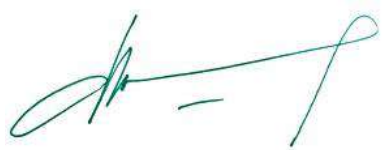
Cover Letter.

Dear Editor-in-Chief Jurnal Elektronika dan Telekomunikasi,

We have completed of the manuscript with the title Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks based on the point-to-point reviewer's comments. This manuscript is original and has never been published or submitted to another journal. This manuscript is original and has never been published or submitted to another journal. We have tried to write this manuscript well. Please consider being published by this trusted journal.

Thank you very much.

Sincerely Yours,



Julian Supardi, Ph.D.

Department of Informatics Engineering, Sriwijaya University, Indonesia.

Tel: (0711) 379249 / Hp. 081242276614

Email: julian@unsri.ac.id

Editor/Author Correspondence

Section Editor	Delete
2024-09-02 09:32 AM	Subject: [JET] Editor Decision

The following message is being delivered on behalf of Jurnal Elektronika dan Telekomunikasi.

Dr. Julian Supardi:

We have reached a decision regarding your submission to Jurnal Elektronika dan Telekomunikasi, "Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks".

Our decision is: Revisions Required

The author has to submit the revised manuscript along with a point-by-point response to the reviewer's comments. Please fill-up the form from the link below to explain your revisions and respond to the reviewers' and editor's comments.
For comments those you choose not to implement, please include a detailed reason why you think a change is inappropriate. Submit this form, along with your revised version of your manuscript once it finished. You can submit this form by click on ADD A SUPPLEMENTARY FILE on Summary Page.

Please submit your revision version through tab "REVIEW" > "editor decision"> "upload author version". We would appreciate a revision by {$reviewDueDate}.

here are some notes before uploaded revision manuscript:
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2. Complete metadata including author's name, author's affiliation, etc.
3. All authors are recommended to use Mendeley Desktop as a tool for reference management and formatting. Installation guidelines of JET reference style can be downloaded at https://www.jurnalet.com/public/JETMendeley.pdf
All authors also should provide all references as a single BibTex file, then upload them as a supplementary file.

I look forward to receiving your revision.

Marlin Ramadhan Baidillah
National Research and Innovation Agency (BRIN)
marlin.ramadhan.baidillah@brin.go.id

Reviewer A:

Presentation and organization
(Title, Abstract, Introduction, Method, Results and Discussion, Conclusion, Language)
• Is the paper well written enough for evaluation of technical content?
• Does the title reflect the contents of the paper?
• Does the abstract describe the essential information in the work?
• Does the introductory section adequately explain the framework and problems of the research?
• Are the importance and usefulness of this research work clear?
• Were the methods adequately described and was the method appropriate to answer the question posed?
• Are the results presented clearly and discussed satisfactorily?
• Are conclusions logically derived from the data presented? Are the figures and tables easily readable, correct and informative?
• Are sufficient references cited for providing a background to the research?
Please provide your detailed comments to the Author(s) on the following.
:
This study explains how to improve the resolution of satellite-based data using the CNN algorithm. The writing is generally reasonable. However, this scientific paper has several things that need to be improved, such as the following points:
1. The abstract does not show concrete research results, such as the percentage of success of the method or the results of the evaluation matrix carried out
2. In the initial part of the explanation of the proposed method, it would be better to explain the methods carried out previously as another perspective of the proposed method.
3. Can you elaborate on what is meant by SSIM and PSNR to clarify the readers of this article

Originality, scientific sound of the paper and its contribution to the field
• How original and creative are the idea and approach?
• Does the paper contain major or significant contribution adequate to justify publication?
• Have any parts of the paper already been published or considered for other publication?
• Is the paper scientifically sound and not misleading?
• Does it provide sufficient information and in-depth discussion?
Please provide your detailed comments to the Author(s) on the following.:
This article proposes a method for improving the resolution of data derived from satellite imagery. The proposed method is commendable because it provides enough information for readers to discuss in depth. The article is scientifically sound and not misleading.

Reviewer C:

Presentation and organization
(Title, Abstract, Introduction, Method, Results and Discussion, Conclusion, Language)
• Is the paper well written enough for evaluation of technical content?
• Does the title reflect the contents of the paper?
• Does the abstract describe the essential information in the work?
• Does the introductory section adequately explain the framework and problems of the research?
• Are the importance and usefulness of this research work clear?
• Were the methods adequately described and was the method appropriate to answer the question posed?
• Are the results presented clearly and discussed satisfactorily?
• Are conclusions logically derived from the data presented? Are the figures and tables easily readable, correct and informative?
• Are sufficient references cited for providing a background to the research?
Please provide your detailed comments to the Author(s) on the following.
:
First of all, the paper demonstrates potential but requires significant improvement in several areas.

Title: The title is really represent the manuscript, the concept idea can be easily grasp from it.
Abstract: The abstract is insufficiently detailed. It should clearly state the problem, provide a concise overview of the proposed method (beyond simply mentioning CNN), and include quantitative results (PSNR/SSIM values).
Introduction: While the introduction is well-written, it underemphasizes the importance of high PSNR/SSIM values. A stronger justification for pursuing these metrics is necessary.
Method: The method section is unclear and lacks essential details. Data preparation is not described, and the network architecture is inconsistent. The illustration should include all layers, and the role of the bicubic connection should be explained. Additionally, the concatenation block with only one input and the unconnected block require clarification. A flowchart would improve the overall understanding of the workflow.
Results: The presentation of both quantitative and qualitative results is effective.
Conclusion: The conclusion is well-supported by the results. Figures and data visualizations are clear and easy to interpret.
References: The reference list is adequate.

Originality, scientific sound of the paper and its contribution to the field

• How original and creative are the idea and approach?
• Does the paper contain major or significant contribution adequate to justify publication?
• Have any parts of the paper already been published or considered for other publication?
• Is the paper scientifically sound and not misleading?
• Does it provide sufficient information and in-depth discussion?
Please provide your detailed comments to the Author(s) on the following.:
Upscaling techniques have been extensively explored, particularly in the field of super-resolution. However, there is always room for improvement in terms of performance. The paper surely offers a contribution to the field, however, the extent of its contribution to the field is somewhat limited (from reviewer point of view). With clearer explanations of the methodology, the paper has the potential to be scientifically sound. While the paper is lack of in-depth discussion of the results (which would enhance the paper's impact if its there), the sufficient information is presented.

Reviewer D:

Presentation and organization
(Title, Abstract, Introduction, Method, Results and Discussion, Conclusion, Language)
• Is the paper well written enough for evaluation of technical content?
• Does the title reflect the contents of the paper?
• Does the abstract describe the essential information in the work?
• Does the introductory section adequately explain the framework and problems of the research?
• Are the importance and usefulness of this research work clear?
• Were the methods adequately described and was the method appropriate to answer the question posed?
• Are the results presented clearly and discussed satisfactorily?
• Are conclusions logically derived from the data presented? Are the figures and tables easily readable, correct and informative?
• Are sufficient references cited for providing a background to the research?
Please provide your detailed comments to the Author(s) on the following.
:
1. Regarding Figure 1, you don't need to put the image in the introduction section
2. Still related to the introduction too, you mention a lot of concepts without being based on citations, please pay attention and correct them.
3. You don't explain what kind of research gap you want to solve. Please fix it

Originality, scientific sound of the paper and its contribution to the field
• How original and creative are the idea and approach?

• Does the paper contain major or significant contribution adequate to justify publication?
• Have any parts of the paper already been published or considered for other publication?
• Is the paper scientifically sound and not misleading?
• Does it provide sufficient information and in-depth discussion?
Please provide your detailed comments to the Author(s) on the following.:
This paper has a good contribution to satellite image data processing.

