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This paragraph of the first footnote will contain support information, including sponsor and financial support acknowledgment. For example, "This work was supported in part by the U.S. Department of Commerce under Grant BS123456."

ABSTRACT This paper proposes a new method of tampered image detection by combining the CNN with a backbone of ResNet50 with ELA. Our method is designed for digital forensics, which is a very important domain for the detection and assessment of image modifications in many other domains, such as cybersecurity, journalism, and criminal investigations This procedure comprises image pre-processing to ascertain altered areas by comparing variations in compression levels to find compression artifacts using ELA. It serves as the foundation for reliable feature extraction: the ResNet50 model, pre-trained on ImageNet, has its basic layers frozen to preserve learned weights. For customization with regard to binary classification, some custom layers are appended on top: global average pooling, batch normalization, dense layers with ReLU, and dropout regularization. The architecture here comes up with a generator-based approach so that large datasets can be handled with better memory consumption, enabling real-time data preprocessing during training of models.Our methodology is assured to optimize resource utilization and enhance generalization, which has been evidenced with extensive experiments. The obtained model offers high accuracy and robustness in detecting tampered images; thus, it presents a scalable solution for real-world forensic applications. This integration of ELA and CNN provides the backbone of fast and accurate analysis of digital evidence to help in better decision-making in sensitive situations.

INDEX TERMS Tampered Image Detection, Error Level Analysis (ELA), Convolutional Neural Network (CNN), ResNet50, Digital Forensics, Image Manipulation Detection, Cybersecurity, Journalism, Criminal Investigations, Feature Extraction, Binary Classification, Data Preprocessing, Dropout Regularization, Compression Artifacts, Real-time Analysis, Scalable Forensic Applications.

I. INTRODUCTION

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Define abbreviations and acronyms the first time they are used in the text, even after they have already been defined in the abstract. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S." Do not use abbreviations in the title unless they are unavoidable (for example, "IEEE" in the title of this article).

B. OTHER RECOMMENDATIONS

Use one space after periods and colons. Hyphenate complex modifiers: "zero-field-cooled magnetization." Avoid dangling participles, such as, "Using (1), the potential was calculated." [It is not clear who or what used (1).] Write instead, "The potential was calculated by using (1)," or "Using (1), we calculated the potential."

Use a zero before decimal points: "0.25," not ".25." Use

"cm^3," not "cc." Indicate sample dimensions as "0.1 cm $\times$ 0.2 cm," not "0.1 $\times$ 0.2 cm^2." The abbreviation for "seconds" is "s," not "sec." Use "Wb/m^2" or "webers per square meter," not "webers/m^2." When expressing a range of values, write "7 to 9" or "7–9," not "7$\sim$9."

A parenthetical statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.) In American English, periods and commas are within quotation marks, like "this period." Other punctuation is "outside"! Avoid contractions; for example, write "do not" instead of "don't." The serial comma is preferred: "A, B, and C" instead of "A, B and C."

If you wish, you may write in the first person singular or plural and use the active voice ("I observed that ..." or "We observed that ..." instead of "It was observed that ..."). Remember to check spelling. If your native language is not English, please get a native English-speaking colleague to carefully proofread your paper.

Try not to use too many typefaces in the same article. Also please remember that MathJax can't handle really weird typefaces.

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Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

$$E = mc^2. \tag{1}$$

The following 2 equations are used to test your LaTeX compiler's math output. Equation (2) is your LaTeX compiler' output. Equation (3) is an image of what (2) should look like. Please make sure that your equation (2) matches (3) in terms of symbols and characters' font style (Ex: italic/roman).

$$\frac{47i + 89jk \times 10rym \pm 2npz}{(6XYZ\pi Ku)Aoq\sum_{i=1}^{r} Q(t)} \int_0^\infty f(g)\mathrm{d}x \sqrt[3]{\frac{abcdelqh^2}{(svw)\cos^3\theta}}. \tag{2}$$

$$\frac{47i + 89jk \times 10rym \pm 2npz}{(6XYZ\pi Ku)Aoq\sum_{i=1}^{r} Q(t)} \int_0^\infty f(g)\mathrm{d}x \sqrt[3]{\frac{abcdelqh^2}{(svw)\cos^3\theta}}. \tag{3}$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (T might refer to temperature, but T is the unit tesla). Refer to "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ... ."

