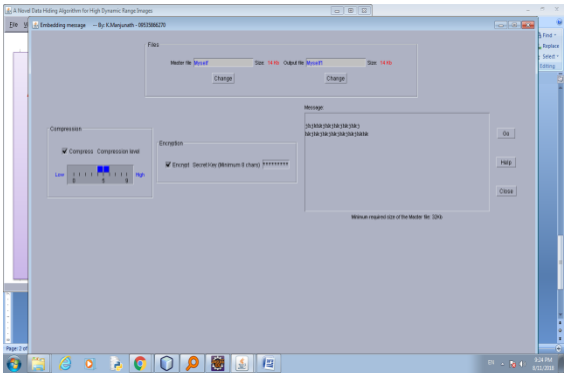
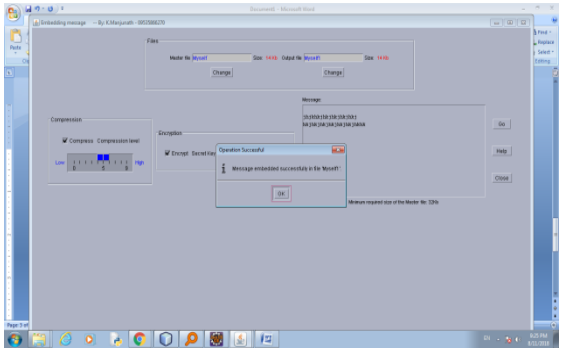
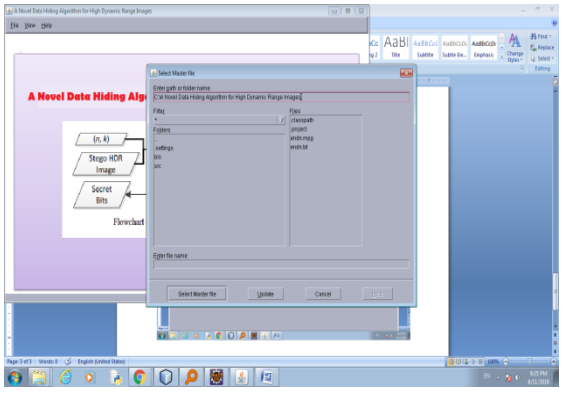
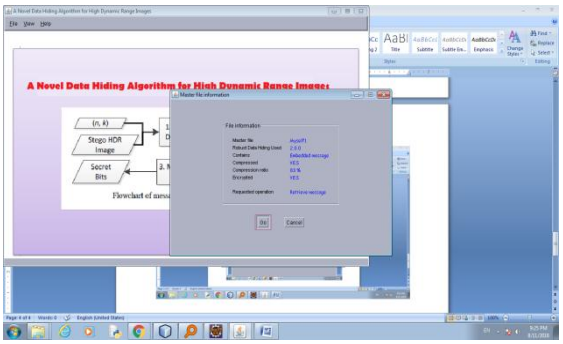
**Registration form**

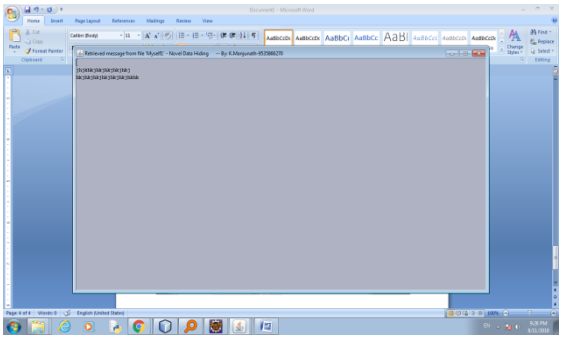












## SYSTEM TESTING

## SYSTEM TESTING METHODOLOGIES

The following are the Testing Methodologies:

Unit Testing.

Integration Testing.

- User Acceptance Testing.
- Output Testing.
- Validation Testing.