Jurnal Elektronika dan Telekomunikasi
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Section Editor Delete

2024-09-12 11:32 AM

Subject: [JET] Editor Decision

The following message is being delivered on behalf of Jurnal Elektronika dan Telekomunikasi.

Dr. Julian Supardi:

Regarding our prior decision, which is "Revision Required", towards your submission to Jurnal Elektronika dan Telekomunikasi, "Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks"; we would like to inform you that we would appreciate a revision by 4 October 2024.

We look forward to receiving your revision.

Dr. Purnomo Husnul Khotimah
National Research and Innovation Agency
purn005@brin.go.id

Jurnal Elektronika dan Telekomunikasi
http://www.jurnalet.com

Cover Letter.

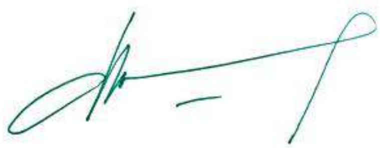
Dear Editor-in-Chief Jurnal Elektronika dan Telekomunikasi,

We have completed the revision of the manuscript with the title Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks based on the point-to-point reviewer's comments. We hope that the responses given are those suggested or asked by the reviewer.

We have checked the revision of the manuscript. Please consider being published by this trusted journal.

Thank you very much.

Sincerely Yours,



Julian Supardi, Ph.D.
Department of Informatics Engineering, Sriwijaya University, Indonesia.
Tel: (0711) 379249 / Hp. 081242276614
Email: julian@unsri.ac.id

Author’s Response to the Review Comments

Journal : **Jurnal Elektronika dan Telekomunikasi**

Title of Paper : **Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks**

We appreciate the time and efforts by the editor and referees in reviewing this manuscript. We have addressed all issues indicated in the review report, and believed that the revised version can meet the journal publication requirements. We have included the line numbers in the revised manuscript to help the reviewers identify our changes.

Comment	Response	Location of Response in Revised Manuscript
EDITOR’S COMMENTS		
The author has to submit the revised manuscript along with a point-by-point response to the reviewer's comments. Please fill-up the form from the link below to explain your revisions and respond to the reviewers' and editor's comments. For comments those you choose not to implement, please include a detailed reason why you think a change is inappropriate. Submit this form, along with your revised version of your manuscript once it finished. You can submit this form by click on ADD A SUPPLEMENTARY FILE on Summary Page.	Thank you verymuch for your comments, We have completed the revision of the manuscript based on the point-to-point reviewer's comments. We hope that the responses given are in accordance with those suggested or asked by the reviewer.	
REVIEWER 1 COMMENTS		
1. The abstract does not show concrete research results, such as the percentage of success of the method or the results of the evaluation matrix carried out	We have added the sentence to the abstract: “To validate the effectiveness of our proposed method, we employed Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) as evaluation metrics. The test datasets consisted of Landsat-8 images, which were segmented into three Regions of Interest (ROI) of sizes 16x16 pixels, 24x24 pixels, and 32x32 pixels. The experimental results demonstrate that the PSNR/SSIM values achieved were 28.94/0.822, 30.24/0.089, and 33.24/0.925 for each respective ROI. These results indicate that the proposed method outperforms several state-of-the-	Page 1, sec. Abstract

Comment	Response	Location of Response in Revised Manuscript
	art techniques in terms of PSNR and SSIM”	
2. In the initial part of the explanation of the proposed method, it would be better to explain the methods carried out previously as another perspective of the proposed method.	We have added the sentence to the Method section: “ To solve the challenge of detecting small objects in remote sensing images, Gan et al. [23] proposed a method that employed a novel edge-enhanced super-resolution GAN (EESRGAN) to enhance the quality of remote sensing images. The method integrated various detector networks in an end-to-end approach. The detector loss was backpropagated into the EESRGAN to optimize detection performance. Furthermore, Zhao et. al. [24] proposed a method consist of two parts architecture: a degraded reconstruction-assisted enhancement branch and a detection branch. Herenafter, Chung et. al [25] proposed a method using bicubic and generative adversarial network (BLG-GAN).	In first columns on page 2.
3. Can you elaborate on what is meant by SSIM and PSNR to clarify the readers of this article	We have added the subsection F to the Method: F. Measurement and Validate To measure the effectiveness of the proposed method, we employ standard metrics commonly used to assess the quality of transformed images, specifically Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM). PSNR compares the maximum signal level of the original image with the noise that appears after the transformation process (output image). Meanwhile, SSIM evaluates the structural and visual information between the output image and the original image. Mathematically, PSNR is calculated using Equation 6, while SSIM is determined by Equation 7.	The first columns on page 4.
REVIEWER 2 COMMENTS		
This article proposes a method for improving the resolution of data derived from satellite imagery. The proposed method is commendable because it provides enough information for readers to discuss in depth. The article is scientifically sound and not misleading.	Thank you very much for your comments.	
REVIEWER 3 COMMENTS		
The abstract is insufficiently detailed. It should clearly state the problem, provide a concise overview of the proposed method (beyond simply mentioning CNN), and include quantitative	In abstract we have added: Our proposed method consists of two main parts: the first part focuses on feature extraction, while the second part	Page 1

Comment	Response	Location of Response in Revised Manuscript
results (PSNR/SSIM values).	is dedicated to image reconstruction. The feature extraction component includes 25 convolutional layers, whereas the reconstruction component comprises 100 convolutional layers. To validate the effectiveness of our proposed method, we employed Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) as evaluation metrics. The test datasets consisted of Landsat-8 images, which were segmented into three Regions of Interest (ROI) of sizes 16x16 pixels, 24x24 pixels, and 32x32 pixels. The experimental results demonstrate that the PSNR/SSIM values achieved were 28.94/0.822, 30.24/0.089, and 33.24/0.925 for each respective ROI. These results indicate that the proposed method outperforms several state-of-the-art techniques in terms of PSNR and SSIM.	
While the introduction is well-written, it underemphasizes the importance of high PSNR/SSIM values. A stronger justification for pursuing these metrics is necessary	In Introduction we have added: Improving image quality is essential for addressing the challenges associated with object detection in remote-sensing images. This enhancement is typically evaluated using two standard metrics in image processing: PSNR and SSIM. In this context, higher PSNR and SSIM values indicate superior image quality.	Page 1
The method section is unclear and lacks essential details. Data preparation is not described, and the network architecture is inconsistent. The illustration should include all layers, and the role of the bicubic connection should be explained	In Method, we have adding: The datasets used in this study are of two types, namely data for training and data for testing. Data for testing comes from Yang et al. [4] and the Berkeley Segmentation Database [5]. Both databases contain high-resolution images. The data sizes vary. Both databases are commonly used in image resolution improvement research, such as in [6][7][8]. The next data is data for testing. This data is obtained from remote sensing images produced by the Lansat 8 satellite, which is downloaded from the website https://www.usgs.gov/.	
Additionally, the concatenation block with only one input and the unconnected block require clarification. A flowchart would improve the overall understanding of the workflow.	We have added a more detailed explanation to the proposed method. We have breakdown the CNN architecture become 3 Figures detail, furthermore providing detailed descriptions, and adding a general algorithm for the proposed method,	Page 2-4
The presentation of both quantitative and qualitative results is effective.	Thank you for your comment	

