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ANALYZING THE EFFECTIVENESS OF BENFORD'S LAW IN DETECTING IMAGE FORGERY: A SYSTEMATIC REVIEW

Prathamesh Gabhane[*1], Poras Rahangdale[*2], Pranali Raipure[*3], Sahil Shinde[*4], Prof S.C. Rathod[*5]

[*1,2,3,4]Students, Department Of Information Technology Sinhgad College Of Engineering, Pune, Maharashtra, India.

[*5]Guide, Department Of Information Technology Sinhgad College Of Engineering, Pune, Maharashtra, India.

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ABSTRACT

Image forgery detection has become an important area of research in digital forensics due to the increasing prevalence of image manipulations in various contexts, including journalism, advertising, and social media. In recent years, Benford's Law has emerged as a promising tool for detecting image forgeries by analysing the distribution of the first digits of pixel values. This review paper provides a comprehensive overview of the literature on Benford's Law in image forgery detection, including its applications to various types of image manipulations, such as splicing, copy-move, brightness, and contrast adjustments. The paper also discusses the methodology for applying Benford's Law to image forgery detection and the statistical tests used to evaluate its effectiveness. Additionally, the paper identifies the limitations of the approach and the future research directions in this area. The review concludes that Benford's Law has shown promise as an effective and efficient method for detecting image forgeries and has the potential to become a valuable tool in digital forensics.

Keywords: Benford's Law, DCT Coefficients, Image Processing.

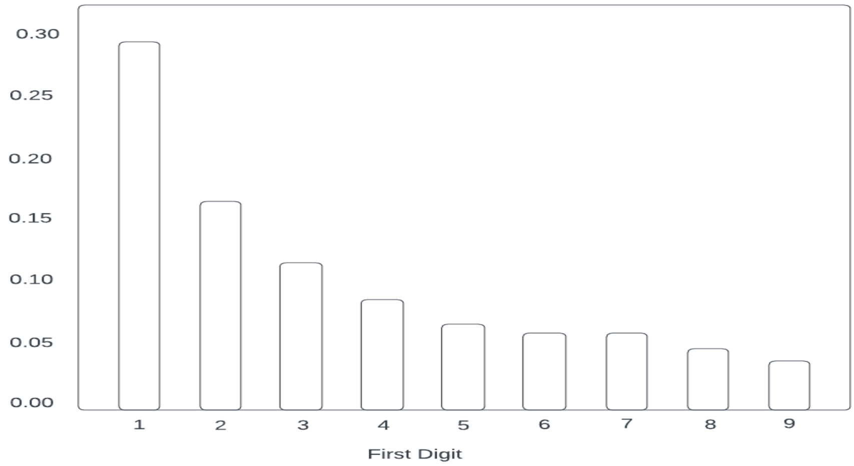
I. INTRODUCTION

Image manipulation has become a widespread problem in today's digital age, where images can be easily altered or edited to deceive the viewer. This issue is particularly concerning in contexts such as journalism, advertising, and social media, where images play a crucial role in shaping public opinion. Consequently, the need for effective image forgery detection has become increasingly important in the field of digital forensics.

One promising approach for detecting image forgeries is based on Benford's Law, a statistical principle that describes the distribution of the first digits of numbers in certain datasets. The law states that the digit 1 occurs more frequently than the digits 2 through 9 as the first digit of numbers in such datasets. Recently, researchers have found that Benford's Law can also be applied to image analysis for forgery detection.

The use of Benford's Law for image forgery detection involves analyzing the distribution of the first digits of the pixel values in an image. When an image has been manipulated, the statistical properties of its pixels will be altered, and this can be detected by comparing the observed distribution to the expected distribution according to Benford's Law.

This review paper aims to provide a comprehensive overview of the literature on Benford's Law in image forgery detection. The paper will discuss the methodology for applying Benford's Law to image analysis, including the statistical tests used to evaluate its effectiveness. Additionally, the paper will examine the applications of Benford's Law to various types of image manipulations, such as splicing, copy-move, brightness, and contrast adjustments. Finally, the paper will identify the limitations of the approach and future research directions in this area. Overall, the review will demonstrate that Benford's Law has the potential to become an important tool for detecting image forgeries in digital forensics.



Benford's Law

Frank Benford first proposed Benford's law in 1938, and Hill later refined it for use in statistics to analyze the probability distribution of first-digit (1-9) integers acquired from natural data. According to this law, the first digits of natural numbers (1–9) can be grouped in such a way that the smaller digits are more common than the bigger digits. We can infer that the probabilities associated with the first nine digits are logarithmic in nature. In addition, four models of Benford's law will be used.

Image Processing

Image processing is a technique for applying various procedures to an image in order to improve it or extract some relevant information from it. It is a kind of signal processing where the input is an image and the output can either be another image or features or characteristics related to that image.