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Please don't use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in LaTeX will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you've discovered a new method of counting.

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Do not use `\nonumber` inside the `{array}` environment. It will not stop equation numbers inside `{array}` (there won't be any anyway) and it might stop a wanted equation number in the surrounding equation.

II. UNITS

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary units (in parentheses). This applies to papers in data storage. For example, write "15 Gb/cm^2 (100 Gb/in^2)." An exception is when English units are used as identifiers in trade, such as "$3^{1/2}$-in disk drive." Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

The SI unit for magnetic field strength H is A/m. However, if you wish to use units of T, either refer to magnetic flux density B or magnetic field strength symbolized as $\mu_0 H$. Use the center dot to separate compound units, e.g., "A·m^2."

A. EXAMPLE TABLE

III. SOME COMMON MISTAKES

The word "data" is plural, not singular. The subscript for the permeability of vacuum μ_0 is zero, not a lowercase letter "o." The term for residual magnetization is "remanence"; the adjective is "remanent"; do not write "remnance" or "remnant." Use the word "micrometer" instead of "micron." A graph within a graph is an "inset," not an "insert." The word "alternatively" is preferred to the word "alternately" (unless you really mean something that alternates). Use the word "whereas" instead of "while" (unless you are referring to

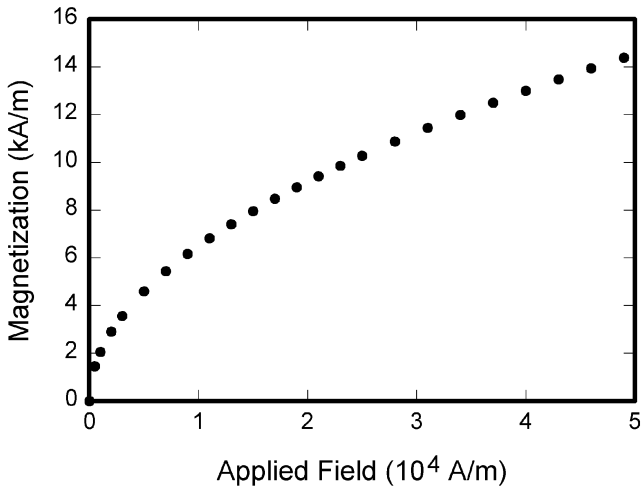

FIGURE 1. Magnetization as a function of applied field. It is good practice to explain the significance of the figure in the caption.

Literature	Dataset	Method	Result
Author et al. (2024) [1]	CICDDoS2019	CNNs	97.7%

TABLE 1. Literature Survey

simultaneous events). Do not use the word "essentially" to mean "approximately" or "effectively." Do not use the word "issue" as a euphemism for "problem." When compositions are not specified, separate chemical symbols by en-dashes; for example, "NiMn" indicates the intermetallic compound $Ni_{0.5}Mn_{0.5}$ whereas "Ni–Mn" indicates an alloy of some composition Ni_xMn_{1-x}.

Be aware of the different meanings of the homophones "affect" (usually a verb) and "effect" (usually a noun), "complement" and "compliment," "discreet" and "discrete," "principal" (e.g., "principal investigator") and "principle" (e.g., "principle of measurement"). Do not confuse "imply" and "infer."

Prefixes such as "non," "sub," "micro," "multi," and "ultra" are not independent words; they should be joined to the words they modify, usually without a hyphen. There is no period after the "et" in the Latin abbreviation "*et al.*" (it is also italicized). The abbreviation "i.e.," means "that is," and the abbreviation "e.g.," means "for example" (these abbreviations are not italicized).

A general IEEE styleguide is available at http://www.ieee.org/authortools.