Comment	Response	Location of Response in Revised Manuscript
Conclusion: The conclusion is well-supported by the results. Figures and data visualizations are clear and easy to interpret		
The reference list is adequate	Thank you for your comment	
Upscaling techniques have been extensively explored, particularly in the field of super-resolution. However, there is always room for improvement in terms of performance. The paper surely offers a contribution to the field, however, the extent of its contribution to the field is somewhat limited (from reviewer point of view). With clearer explanations of the methodology, the paper has the potential to be scientifically sound. While the paper is lack of in-depth discussion of the results (which would enhance the paper's impact if its there), the sufficient information is presented.	Thanks to the positive feedback from the reviewers, we have added a more detailed explanation to improve the understanding of the proposed method. In this study, we developed an architecture aimed at enhancing the quality of remote sensing images. The CNN architecture we propose is novel and constitutes a key contribution of this article. Additionally, the partitioning mechanism based on the region of interest enables the enlargement of remote sensing images to be performed even on computers with relatively modest specifications.	
REVIEWER 4 COMMENTS		
aRegarding Figure 1, you don't need to put the image in the introduction section	We have removed the Figure 1 in the introduction	The second column on Page 1
Still related to the introduction too, you mention a lot of concepts without being based on citations, please pay attention and correct them	We have added the subsection citation on concept in introduction section, such as in the firt paragraph " AI algorithms can be divided into two broad categories: algorithms that imitate animal behavior[1] and algorithms based on humans thinking[2]" and the second paragraph: One branch of AI that has developed very rapidly in the past decade is Deep Learning, which is an extension of Artificial Neural Networks[3].	The first and second paragraph on the page 1
You don't explain what kind of research gap you want to solve. Please fix it	Several methods have been proposed to address the problem of increasing image resolution, including bicubic interpolation, SRCNN, and DCSCN. However, the results still require improvement, especially when dealing with images that have extremely low resolution, such as object images in remote sensing data.	The second and third paragraph on the first column on page 2
This paper has a good contribution to satellite image data processing.	Thank you very much for your commnet and suggestion.	

Sincerely Yours,

Julian Supardi, Ph.D.

Department of Informatics Engineering,

Sriwijaya University, Indonesia.

Tel: (0711) 379249 / Hp. 081242276614

Email: julian@unsri.ac.id

JET Editor/Author Correspondence - Google Chrome

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Editor/Author Correspondence

Section Editor
2024-09-02 09:32 AM

Subject: [JET] Editor Decision

DELETE

The following message is being delivered on behalf of Jurnal Elektronika dan Telekomunikasi.

Dr. Julian Supardi:

We have reached a decision regarding your submission to Jurnal Elektronika dan Telekomunikasi, "Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks".

Our decision is: Revisions Required

The author has to submit the revised manuscript along with a point-by-point response to the reviewer's comments. Please fill-up the form from the link below to explain your revisions and respond to the reviewers' and editor's comments.
For comments those you choose not to implement, please include a detailed reason why you think a change is inappropriate. Submit this form, along with your revised version of your manuscript once it finished. You can submit this form by click on ADD A SUPPLEMENTARY FILE on Summary Page.

Please submit your revision version through tab "REVIEW" > "editor decision"> "upload author version". We would appreciate a revision by {$reviewDueDate}.

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https://www.jurnalet.com/public/JET_Review_Response.docx
2. Complete metadata including author's name, author's affiliation, etc.
3. All authors are recommended to use Mendeley Desktop as a tool for reference management and formatting. Installation guidelines of JET reference style can be downloaded at https://www.jurnalet.com/public/JETMendeley.pdf
All authors also should provide all references as a single BibTex file, then upload them as a supplementary file.

I look forward to receiving your revision.

Marlin Ramadhan Baidillah
National Research and Innovation Agency (BRIN)
marlin.ramadhan.baidillah@brin.go.id

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10:46 PM
9/24/2024

Cover Letter.

Dear Editor-in-Chief Jurnal Elektronika dan Telekomunikasi,

We have completed the second round revision of the manuscript with the title Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks based on the point-to-point review comments from editor. We hope that the responses given are those suggested or asked by the editor. We have checked the revision of the manuscript. Please consider being published by this trusted journal.

Thank you very much.

Sincerely Yours,

Julian Supardi, Ph.D.
Department of Informatics Engineering, Sriwijaya University, Indonesia.
Tel: (0711) 379249 / Hp. 081242276614
Email: julian@unsri.ac.id

Author’s Response to the Review Comments

Journal : **Jurnal Elektronika dan Telekomunikasi**

Title of Paper : **Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks**

We appreciate the time and efforts by the editor and referees in reviewing this manuscript. We have addressed all issues indicated in the review report, and believed that the revised version can meet the journal publication requirements. We have included the line numbers in the revised manuscript to help the reviewers identify our changes.

Comment	Response	Location of Response in Revised Manuscript
EDITOR’S COMMENTS		
Review comments from Section Editor: 1. In figure 3 and 4, define clearly each variable. Also, the bias symbol is not consistence, I found it is as "b" in other parts it is as "B". please check the consistency of all variables.	We have revised the ambigu notation of B became OP1(output of Part-1) in Figure 3 and Figure 4	Page 3, Columns 1 (figure 3) and page 4, columns 1 (figure 4)
2. Usually variables in bold type is for vector. use consistency the font type of all variables.	We have revised the bold type based on recommendation	Page 4, sections D, Column 2.
3. The figure size of figure 5 is not proportional. make it more better.	We have changed image 5 with a clearer and more proportional image as per your suggestion.	Page 5. Column 2.
4. The discussion part should consider the different or comparison accuracy results between this study and the published studies	Since this study focuses on image enhancement, the evaluation of our method’s superiority over existing methods is based on the quality of the output images. In this context, image quality is typically measured using the Structural Similarity Index (SSIM) and Peak Signal-to-Noise Ratio (PSNR), which are standard metrics widely used by researchers. Therefore, we have thus revised section B: “In this experiment, we compare the result from our proposed method with previous methods widely used to improve the quality of low-resolution images, i.e. Bicubic, SRCNN [35], SRCNN-IBP [36], DRL [37], DCSCN [38]. These	Page 6, columns 1 and 2.

Comment	Response	Location of Response in Revised Manuscript
	five methods are considered very well and are commonly used in the wider world. The results of comparison obtained can be seen visually from Figure 8, while mathematically the comparison of PSNR and SSIM from each method is presented in Table 3 As illustrated in Figure 8, the images generated by the our method exhibit superior visual quality compared to those produced by previously established methods. This observation is further substantiated by the quantitative results, specifically the SSIM and PSNR values presented in Table 3. The SSIM and PSNR values for all partition sizes (i.e. 16×16 pixels, 24×24 pixels, and 32×32 pixels) indicate that the quality of the images produced by the proposed method is consistently higher compared to existing methods. Accordingly, it can be concluded that the proposed method outperforms existing approaches.	

Jurnal Elektronika dan Telekomunikasi (JET), Vol. 24, No. 2, December 2024, pp. 112-119
Accredited by KEMDIKBUDRISTEK, Decree No: 158/E/KPT/2021
doi: 10.55981/jet.653

Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks

Julian Supardi [a], [*], Samsuryadi Samsuryadi [~~b~~][a], Hadipurnawan ~~Satria~~[~~c~~] Satria [a], Philip Alger M. ~~Serrano~~[~~d~~] Serrano [b], ~~Arnelawati~~[~~e~~] Arnelawati Arnelawati [a]

[a][~~, b, c, e~~] Depart~~e~~ment of Informatics Engineering
Sriwijaya ~~Unverisity~~ University
Jl. Srijaya Negara-Bukit Besar,
Palembang, Indonesia 30129
[~~d~~] ~~College~~ [b] College of Computer Studies
Camarines Sur Polytechnic Colleges,
San Miguel, Nabua, Camarines Sur, Philippines 4434

~~julian@unsri.ac.id~~

Abstract

Remote sensing imagery is a very interesting topic for researchers, especially in the fields of image and pattern recognition. Remote sensing images differ from ordinary images taken with conventional cameras. Remote sensing images are captured from satellite photos taken far above the Earth's surface. As a result, objects in satellite images appear small and have low resolution when enlarged. This condition makes it difficult to detect and recognize objects in remote-sensing images. However, detecting and recognizing objects in these images is crucial for various aspects of human life. This paper aims to address the problem of remote sensing image quality. The method used is a convolutional neural network. Our proposed method consists of two main parts: the first part focuses on feature extraction, and the second part is dedicated to image reconstruction. The feature extraction component includes 25 convolutional layers, whereas the reconstruction component comprises 75 convolutional layers. To validate the effectiveness of our proposed method, we employed the peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM) as evaluation metrics. The test datasets consisted of Landsat-8 images, which were segmented into three regions of interest (ROI) of sizes 16×~~x~~16 pixels, 24×~~x~~24 pixels, and 32×~~x~~32 pixels. The experimental results demonstrate that the PSNR/SSIM values achieved were 28.94/0.822, 30.24/0.089, and 33.24/0.925 for each respective ROI. These results indicate that the proposed method outperforms several state-of-the-art techniques in terms of PSNR and SSIM.

