# Red Lesion Segmentation for Diabetic Retinopathy

1st Kartikeya Pusapati
*Ctech*
*SRMIST)*
Chennai, India
kartikeyapusapati@gmail.com

2nd Haresh Kothamandaram
*CTECH*
*SRMIST*
Chennai, India

*Abstract*—Diabetic retinopathy (DR) is a leading cause of vision loss, with early detection of red lesions (microaneurysms and hemorrhages) being critical for timely intervention. This paper presents a hybrid approach combining advanced morphological preprocessing—including CLAHE, green channel enhancement, and optic disc suppression—with a dual-branch deep learning model (ResNet50 and EfficientNetB0 fusion) for robust red lesion segmentation. The method is evaluated on large-scale, augmented datasets and demonstrates superior accuracy and efficiency compared to traditional and recent state-of-the-art techniques.

## I. INTRODUCTION

Diabetic retinopathy is a microvascular complication of diabetes, manifesting as various retinal lesions, including microaneurysms, hemorrhages, and exudates. Red lesions, in particular, are early indicators of DR progression and are essential for disease grading and management. Automated, accurate, and efficient detection of these lesions is vital for large-scale screening and clinical decision support.

Recent advances in deep learning have significantly improved lesion detection and grading. However, challenges remain in segmenting small, low-contrast lesions and reducing false positives, especially in the presence of anatomical structures like blood vessels and the optic disc. This work addresses these challenges by integrating robust preprocessing with a hybrid CNN architecture.

## II. RELATED WORK

### A. 1.1 Morphological and Traditional Approaches

Early methods focused on intensity and morphological features, often using the green channel for its superior vessel and lesion contrast. Techniques such as directional intensity analysis, region growing, and shape-based filtering have achieved sensitivities up to 0.88 on standard datasets like Diaretdb1. Recent work by Zarei et al. introduced a boundary pixel analysis method, leveraging intensity changes in all directions to distinguish red lesions from vessels, achieving high sensitivity and specificity with efficient computation.

Other approaches model red lesions as roundish, dark regions and use pixel-wise verification in curved neighborhoods,

reducing the need for complex vessel or optic disc segmentation. These methods, while computationally efficient, may struggle with variable image quality and require careful feature engineering. Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

### B. Deep Learning and Hybrid Models

- Deep learning, particularly CNNs, has revolutionized DR lesion detection. Models such as U-Net, ResNet, and EfficientNet have been applied for both classification and segmentation tasks, often outperforming traditional methods. Hybrid approaches that combine handcrafted features with deep features, or fuse multiple CNN backbones, have shown further improvements in accuracy and robustness.
- Recent multi-model systems integrate image enhancement (e.g., CLAHE), object detection (YOLO variants), and severity grading, achieving mAP scores above 97 and classification accuracies above 98 on diverse datasets. However, these systems often require large, well-annotated datasets and significant computational resources.

## III. METHODOLOGY

### A. Preprocessing Pipeline

- CLAHE on LAB L-channel: Enhances global and local contrast, making subtle lesions more visible.
- Green Channel Enhancement: Further contrast improvement, as the green channel best highlights red lesions and vessels.
- Morphological Operations: Black-hat and top-hat filtering accentuate dark (red lesions) and bright (exudates) regions, respectively.
- Optic Disc Suppression: Hough circle detection and inpainting remove the optic disc, reducing false positives.
- Gamma Correction and Normalization: Standardizes intensity distribution for robust model input.

## B. Deep Learning and Hybrid Models

- Deep learning, particularly CNNs, has revolutionized DR lesion detection. Models such as U-Net, ResNet, and EfficientNet have been applied for both classification and segmentation tasks, often outperforming traditional methods. Hybrid approaches that combine handcrafted features with deep features, or fuse multiple CNN backbones, have shown further improvements in accuracy and robustness.
- Recent multi-model systems integrate image enhancement (e.g., CLAHE), object detection (YOLO variants), and severity grading, achieving mAP scores above 97 and classification accuracies above 98 on diverse datasets. However, these systems often require large, well-annotated datasets and significant computational resources.

## C. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

## D. LaTeX-Specific Advice

Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

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.

BibTeX does not work by magic. It doesn't get the bibliographic data from thin air but from .bib files. If you use BibTeX to produce a bibliography you must send the .bib files.

LaTeX can't read your mind. If you assign the same label to a subsubsection and a table, you might find that Table I has been cross referenced as Table IV-B3.

LaTeX does not have precognitive abilities. If you put a `\label` command before the command that updates the counter it's supposed to be using, the label will pick up the last counter to be cross referenced instead. In particular, a `\label` command should not go before the caption of a figure or a table.

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.

## E. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum $\mu_0$, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- 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).
- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [7].

## F. Authors and Affiliations

**The class file is designed for, but not limited to, six authors.** A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

## G. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

## H. Figures and Tables

*a) Positioning Figures and Tables:* Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1", even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

| Table Head | Table Column Head | | |
|---|---|---|---|
| | *Table column subhead* | *Subhead* | *Subhead* |
| copy | More table copy[a] | | |

[a]Sample of a Table footnote.
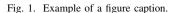


Fig. 1. Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization $\{A[m(1)]\}$", not just "A/m". Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)", not "Temperature/K".

## REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first . . ."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

## REFERENCES

[1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

IEEE conference templates contain guidance text for composing and formatting conference papers. Please ensure that all template text is removed from your conference paper prior to submission to the conference. Failure to remove the template text from your paper may result in your paper not being published.