IV. PROPOSED METHOD

In this paper, we demonstrate that combining ELA with CNN model while freezing the base layers and adding custom layers to the base model which will provide a significant increase in the robustness of the final model and significantly improve performance of the classification task to detect images, which are tampered. We explore this idea in the context of digital forensics, where the goals are to analyze the images and detect suspicious activity in the field of crime, journalism etc. Since digital forensics helps uncover activities and patterns, determine the root causes of incidents, and establish a chain of evidence admissible in court, it becomes essential to identify, recover, analyze and present digital evidence from electronic devices and digital storage. Additionally, an ELA based model helps in identifying the difference in various layers of the images to help us uncover the underlying changes made to the image that is suspected to be tampered with. The model allows us to help various fields where criminal investigations, legal disputes and cybersecurity incidents occur and images need to be analyzed quicky to help user make quick informed decisions. The following sections outline the details of each step in the process.

A. INITIALIZATION

The initialization of the framework is preprocessing the images based on the number of images available in the dataset, it corresponds to the total number of images which are categorized in two classes specifically: 1) Authentic and 2) Tampered. The classes with their labels are split initially to ensure we have a sizeable amount of image to work with, we ensure that the classes are not biased and are equally balanced to provide a robust model and reduce overfitting. The classes are initialized with ones and zeros, zero if the image is authentic and one if the image has been tampered. For images to get preprocessed, we need to handle a chuck of images at a time, which will require us to take images in batches to preprocess and analyze further.

After reshaping the images according to our input shape which will reduce the size of the image so that our next function would work effectively. Creating batches to handle memory overflow and preprocessing image before feeding them to the ELA function ensures that the system doesn't require a lot of resources and is more optimized to create a more robust model.

Further, we take each resized image and input it to our ELA function, this step is iterated over multiple images to get robust images with reduced quality to take forward for our ELA function.

B. ELA PROCESS WITH GENERATORS

For each image in our ELA function, we generate a buffer to save the original image to a temporary in-memory file with reduced quality, which helps us in reducing the overall memory utilization of the system. We load the compressed image from the buffer and calculate the difference between the original image and the one which was compressed to get the Pillow image object, this is a technique used in image forensics to detect tampering or inconsistencies in an image. We enhance the brightness of the image according to the extrema we get in the pillow image object.

This returns us the ELA image which is a new image that emphasizes regions with differing compression levels, useful for detecting tampering or manipulation. This image will highlight differences due to compression artifacts. To feed the image forward to the model for training, it requires the image to be converted to an array for numerical processing and is normalized making the data compatible with many machine learning models. We close the image further to free up resources and it is a good practice to avoid file locks or memory leaks, especially when processing multiple images in a loop. For the model to handle such large number of images at once would require a lot of resources, to tackle this issue we provide generators to the model.

These generators help in handle image preprocessing and feeding batches of data to the model during training. They are often used in deep learning workflows when the model requires to load images in batches and apply transformations or augmentation. Instead of loading all images into memory at once, generators load and process batches on-the-fly, reducing memory consumption. Generators often include on-the-fly preprocessing, which enhances the dataset and helps the model generalize better, increasing its robustness and generalizability for better performance. We also try to visualize the batch of images after the ELA function to ensure that the shape of the generator and preprocessed images are according to the requirements.

C. RESNET50 MODEL ARCHITECTURE WITH TRAINING EVOLUTION

In this study, we employ a Resnet50 model to classify the images into two categories (Authentic and Tampered), we use a transfer learning approach based on the ResNet50 architecture, pre-trained on ImageNet to solve our classification problem. This method capitalizes on the robust feature extraction capabilities of ResNet50, significantly reducing training time and computational resources while improving model accuracy. The model was customized to adapt the pre-trained base for the task by introducing additional trainable (Custom) layers specifically designed for binary classification.Figure 2: shows the architecture of the base model we have used featuring Resnet50 in a five-stage design to represent the overall function of the layers

The base of our architecture is the ResNet50 model, known for its depth and efficient handling of the vanishing gradient problem through residual connections. The model was loaded without the top layers, removing the full-connected top layers helped us retained only the convolutional layers which are responsible for extracting hierarchical features from the input images. The input shape was fixed to match the requirement of the model while ensuring compatibility with pre-trained weights. The freezing of all layers in the base model during training aimed at preserving the learned weights and keeping the feature extraction capability unaltered by the new task-specific data. To this binary classification problem, we attached five different types of custom layers to the base pre-trained model in an attempt to make it adapt. First, there is a global average pooling layer that reduces the high-dimensional feature maps output by ResNet50 into a single vector for each feature map, reducing the number of trainable parameters and hence improving generalization. Unlike the traditional Flatten layer, this preserves spatial information and improves model performance when using ResNet-based architectures. Further, we added batch normalization to normalize the activations from the pooling layer, reducing internal covariate shift and accelerating convergence.