Keywords: remote sensing, convolutional neural network, image enhancement, deep learning, object recognition.

I. INTRODUCTION

Artificial Intelligence (AI) primarily focuses on developing computerized systems that enable software to work like living creatures in solving problems. Regarding decision-making techniques, AI algorithms can be divided into two broad categories: algorithms that imitate animal behavior [1] and algorithms based on human thinking [2]. The first group includes Ant Colony Optimization [3], Particle Swarm Optimization [4], Genetic Algorithms [5], Bee Colony Optimization [6], and others. Meanwhile, algorithms that imitate humans in solving problems include fuzzy logic[7], Support Vector Machines (SVM) [8], Expert Systems [9], Artificial Neural Networks (ANNs) [10], [11], and more.

One branch of AI that has developed rapidly in the past decade is Deep Learning (DL), which is an extension of ANNs [12]. This field gained significant attention following the success of several ANN models in the ILSVRC competition, including AlexNet (2012) [13], Clarifai (2013) [14], GoogLeNet (2014) [15], and ResNet (2015) [16]. Building on this success, deep learning has been widely applied in various fields, such as classification, forecasting, image enhancement, remote sensing, and more.

On the other hand, the problem of detecting and recognizing objects in remote-sensing images has been a major focus for researchers over the last three decades. The main goal of object detection and recognition in remote-sensing images is to quickly and accurately locate and identify objects of interest to survey within the vast expanse of remote-sensing images.

Remote sensing technology has advanced significantly, enabling the capture of intricate details such as contours, colors, textures, and other distinctive attributes [17]. Nevertheless, object detection algorithms face numerous formidable challenges. This complexity arises from the differences in acquisition methods employed for remote optical sensing imagery compared to those used for natural imagery. Remote sensing imagery utilizes sensors, including optical, microwave, or laser devices, to gather data about the Earth's surface by detecting and recording radiation or reflections across various spectral ranges. In contrast, natural images are captured using electronic devices, such as cameras, or sensors that capture visible light, infrared radiation, and

* Corresponding Author.
Email: julian@unsri.ac.id~~rifki.muhendra@dsn.ubharajaya.ac.id~~
Received: ~~November~~ July ~~11~~08, ~~2022~~2024 ; Revised: ~~January~~ September 02~~0~~, ~~2023~~2024
Accepted: ~~February~~ November ~~17~~21, ~~2022~~2024 ; Published: ~~August~~ December 31, ~~2023~~2024

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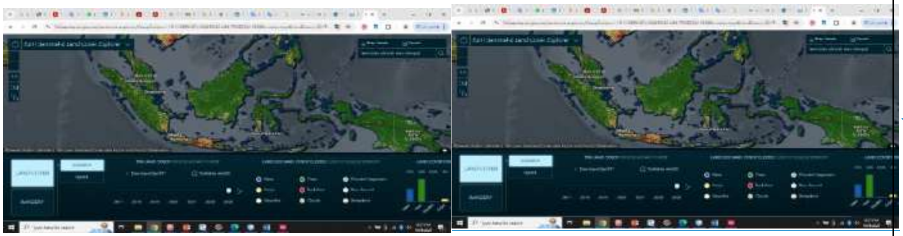

Figure 1. Capture of the remote sensing image from Landsat 8.

other forms of radiation present in the natural environment to obtain everyday image data. Unlike natural images captured horizontally by ground cameras, satellite images are obtained from an aerial perspective, providing extensive imaging coverage and comprehensive information about the Earth's surface in the areas where the images are acquired.

Given those characteristics, detecting and recognizing objects in remote-sensing images represents one of the most complex tasks in pattern recognition. This is due to the satellite's distant position, causing the object to appear very small. Despite efforts that have been made to enlarge the remote sensing image, the resulting image of the object still has low resolution. These low-resolution object images present a challenge in object detection and recognition based on remote sensing images. This is because a subtle difference between pixels in low-resolution images makes it difficult for computers to distinguish between individual objects effectively.

This study aims to improve the quality of object images in remote sensing images. Improving image quality is essential for addressing the challenges associated with object detection in remote-sensing images. This enhancement is typically evaluated using two standard metrics in image processing: peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM). In this context, higher PSNR and SSIM values indicate superior image quality.

Several methods, including bicubic interpolation, SRCNN, and DCSCN, have been proposed to address the problem of increasing image resolution. However, the results still require improvement, especially when dealing with extremely low-resolution images, such as object images in remote sensing data.

The main contribution of this research is a relatively simple convolutional neural network (CNN) architecture that uses convolutional layers to improve the quality of remote remote-sensing images. This architecture can be combined with various architectures to recognize objects in remote-sensing images.

The rest of this paper is structured as follows. Section 1 introduces the introduction and the motivation. Section 2 discusses the proposed method in detail. Section 3 presents the experiments, and the final section provides the concluding remarks.

II. PROPOSED METHODS

A. Datasets

The datasets used in this study are of two types, training data and testing data. Data for training comes from Yang et al. [18] and the Berkeley Segmentation Database [19]. Both databases contain high-resolution images, and the data sizes vary. Both databases are commonly used in image resolution improvement research, such as in [20], [21], [22].

The next data set is for testing. It is obtained from remote sensing images produced by the Lansat 8 Satellite, downloaded from the official website of GIS Geography (https://gisgeography.com/landsat/). The illustration of the image for the dataset is shown in Figure 1.

Figure 1. Capture of the remote sensing image from Landsat 8

Figure 1. Capture of the remote sensing image from Landsat

gThe image can be downloaded by following these steps:

Step 1. Set your area of interest in the "Search Criteria" tab

Step 2. Select your data to download in the "Datasets" tab

Step 3. Filter your data in the "Additional Criteria" tab

Step 4. Download free Landsat imagery in the "Results" tab.

B. Architecture of Proposed Method

To solve the challenge of detecting small objects in remote sensing images, Gan et al. [23] proposed a method that employed a novel edge-enhanced super-resolution GAN (EESRGAN) to enhance the quality of remote sensing images. The method integrated various detector networks in an end-to-end approach. The detector loss was backpropagated into the EESRGAN to optimize detection performance. Furthermore, Zhao et al. [24] proposed a method consisting of two parts of architecture: a degraded reconstruction-assisted enhancement branch and a detection branch. Hereinafter, Chung, et al [25] proposed a method using a bicubic and generative adversarial network (BLG-GAN).