### Unit Testing

Unit testing focuses verification effort on the smallest unit of Software design that is the module. Unit testing exercises specific paths in a module's control structure to ensure complete coverage and maximum error detection. This test focuses on each module individually, ensuring that it functions properly as a unit. Hence, the naming is Unit Testing.

During this testing, each module is tested individually and the module interfaces are verified for the consistency with design specification. All-important processing path are tested for the expected results. All error handling paths are also tested.

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### Integration Testing

Integration testing addresses the issues associated with the dual problems of verification and program construction. After the software has been integrated a set of high order tests are conducted. The main objective in this testing process is to take unit tested modules and builds a program structure that has been dictated by design.

### The following are the types of Integration Testing:

### 1. Top Down Integration

This method is an incremental approach to the construction of program structure. Modules are integrated by moving downward through the control hierarchy, beginning with the main program module. The module subordinates to the main program module are incorporated into the structure in either a depth first or breadth first manner.

In this method, the software is tested from main module and individual stubs are replaced when the test proceeds downwards

### 2. Bottom-up Integration

This method begins the construction and testing with the modules at the lowest level in the program structure. Since the modules are integrated from the bottom up, processing required for modules subordinate to a given level is always available and the need for stubs is eliminated. The bottom up integration strategy may be implemented with the following steps:

- The low-level modules are combined into clusters into clusters that perform a specific Software sub-function.
- A driver (i.e.) the control program for testing is written to coordinate test case input and output.
- The cluster is tested.
- Drivers are removed and clusters are combined moving upward in the program structure
- The bottom up approaches tests each module individually and then each module is module is integrated with a main module and tested for functionality.

## OTHER TESTING METHODOLOGIES

### User Acceptance Testing

User Acceptance of a system is the key factor for the success of any system. The system under consideration is tested for user acceptance by constantly keeping in touch with the prospective system users at the time of developing and making changes wherever required. The system developed provides a friendly user interface that can easily be understood even by a person who is new to the system.

### Output Testing

After performing the validation testing, the next step is output testing of the proposed system, since no system could be useful if it does not produce the required output in the specified format. Asking the users about the format required by them tests the outputs generated or displayed by the system under consideration. Hence the output format is considered in 2 ways – one is on screen and another in printed format.

### Validation Checking

Validation checks are performed on the following fields.

### Text Field

The text field can contain only the number of characters lesser than or equal to its size. The text fields are alphanumeric in some tables and alphabetic in other tables. Incorrect entry always flashes and error message.

### Numeric Field

The numeric field can contain only numbers from 0 to 9. An entry of any character flashes an error message. The individual modules are checked for accuracy and what it has to perform. Each module is subjected to test run along with sample data. The individually tested modules are integrated into a single system. Testing involves executing the real data information is used in the program the existence of any program defect is inferred from the output. The testing should be planned so that all the requirements are individually tested.

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A successful test is one that gives out the defects for the inappropriate data and produces and output revealing the errors in the system.

### Preparation of Test Data

Taking various kinds of test data does the above testing. Preparation of test data plays a vital role in the system testing. After preparing the test data the system under study is tested using that test data. While testing the system by using test data errors are again uncovered and corrected by using above testing steps and corrections are also noted for future use.

### Using Live Test Data:

Live test data are those that are actually extracted from organization files. After a system is partially constructed, programmers or analysts often ask users to key in a set of data from their normal activities. Then, the systems person uses this data as a way to partially test the system. In other instances, programmers or analysts extract a set of live data from the files and have them entered themselves.

It is difficult to obtain live data in sufficient amounts to conduct extensive testing. And, although it is realistic data that will show how the system will perform for the typical processing requirement, assuming that the live data entered are in fact typical, such data generally will not test all combinations or formats that can enter the system. This bias toward typical values then does not provide a true systems test and in fact ignores the cases most likely to cause system failure.

## USER TRAINING

Whenever a new system is developed, user training is required to educate them about the working of the system so that it can be put to efficient use by those for whom the system has been primarily designed. For this purpose the normal working of the project was demonstrated to the prospective users. Its working is easily understandable and since the expected users are people who have good knowledge of computers, the use of this system is very easy.