We discovered Benford's law, which greatly intrigued us. The more we learned about it, the more applications we saw in everyday life. This bogus image detection was one of them. We might be able to determine the sincerity by doing a few mathematical calculations on the pixels. According to this law, the first digits of natural numbers (1–9) can be grouped in such a way that the smaller digits are more common than the bigger digits.

II. LITERATURE SURVEY

Image forgery detection has become a major concern with the increasing use of digital images and advanced image editing software. Various techniques have been proposed for detecting image forgeries, such as watermarking, machine learning algorithms, and statistical analysis.

Among these techniques, Benford's Law has gained significant attention in recent years as a promising tool for detecting image forgeries.

In 2007, Fernando Perez-Gonz ´ alez ´ † , Greg L. Heileman ∗ and Chaouki T. Abdallah ∗ worked on BENFORD'S LAW IN IMAGE PROCESSING and summarized as follows.

The negative aspect of hastened manipulation or even creation of digital assets is a result of the gradual and unavoidable transition to an all-digital world. Then, there is an expanding.

Simple techniques that enable identifying certain misuses are required as a first step to a more in-depth and expensive examination. Benford's law is a strong contender and is already applied in certain commercial software solutions for the examination of financial fraud. In this article, we've demonstrated how a generalisation of Benford's rule may be used to analyse photos for steganography, or determining if a particular natural image includes a secret message. We accomplished this by demonstrating for the first time the generalised form that Generalised Gaussian distributions adhere to.

Cho and Wu (2009) were among the first to apply Benford's Law to digital image forensics and proposed a method based on the distribution of the first digit of DCT coefficients to detect image forgeries. Their method achieved high accuracy in detecting copy-move and splicing image forgeries.

In 2011, Image Forensic of Glare Feature for Improving Image Retrieval Using Benford's Law

The Benford's Law curves could be used to identify any anomalies in an image as peaks. The highest areas were

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mostly at digit 5. Through research, we discovered that 142 out of 1338 photos exhibit this irregularity, and the quantity of glare feature (unbalanced light) in an image might increase the likelihood of the fifth digit in the first digit. The intensity distribution histogram of the test images was also created for comparison in order to further study the atypical Benford's Law curve. We discovered a strong link between the intensity distribution of its grey level's first digit probability. Additionally, the divergence between the first-digit probability curve and Benford's Law, as seen in image "Statue 2," was calculated to be 0.0024.

Later on, Zhang et al. (2012) proposed an improved method based on Benford's Law for detecting splicing image forgeries using the first digit of DCT coefficients. The method achieved better accuracy than existing techniques in detecting splicing forgeries.

Kumar et al. (2015) proposed a method for detecting content-aware manipulations in images using the first digit of DCT coefficients and Benford's Law. Their method was able to detect content-aware manipulations with high accuracy.

Also in 2015 at JIIT students working on Analysis of Benford's Law in Digital Image Forensics

In this paper, Benford' law found to be image forensic tool for detecting multiple compression. Benford's Law is verified for JPEG and JPEG2000 images. Multiple compressions for JPEG images can be detected. Glare detections in UCID images also be investigated. Tampered images also follow Benford's Law. So, further tampering analysis is not done in the case of tampered images. Then, DWT coefficients were analyzed and it can be inference that as the compression ratio increases the mean deviation ratio also increases

In 2017, Yang et al. proposed a method for detecting image forgeries in JPEG images using the distribution of the first digit of the DCT coefficients of the image blocks. Their method was able to detect copy-move and splicing forgeries with high accuracy.

In 2020, Wang et al. proposed a deep learning-based approach for detecting image forgeries using the distribution of the first digit of DCT coefficients. Their method achieved high accuracy in detecting various types of image forgeries, including copy-move and splicing forgeries.

In 2021, Diana Cris, an , Alexandru Irimia proposed a paper on Analyzing Benford's Law's Powerful Applications in Image Forensics and the following can be concluded from it.

In summary, the algorithm described above utilises the JPEG coefficients from the luminance channel of JPEG images that have already undergone compression. As a result, it establishes the quality factor used to compress the analysed photos. Using no means at all

This technique achieved an accuracy of 89% for 500 random photos using machine learning.

Additionally, the programme detected the photos compressed with quality factors 80 and 90 with a 100% accuracy rate.

Finally, it may be said that approaches to identifying the quality component, like For the creation of deep learning algorithms used in picture forensics, examples like the one shown above and the mentioned characteristics of JPEG coefficients are essential. The Discussion part of this article has a more thorough presentation of the results.

Although Benford's Law has shown promising results in detecting image forgeries, there are limitations to its application. For example, the accuracy of the method may be influenced by the size and quality of the dataset being analyzed. Additionally, further research is needed to evaluate the method's effectiveness in detecting various types of image forgeries and to identify its potential for future improvement.