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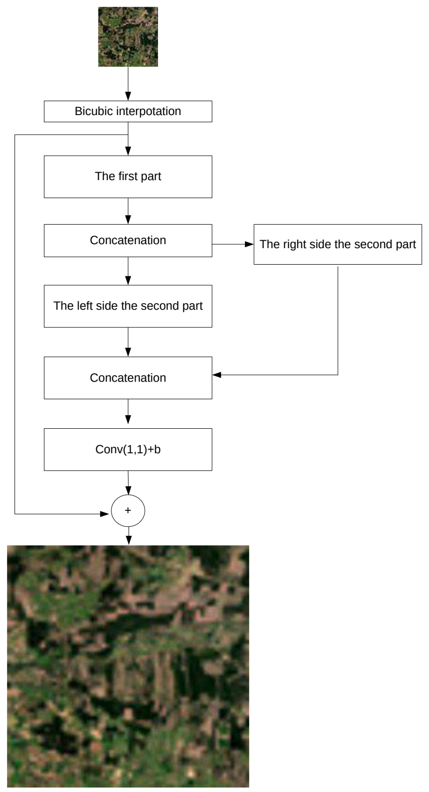

~~Figure 2. Framework of the enhancing remote sensing image resolution using CNN~~

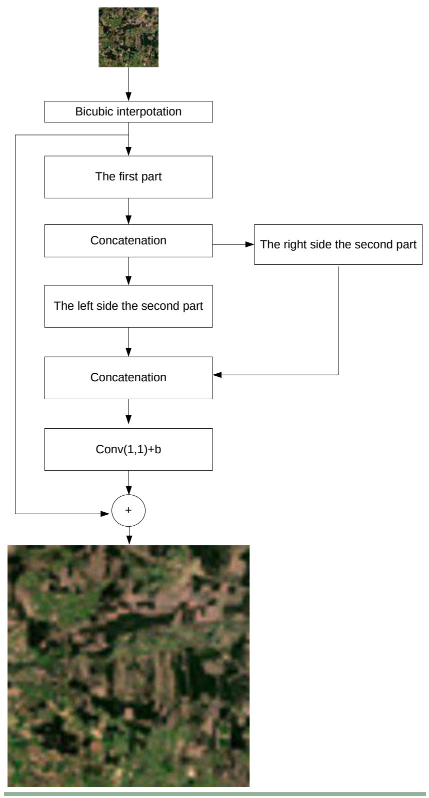

Figure 2. Framework of the enhancing remote sensing image resolution using CNN

In this research, we propose a method consisting of two main parts: feature extraction and reconstruction. Both parts consist of deeply convolutional layers. The purpose of the feature extraction network is to extract the most relevant features of the image, while the reconstruction network aims to enhance image resolution through deconvolution. Overall, Figure 2 shows the framework of the proposed method, with details of the first and second parts shown in Figures 3 and 4, respectively.

1) Bicubic Interpolation

Bicubic interpolation is employed to enlarge an image by a specified scale factor prior to its processing by a CNN. For instance, a low-resolution image can be upsampled to a higher resolution using this method. This step provides CNN with a larger input image, allowing it to concentrate on enhancing the details and overall quality of the interpolated image.

In cases where a low-resolution image is directly input into the CNN without prior interpolation, the network may require additional layers or greater complexity to effectively learn from the data and produce a high-resolution output. Bicubic interpolation alleviates this challenge by offering an image with an initially higher resolution, thus enabling CNN to focus on refining quality aspects, such as texture details and object edges, rather than merely enlarging the image.

In summary, the function of bicubic interpolation is to furnish a larger image as a foundation, thereby allowing CNN to prioritize the improvement of image quality over simple image enlargement.

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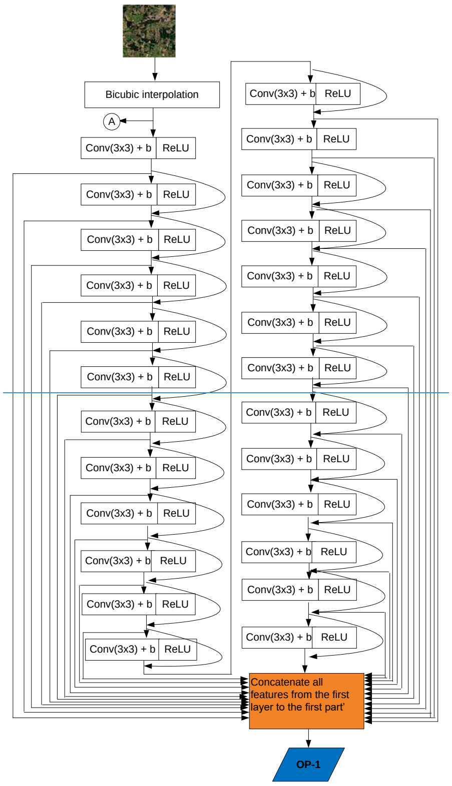

Figure 3. The architecture of CNN in the first part of the proposed method. OP-1 is output from the feature extraction layer.

4) *Bicubic Interpolation*

Bicubic interpolation is employed to enlarge an image by a specified scale factor prior to its processing by a CNN. For instance, a low-resolution image can be upsampled to a higher resolution using this method. This step provides the CNN with a larger input image, allowing it to concentrate on enhancing the details and overall quality of the interpolated image.

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In summary, the function of bicubic interpolation is to furnish a larger image as a foundation, thereby allowing CNN to prioritize the improvement of image quality over simple image enlargement.

9)2) *Feature Extraction Layers*

The feature extraction network consists of 25 convolutional layers. Each layer employs a kernel size of 3××3, but the number of kernels per layer varies. Specifically, the first layer contains 139 kernels, and each subsequent layer decreases by 3 kernels. Table 1 shows the kernel and bias used on feature extraction layers, and Figure 3 shows the architecture of CNN in the first part of the proposed method.

TABLE 1. DETAILED CONVOLUTIONAL LAYER ON FEATURE EXTRACTION NETWORK

No. Layers	Size of Kernel	Number of Kernels	Number of Biases
1	3x3	139	139
2	3x3	136	136
3	3x3	133	133
4	3x3	130	130
5	3x3	127	127
6	3x3	124	124
7	3x3	121	121
8	3x3	118	118
9	3x3	115	115
10	3x3	112	112
11	3x3	109	109
12	3x3	106	106
13	3x3	103	103
14	3x3	100	100
15	3x3	97	97
16	3x3	94	94
17	3x3	91	91
18	3x3	88	88
19	3x3	85	85
20	3x3	82	82
21	3x3	79	79
22	3x3	76	76
23	3x3	73	73
24	3x3	70	70
25	3x3	67	67

141)3) *Reconstruction Layer*

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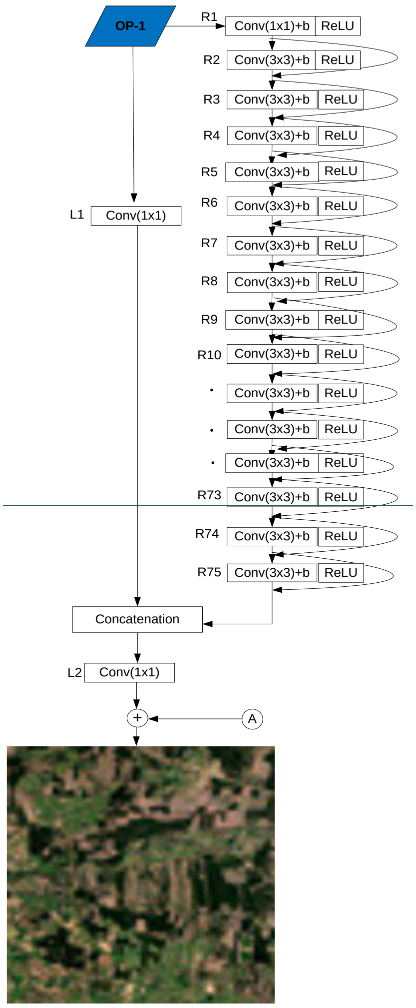