Once we are done with that, we added a series of two dense layers. The first layer consists of 512 neurons providing substantial capacity to capture complex patterns. The second contains 256 neurons for further refinement of feature extraction. Both are activated by the ReLU activation function, which introduces non-linearity in deep networks and provides output zero for negative inputs, creating sparsity in the activations that could further be helpful in efficient computations with a reduction in overfitting. While being computationally less expensive than sigmoid or tanh function. The custom layers then involved a dropout regularization technique which was employed after each dense layer to with a rate of 0.75 after the first dense layer to impose strong regularization and rate of 0.5 was applied after the second dense layer for moderate regularization. This helped in preventing overfitting of the model during training. After dropout regularization, there was a single neuron in the output layer with sigmoid activation to predict the probability of the positive class, which is suitable for binary classification tasks.

It achieves a very good trade-off among accuracy, training efficiency, and robustness, making it pretty effective in real-world applications. This model was trained for more than 100 epochs with a step size of about 145 while capturing essential evaluation metrics such as accuracy, the f1 score, and validation accuracy. This will make sure we minimize the gap between the training and validation accuracy of the

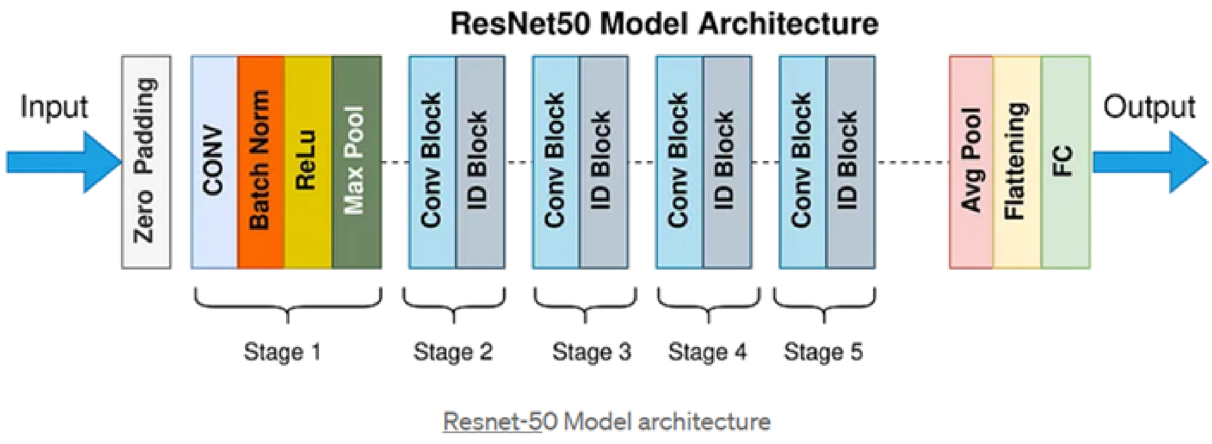

FIGURE 2. Architecture of the base model

model, which will be robust and very effective in real-world applications.

D. TYPES OF GRAPHICS

The following list outlines the different types of graphics published in IEEE journals. They are categorized based on their construction, and use of color/shades of gray:

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Figures that are meant to appear in color, or shades of black/gray. Such figures may include photographs, illustrations, multicolor graphs, and flowcharts. For multicolor graphs, please avoid any gray backgrounds or shading, as well as screenshots, instead export the graph from the program used to collect the data.

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Author photographs should be included with the author biographies located at the end of the article underneath References.

4) Tables

Data charts which are typically black and white, but sometimes include color.

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Figures compiled of more than one sub-figure presented side-by-side, or stacked. If a multipart figure is made up of multiple figure types (one part is lineart, and another is grayscale or color) the figure should meet the stricter guidelines.