## MAINTAINENCE

This covers a wide range of activities including correcting code and design errors. To reduce the need for maintenance in the long run, we have more accurately defined the user's requirements during the process of system development. Depending on the requirements, this system has been developed to satisfy the needs to the largest possible extent. With development in technology, it may be possible to add many more features based on the requirements in future. The coding and designing is simple and easy to understand which will make maintenance easier.

## TESTING STRATEGY

A strategy for system testing integrates system test cases and design techniques into a well-planned series of steps that results in the successful construction of software. The testing strategy must co-operate test planning, test case design, test execution, and the resultant data collection and evaluation. A strategy for software testing must accommodate low-level tests that are necessary to verify that a small source code segment has been correctly implemented as well as high level tests that validate major system functions against user requirements.

Software testing is a critical element of software quality assurance and represents the ultimate review of specification design and coding. Testing represents an interesting anomaly for the software. Thus, a series of testing are performed for the proposed system before the system is ready for user acceptance testing.

## SYSTEM TESTING:

Software once validated must be combined with other system elements (e.g. Hardware, people, database). System testing verifies that all the elements are proper and that overall system function performance is achieved. It also tests to find discrepancies between the system and its original objective, current specifications and system documentation.

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## UNIT TESTING:

In unit testing different are modules are tested against the specifications produced during the design for the modules. Unit testing is essential for verification of the code produced during the coding phase, and hence the goals to test the internal logic of the modules. Using the detailed design description as a guide, important Conrail paths are tested to uncover errors within the boundary of the modules. This testing is carried out during the programming stage itself. In this type of testing step, each module was found to be working satisfactorily as regards to the expected output from the module.

In Due Course, latest technology advancements will be taken into consideration. As part of technical build-up many components of the networking system will be generic in nature so that future projects can either use or interact with this.The future holds a lot to offer to the development and refinement of this project.

## CONCLUSION

This paper presents a novel data hiding algorithm for HDR images encoded by the OpenEXR format. The proposed algorithm conceals secret messages in the 10-bit mantissa field in each pixel, while the 1-bit sign and 5-bit exponent fields are kept intact. We recommend an optimal base allowing secret messages to be concealed with the least pixel distortion. An aggressive bit encoding and decomposition scheme is introduced herein, which offers the benefit for concealing an extra bit in a pixel group without incurring pixel distortion. The influence of the message probability is analyzed, and the embedding capacity is further increased by taking advantage of the recommended bit inversion embedding scheme.

The proposed algorithm is extended to support luminance-aware adaptive data hiding, where the luminance of an HDR image is classified into high, middle and low levels. More secret bits are conveyed in pixels with a low luminance level and vice versa. We adopted two groups of image databases for testing, each of which contains 15 HDR images with different luminance. The results of the HDR visual difference predictor demonstrate that the tone-mapped stego LDR images or stego HDR images have high image quality with a low probability of detection that differences between the cover and stego images are difficult to be visible to an average viewer. A stego HDR image generated by our algorithm preserves the original file format and is unlikely to arouse suspicion from eavesdroppers. The analysis indicates that the proposed algorithm can resist attacks from the LDR and HDR RS steganalyzer and the LDR and HDR SPAM steganalysis.

The contribution of this work is in presenting the first data hiding algorithm for OpenEXR HDR images. The proposed algorithm provides a high embedding capacity, which makes use of an aggressive bit encoding and decomposition scheme, as well as the bit inversion technique. Our scheme produces a stego image with high quality, taking advantage of the optimal bases to produce the least pixel distortion. The comparison shows that our algorithm has the best results, outperforming the current state-of-the-art schemes. The proposed scheme provides advantages for data hiding applications such as image annotation and covert communications. While our algorithm already performs well, some further improvements are still possible. Future study will investigate a more effective message encoding method to further increase the embedding capacity.

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