Figure 4. The architecture of CNN in the second part of the proposed method

TABLE 1
DETAILED CONVOLUTIONAL LAYER ON FEATURE EXTRACTION NETWORK

No. Layers	Size of Kernel	Number of Kernels	Number of Biases
1	3×3	139	139
2	3×3	136	136
3	3×3	133	133
4	3×3	130	130
5	3×3	127	127
6	3×3	124	124
7	3×3	121	121
8	3×3	118	118
9	3×3	115	115
10	3×3	112	112
11	3×3	109	109
12	3×3	106	106
13	3×3	103	103
14	3×3	100	100
15	3×3	97	97
16	3×3	94	94
17	3×3	91	91
18	3×3	88	88
19	3×3	85	85
20	3×3	82	82
21	3×3	79	79
22	3×3	76	76
23	3×3	73	73
24	3×3	70	70
25	3×3	67	67

Layers	L1	R1	R2	...	R75	L2
Size of Kernel	1x1	1x1	3x3	...	3x3	1x1
Number of Kernels	32	32	32	...	32	1
Number of Biases	32	32	32	...	32	0

TABLE 2. THE DETAILED KERNEL SIZE OF CONVOLUTIONAL LAYER ON RECONSTRUCTION NETWORKS.

In the reconstruction network, the feature maps generated in the first part are manipulated to enhance image resolution. See Figure 4, which comprises two convolutional neural network segments: the first segment (the left segment) contains a single convolutional layer, while the second segment (the right segment) consists of seventy-five convolutional layers. Additionally, the second segment concludes with a convolutional layer featuring a 1××x1 kernel size. The architecture of the CNN in the second part of the proposed method is detailed in Figure 4. Here, OP-1 is output from the feature extraction layer. Table 2 shows the kernel and bias used in the feature extraction part.

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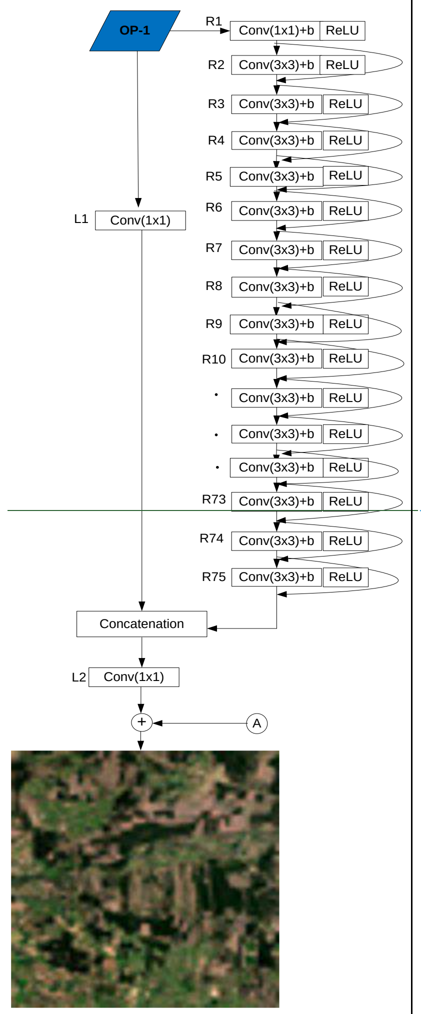

~~Figure 4. The architecture of CNN in the second part of the proposed method~~

Furthermore, the detailed steps of the proposed method are outlined in Algorithm 1.

Algorithm 1:

Step 1: Input Image Enlargement: Enlarge the small input image using the bicubic interpolation method based on the desired scale.

Step 2: Perform feature extraction by running all convolution operations in the first part of the architecture.

Step 3: Combine all features generated by all channels through a concatenation operation to form a single image.

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TABLE 2
THE DETAILE... L SIZE OF CONVOLUTIONAL LAYER ON ... STRUCTION NETWORKS

Layers	L1	R1	R2	...	R75	L2
Size of Ker...					×3	1×1
Number of Kernels	32	32	32	...	32	1
Number of Biases	32	32	32	...	32	0

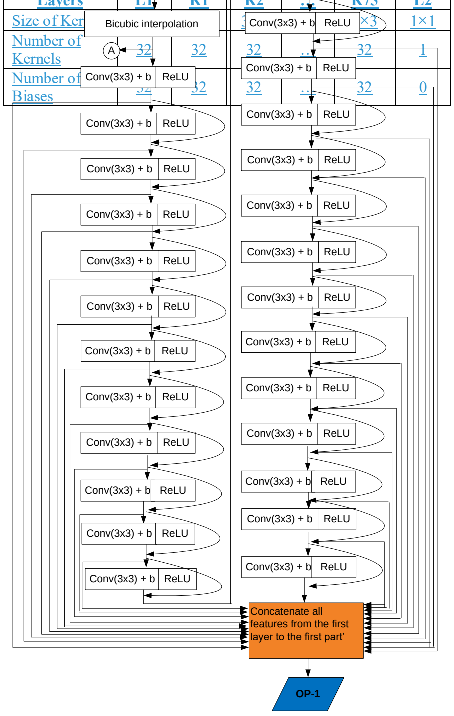


Figure 3. The architecture of CNN in the first part of the proposed method. OP-1 is output from the feature extraction layer.

Step 4: (a) Run convolution operations on the left segment of the image in the second part of the architecture.
(b) Run convolution operations on the right segment of the image in the second part of the

$$Y_{r,s}^{(l)} = B^{(l)} + \sum_{u=-H_1}^{H_1} \sum_{v=-H_2}^{H_2} \sum_{d=0}^{D} K_{u,v}^{(l)} * I_{r+u,s+v}^{(l)} \quad (1)$$

architecture.

Step 5: Combine the results of the left and right segment operations into a single image.

Step 6: Apply a 1x1 convolution to transform the combined output image from the second part of the architecture.

Step 6. Apply a 1x1 convolution to transform the combined output image from the second part of the architecture.

Step 7.: Add the initial bicubic interpolation image to the transformed image from Step 6 to finalize the image reconstruction.

4) Convolution Layer

142) *Convolution Layer*

Let I be the input of the convolution layer, K the kernel, and B the bias. The output of the convolution layer $l+1$ can be calculated using Equation (1) and (2) [11].

$$Y_{r,s}^{(l)} = B^{(l)} + \sum_{u=-H_1}^{H_1} \sum_{v=-H_2}^{H_2} \sum_{d=0}^{D} K_{u,v}^{(l)} * I_{r+u,s+v}^{(l)} \quad (1)$$

$$I_{r,s}^{(l+1)} = \varphi(Y_{r,s}^{(l)}). \quad (2)$$

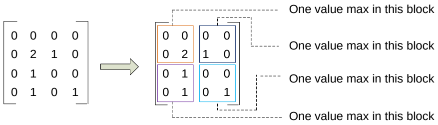
Let I be the input of the convolution layer, K the kernel, and B the bias. The output of the convolution layer $l+1$ can be calculated using (1) and (2) [11].

$$I_{r,s}^{(l+1)} = \varphi(Y_{r,s}^{(l)}). \quad (2)$$

where H_1 and H_2 are the sizes of the kernel *K*, *D* is the number of kernels *K*, *r=0, 1,..., m* and *s=0, 1,..., n*, and φ is the sigmoid function, defined as: $\varphi(x) = \frac{1}{1+e^{-x}}$.

143)5) *Pooling Layer*

A pooling layer (a subsampling layer) aims to reduce the feature resolution maketo make the features more resistant to noise and distortion. There are two primary methods of pooling: maximum pooling and average pooling. Both methods start by dividing the pixel matrix into several two-dimensional matrices (see Figure 5). Maximum pooling selects the highest value from each region, whereas average pooling computes the average value from each region [11].