TABLE 2. Units for Magnetic Properties

Symbol	Quantity	Conversion from Gaussian and CGS EMU to SI [a]
Φ	magnetic flux	1 Mx $\rightarrow 10^{-8}$ Wb $= 10^{-8}$ V·s
B	magnetic flux density, magnetic induction	1 G $\rightarrow 10^{-4}$ T $= 10^{-4}$ Wb/m^2
H	magnetic field strength	1 Oe $\rightarrow 10^3/(4\pi)$ A/m
m	magnetic moment	1 erg/G = 1 emu $\rightarrow 10^{-3}$ A·m^2 $= 10^{-3}$ J/T
M	magnetization	1 erg/(G·cm^3) = 1 emu/cm^3 $\rightarrow 10^3$ A/m
$4\pi M$	magnetization	1 G $\rightarrow 10^3/(4\pi)$ A/m
σ	specific magnetization	1 erg/(G·g) = 1 emu/g $\rightarrow$ 1 A·m^2/kg
j	magnetic dipole moment	1 erg/G = 1 emu $\rightarrow 4\pi \times 10^{-10}$ Wb·m
J	magnetic polarization	1 erg/(G·cm^3) = 1 emu/cm^3 $\rightarrow 4\pi \times 10^{-4}$ T
χ, κ	susceptibility	$1 \rightarrow 4\pi$
χ_ρ	mass susceptibility	1 cm^3/g $\rightarrow 4\pi \times 10^{-3}$ m^3/kg
μ	permeability	$1 \rightarrow 4\pi \times 10^{-7}$ H/m $= 4\pi \times 10^{-7}$ Wb/(A·m)
μ_r	relative permeability	$\mu \rightarrow \mu_r$
w, W	energy density	1 erg/cm^3 $\rightarrow 10^{-1}$ J/m^3
N, D	demagnetizing factor	$1 \rightarrow 1/(4\pi)$

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

[a]Gaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

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Most charts, graphs, and tables are one column wide (3.5 inches/88 millimeters/21 picas) or page wide (7.16 inches/181 millimeters/43 picas). The maximum depth a graphic can be is 8.5 inches (216 millimeters/54 picas). When choosing the depth of a graphic, please allow space for a caption. Figures can be sized between column and page widths if the author chooses, however it is recommended that figures are not sized less than column width unless when necessary.

There is currently one publication with column measurements that do not coincide with those listed above. Proceedings of the IEEE has a column measurement of 3.25 inches (82.5 millimeters/19.5 picas).

The final printed size of author photographs is exactly 1 inch wide by 1.25 inches tall (25.4 millimeters × 31.75 millimeters/6 picas × 7.5 picas). Author photos printed in editorials measure 1.59 inches wide by 2 inches tall (40 millimeters × 50 millimeters/9.5 picas × 12 picas).

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The term color space refers to the entire sum of colors that can be represented within the said medium. For our purposes, the three main color spaces are Grayscale, RGB (red/green/blue) and CMYK (cyan/magenta/yellow/black). RGB is generally used with on-screen graphics, whereas CMYK is used for printing purposes.

All color figures should be generated in RGB or CMYK color space. Grayscale images should be submitted in Grayscale color space. Line art may be provided in grayscale OR bitmap colorspace. Note that "bitmap colorspace" and "bitmap file format" are not the same thing. When bitmap color space is selected, .TIF/.TIFF/.PNG are the recommended file formats.

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A safe option when finalizing your figures is to strip out the fonts before you save the files, creating "outline" type. This converts fonts to artwork what will appear uniformly on any screen.

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1) Figure Axis labels

Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity "Magnetization," or "Magnetization M," not just "M." Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write "Magnetization (A/m)" or "Magnetization ($A{\cdot}m^{-1}$)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (10^3 A/m)." Do not write "Magnetization (A/m) × 1000" because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 10 point type.

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Figures (line artwork or photographs) should be named starting with the first 5 letters of the author's last name. The next characters in the filename should be the number that represents the sequential location of this image in your article. For example, in author "Anderson's" paper, the first three figures would be named ander1.tif, ander2.tif, and ander3.ps.