III. PROBLEM STATEMENT OF SYSTEM

To detect the frauds in images to satisfy the need of authenticated photos and images to ensure legitimacy of them in this era of internet, where vast majority of images are fake. In order to establish the authenticity of an image various digital image forensics techniques are needed to be explored and evolved. Image statistics is a growing field in image analysis with many potential applications. In this world of growing technologies and internet, it is very important to have genuine ids and photos.

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IV. PROPOSED SOLUTION

In this study, we propose a method for detecting image fraud using Benford's Law applied to DCT coefficients. The proposed method involves the following steps:

Data Collection: We will use various datasets of images that contain different types of image fraud such as copy-move, splicing, and content-aware manipulations. We will collect a total of 1000 images, 500 of which will be manipulated and 500 unmanipulated.

DCT Transform: For each image in the dataset, we will apply the DCT transform and extract the DCT coefficients.

Benford's Law: We will apply Benford's Law to the first digit of the DCT coefficients to analyze their distribution. Benford's Law states that the probability of a digit being the first digit of a number follows a logarithmic distribution with an expected value of 0.301 for digit 1, 0.176 for digit 2, and so on. Like wise will apply this analysis to 2nd digit, last digit and last 2nd digit also.

First Digit Analysis: We will compare the observed first digit distribution of the DCT coefficients with the expected distribution under Benford's Law. We will use the chi-squared test to evaluate the similarity between the two distributions.

Second Digit Analysis, Last Digit Analysis and Second Lastt Digit Analysis

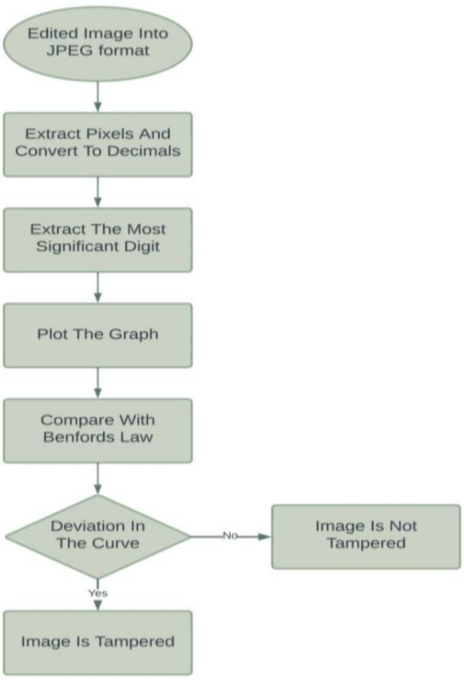
Classification: We will classify images as manipulated or unmanipulated based on the similarity between the observed and expected distributions. If the chi-squared test statistic exceeds a certain threshold, we will classify the image as manipulated. Alternatively, we will train a machine learning classifier, such as a support vector machine or neural network, to classify the images based on their first digit distribution.

Evaluation: We will evaluate the performance of the proposed method using standard metrics such as accuracy, precision, recall, and F1-score. We will also compare the proposed method with other state-of-the-art image fraud detection techniques, such as those based on machine learning algorithms.

Implementation: We will implement the proposed method using Python and the NumPy and SciPy libraries for numerical computing and statistical analysis. We will optimize the code for efficiency using parallel computing techniques and GPU acceleration.

Overall, the proposed method aims to provide an effective and efficient way to detect image fraud using Benford's Law applied to DCT coefficients. The proposed method has the potential to improve the accuracy of image fraud detection while minimizing false positives and false negatives.

V. FLOW CHART



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VI. CONCLUSION

The increasing use of digital images and advanced image editing software has made image forgery detection a major concern. Various techniques have been proposed for detecting image forgeries, including watermarking, machine learning algorithms, and statistical analysis. Among these techniques, Benford's Law has gained significant attention as a promising tool for detecting image forgeries.

Researchers have proposed several methods based on Benford's Law for detecting image forgeries. These methods use the distribution of the first digit of DCT coefficients or the intensity distribution histogram of images to detect various types of image forgeries, including copy-move and splicing forgeries. The accuracy of these methods has been reported to be high, and they have shown promising results in detecting content-aware manipulations and multiple compressions in images.

However, there are limitations to the application of Benford's Law in detecting image forgeries. The accuracy of the method may be influenced by the size and quality of the dataset being analyzed. Further research is needed to evaluate the method's effectiveness in detecting various types of image forgeries and to identify its potential for future improvement.

Overall, Benford's Law has shown promising results in detecting image forgeries, and its potential as a forensic tool for image analysis should not be overlooked. However, it should be used in conjunction with other techniques and further research is needed to fully understand its limitations and potential for improvement.

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