~~Figure 5. Illustration of max pooling~~

144)6) *Training Phase*

Training is a very crucial stage in deep learning. The purpose of training is to determine the best model to solve the problem. Training calculations are carried out by minimizing the loss function. In this study, to minimize the error in the training phase, we use the loss function L_2 as given by Equation (3).:

$$\xi = \left(\sum_{i=1}^{n} \|h(x) - t(x)\|\right)^2 \qquad (3)$$

~~$\xi = (\sum_{i=1}^{n} \|h(x) - t(x)\|)^2,$ (3)~~

where ξ is the loss function, *h(x)* is the image output from the network, and *t(x)* is ground truth images.

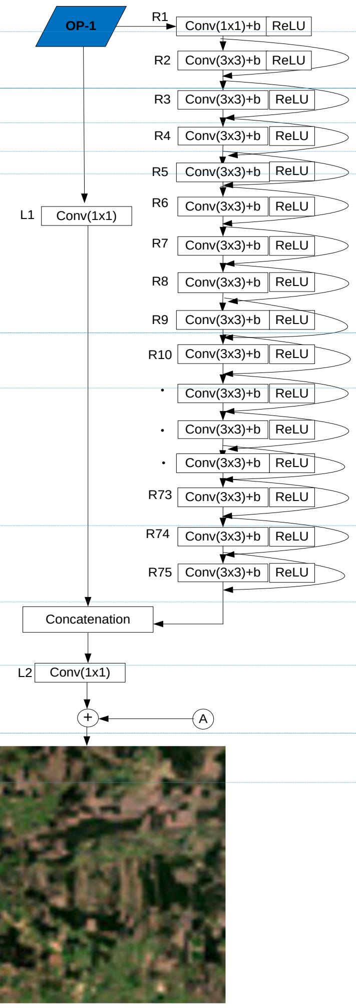


Figure 4. The architecture of CNN in the second part of the proposed method.

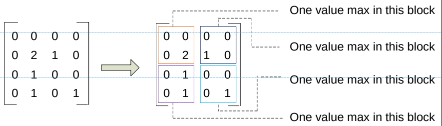
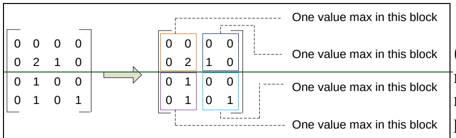


Figure 5. Illustration of max pooling.

Hereafter, to optimize the training phase, we employed the Adam Optimizer with $\beta_1 = 0.9$, $\beta_2 = 0.999$, and $\epsilon = 1e-8$. The optimizer and RMSprop momentum were both set to a value of 0.9. The learning rate started at 0.002 and increased to 0.005. The training process would terminate upon reaching the final learning rate. If the loss remained constant for 10 consecutive epochs, we reduced the learning rate by a factor of 2 until



~~Figure 5. Illustration of max pooling~~

the final learning rate was achieved. We implemented a technique to create high resolution based on instructional techniques, as referenced in [26], [27]. This method aims to improve prediction accuracy [28]. Additionally, we applied the strategy proposed by Wang et al. in [29] to the self-ensemble. During this training phase, a cross-validation ensemble of five was utilized.

In addition, the calculation steps for each layer's feed-forward phase are derived from [30], and those for the feed-backward phase are derived from [31]. The weight update rule follows the classic backpropagation method [32] and employs the Adam Optimizer [33]. To mathematically update the weights w and bias b at time t, we use Equation (4) and (5), respectively [11]:

$$w(t+1) = w(t) - \alpha \frac{\hat{m}_{t_w}}{\sqrt{\hat{v}_{t_w}} + \epsilon}, \text{for } \epsilon > 0 \quad (4)$$

$$b(t+1) = b(t) - \alpha \frac{\hat{m}_{t_b}}{\sqrt{\hat{v}_{t_b}} + \epsilon}, \text{for } \epsilon > 0 \quad (5)$$

$$m_{t_w} = \beta_1 m_{t_w-1} + (1-\beta_1)\, g_{t_w}$$

$$m_{t_b} = \beta_1 m_{t_b-1} + (1-\beta_1)\, g_{t_b}$$

$$v_{t_w} = \beta_2 v_{t_w-1} + (1-\beta_2)\, g_{t_w}^2$$

$$v_{t_b} = \beta_2 v_{t_b-1} + (1-\beta_2)\, g_b^2$$

$$\hat{m}_{t_w} = \frac{m_{t_w}}{(1-\beta_1^t)};\ \hat{m}_{t_b} = \frac{m_{t_b}}{(1-\beta_1^t)}$$

$$\hat{v}_{t_w} = \frac{v_{t_w}}{(1-\beta_2^t)};\ \hat{v}_{t_b} = \frac{v_{t_b}}{(1-\beta_2^t)}$$

where m_{t_w} is the first moment of weight w, v_{t_w} is the second raw moment of weight w, m_{t_b} is the 1st moment of bias b, v_{t_b} is 2nd raw-moment of bias b, $\hat{m}_{t_w}$ is the weight-corrected 1st moment, $\hat{v}_{t_w}$ is the weight-corrected 2nd raw moment, $\hat{m}_{t_b}$ is the bias-corrected 1st moment, $\hat{v}_{t_b}$ is the bias-corrected 2nd raw-moment, α is learning rate, β_1 and β_2 are hyperparameters, $g_{t_w} = \frac{\partial \mathcal{L}}{\partial w}$ is the partial derivative of the loss function with respect to w, and $g_{t_b} = \frac{\partial \mathcal{L}}{\partial b}$ is the partial derivative of the loss function with respect to b.

7) Measurement and Validation

To measure the effectiveness of the proposed method, we employ standard metrics commonly used to assess the quality of transformed images, specifically the Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) [34]. PSNR compares the maximum signal level of the original image with the noise that appears after the transformation process (output image). Meanwhile, SSIM evaluates the structural and visual information between the output and original images. Mathematically, PSNR is calculated using Equation (6), while SSIM is determined by Equation (8).

$$PSNR = 20\, Log_{10}\left(\frac{Max_f}{\sqrt{MSE}}\right) \quad (6)$$

$$MSE = \frac{1}{mn} \sum_0^{m-1} \sum_0^{n-1} \| f(i,j) - g(i,j) \|^2 \quad (7)$$

Here, f denotes the pixel matrix of the original image, while g represents the pixel matrix of the resulting image. The variable m indicates the number of rows of pixels in the images, with i as the index of a specific row. Additionally, n signifies the number of columns of pixels in the image, and j represents the index of a specific column. Furthermore, Max_f represents the maximum signal value present in the original image.

$$SSIM_{(x,y)} = \frac{(2\mu_x\mu_y + C_1)(2\tau_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\tau_x^2 + \tau_y^2 + C_2)} \quad (8)$$

Where μ_x and μ_y are the average brightness of images x and y, τ_x^2 and τ_y^2 are the variants of image x and image y that is contrast, τ_{xy} covariance of image x and image y that is structure measure, and C_1 and C_2 are small constants to stabilization numerical.

III. Results and Discussion

A. Training Model

For the training phase, we utilized databases commonly used to train CNN models for generating high-resolution images, i.e. the database from Yang et al. [18] and the Berkeley Segmentation Database [19]. The Yang database consists of 96 nature images, while the Berkeley database (BSD200) contains 200 images. An illustration of some images from the BSD200 database [19] is shown in Figure 6. Furthermore, we initialized the weights using random numbers generated by a Gaussian distribution with a mean of zero and a standard deviation of 0.001, while setting the biases to zero for every part.