Tables should contain only the body of the table (not the caption) and should be named similarly to figures, except that '.t' is inserted in-between the author's name and the table number. For example, author Anderson's first three tables would be named ander.t1.tif, ander.t2.ps, ander.t3.eps.

Author photographs should be named using the first five characters of the pictured author's last name. For example, four author photographs for a paper may be named: oppen.ps, moshc.tif, chen.eps, and duran.pdf.

If two authors or more have the same last name, their first initial(s) can be substituted for the fifth, fourth, third... letters of their surname until the degree where there is differentiation. For example, two authors Michael and Monica Oppenheimer's photos would be named oppmi.tif, and oppmo.eps.

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Because IEEE will do the final formatting of your paper, you do not need to position figures and tables at the top and bottom of each column. In fact, all figures, figure captions, and tables can be placed at the end of your paper. In addition to, or even in lieu of submitting figures within your final manuscript, figures should be submitted individually, separate from the manuscript in one of the file formats listed above in Section IV-F. Place figure captions below the figures; place table titles above the tables. Please do not include captions as part of the figures, or put them in ''text boxes'' linked to the figures. Also, do not place borders around the outside of your figures.

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All IEEE Transactions, Journals, and Letters allow an author to publish color figures on IEEE *Xplore*® at no charge, and automatically convert them to grayscale for print versions. In most journals, figures and tables may alternatively be printed in color if an author chooses to do so. Please note that this service comes at an extra expense to the author. If you intend to have print color graphics, include a note with your final paper indicating which figures or tables you would like to be handled that way, and stating that you are willing to pay the additional fee.

V. CONCLUSION

This study is essential in maintaining integrity is crucial in fields like Law enforcement, Cyber security, and Legal investigations. In this project, we aimed to design a robust system capable of determining whether an image is tampered with. The research compares the performance of two widely known CNN models, VGG16 and ResNet50, with traditional preprocessing methods like ELA and data augmentation. The project concludes with viable results that taking colour inconsistencies and compression differences significantly improves model capability compared to conventional grayscale-based ELA methods.The system can be integrated into social media to moderate content in real-time, flagging misleading images and advancing platform integrity. In journalism, it makes sure that media is authentic by verifying images before publication; this helps in debunking fake news and fosters ethical reporting as a way of maintaining the public's trust in digital journalism.Although promising performance may be seen in the CASIA v2 dataset, it does not generalize upon exposure to other datasets or real-world scenarios. This needs to be handled in future work by enrichment of the dataset with diversity and updates for further strengthening the resistance and longevity of the model. Moreover, interpreting it with Explainable AI by using Grad-CAM will illustrate the regions of interest influential in the model's choices for transparent decisions and gaining the trust of the users. The dataset and code for further research are available [here] and [repository link].

ACKNOWLEDGMENT

The preferred spelling of the word ''acknowledgment'' in American English is without an ''e'' after the ''g.'' Use the singular heading even if you have many acknowledgments. Avoid expressions such as ''One of us (S.B.A.) would like to thank . . . .'' Instead, write ''F. A. Author thanks . . . .'' In most cases, sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page, not here.

REFERENCES

[1] A. Chandio, G. Gui, T. Kumar, I. Ullah, R. Ranjbarzadeh, A. M. Roy, A. Hussain, and Y. Shen, ''Precise single-stage detector,'' 2022.

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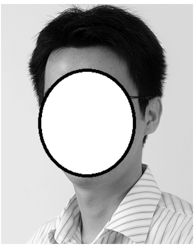
Dr. Author was a recipient of the International Association of Geomagnetism and Aeronomy Young Scientist Award for Excellence in 2008, and the IEEE Electromagnetic Compatibility Society Best Symposium Paper Award in 2011.

SECOND B. AUTHOR (M'76–SM'81–F'87) and all authors may include biographies. Biographies are often not included in conference-related papers. This author became a Member (M) of IEEE in 1976, a Senior Member (SM) in 1981, and a Fellow (F) in 1987. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state, and country, and year the degree was earned. The author's major field of study should be lower-cased.

The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (publisher name, year) similar to a reference. Current and previous research interests end the paragraph.

The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, it should be of good quality, and professional-looking. Following are two examples of an author's biography.



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