~~Figure 6. Sample images from Berkeley Segmentation [19].~~

In addition, the configuration of our training is divided into multiple scaling factors: 2, 4, 8, and 16. Each scale factor defines the desired improvement in image resolution. For instance, if the input image resolution is to be increased by a factor of 2, the training scale factor is 2; if the resolution is to be increased by a factor of 4, the training scale factor is 4; and so on.

B. Testing Model

To verify the proposed method, we used a dataset originating from Landsat 8 imagery, which was downloaded from the Google Earth Engine platform (https://developers.google.com/earth-engine/datasets/catalog/landsat-8).

As we know, remote sensing images are taken from distant locations and cover large areas. For example, the Landsat 8 satellite has an imaging area of 185 km². Despite its wide coverage, the objects in the image are tiny. Enlarging the entire image directly is not the best solution, as it requires large resources and high computational complexity.

To overcome this problem, this research applies a partition technique based on area. In this case, we experimented with three different partition sizes: 16×16 pixels, 24×24 pixels, and 32×32 pixels. Next, each partition is increased to 128×128 pixels. An illustration of the image partitioning process is presented in Figure 7.

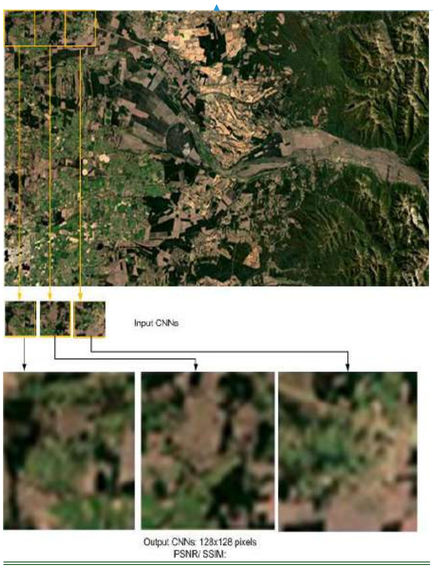


Figure 7. The Ssegmentation of image for input CNN process.s

In this experiment, we compare the result from our proposed method with previous methods widely used to improve the quality of low-resolution images, i.e. Bicubic, SRCNN [35], SRCNN-IBP [36], DRL [37], DCSCN [38]. These five methods are considered very good and are commonly used in the wider world. The results of the comparison obtained can be seen visually in Figure 8, while mathematically, the comparison of PSNR and SSIM from each method is presented in Table 3.

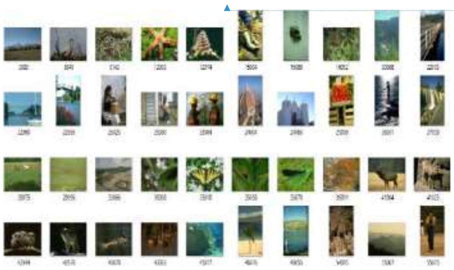


Figure 6. Sample images from Berkeley Segmentation [19].

Figure 7. The Segmentation of image for input CNN process

TABLE 3
THE PSNR AND SSIM COMPARISON OF THE OUTPUT OF SOME STATE OF THE ART

Methods	PSNR/SSIM		
	16×16 pixels	24×24 pixels	32×32 pixels
Bicubic	26.45/0.520	27.16/0.721	29.75/0.831
SRCNN [35]	26.74/0.632	27.66/0.722	30.84/0.856
SRCNN-IBP [36]	27.78/0.641	28.87/0.746	30.90/0.859
DRL[37]	28.77/0.779	29.83/0.841	30.38/0.896
DCSCN [38]	28.66/0.790	29.88/0.861	32.93/0.910
Our Method	**28.94/0.822**	**30.24/0.089**	**33.24/0.925**

TABLE 3. THE PSNR AND SSIM COMPARISON OF THE OUTPUT OF SOME STATE OF THE ART

Methods	PSNR/SSIM		
	16×16 pixels	24×24 pixels	32×32 pixels
Bicubic	26.45/0.520	27.16/0.721	29.75/0.831
SRCNN [35]	26.74/0.632	27.66/0.722	30.84/0.856
SRCNN-IBP [36]	27.78/0.641	28.87/0.746	30.90/0.859
DRL [37]	28.77/0.779	29.83/0.841	30.38/0.896
DCSCN [38]	28.66/0.790	29.88/0.861	32.93/0.910
Our Method	**28.94/0.822**	**30.24/0.089**	**33.24/0.925**

As illustrated in Figure 8, the images generated by our method exhibit superior visual quality compared to those produced by previously established methods. This observation is further substantiated by the quantitative results, specifically the SSIM and PSNR values presented in Table 3. The SSIM and PSNR values for all partition sizes (i.e. 16×16 pixels, 24×24 pixels, and 32×32 pixels) indicate that the quality of the images produced by the proposed method is consistently higher compared to existing methods. Accordingly, it can be concluded that the proposed method outperforms existing approaches.

Figure 8. The comparison of some output from our proposed method with the existing methods for segment size areas 16×16 pixels, 24×24 pixels, and 32×32 pixels.

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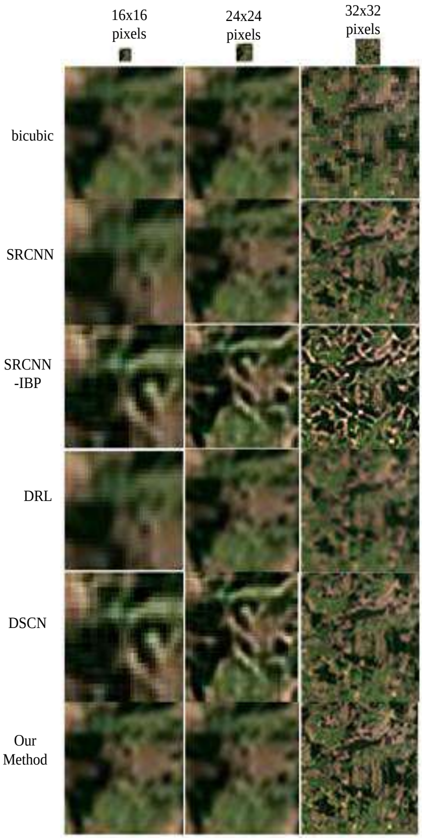

Figure 8. The comparison of some output from our proposed method with the existing methods for segment size areas 16×16 pixels, 24×24 pixels, and 32×32 pixels.

IV. Conclusion

This research has successfully developed an architecture for convolutional neural networks (CNNs) to enhance the quality of remote-sensing images. The architecture, classified as a deep-CNN model, incorporates over 75 convolutional layers. Moreover, the proposed method outperforms existing methods based on peak signal-to-noise ratio (PSNR) and structural similarity index measure (SSIM).

Declarations

Conflict of Interest

The authors have declared that there is no conflict of interest in this publication and research.

CRediT Authorship Contribution

Julian Supardi: Conceptualization, Methodology, Coding Software, Visualization, Investigation, Writing-Original draft preparation , Writing-Reviewing and Editing; Samsuryadi: Data curation, Writing-Reviewing and Editing; Hadipurnawan Satria: Coding Software; Philip Alger M. Serrano: Writing-Reviewing and Editinga review manuscript; Arnelawati: data Data curationolecting.

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Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks

Julian Supardi [a], Samsuryadi[b], Hadipurnawan Satria[c], Philip Alger M. Serrano[d], Arnelawati[e]

[a,b,c,e]Departement of Informatics Engineering
Sriwijaya Unverisity
Jl. Srijaya Negara-Bukit Besar,
Palembang, Indonesia 30129
[d]College of Computer Studies
Camarines Sur Polytechnic Colleges,
San Miguel, Nabua, Camarines Sur, Philippines 4434

julian@unsri.ac.id

Abstract

Remote sensing imagery is a very interesting topic for researchers, especially in the fields of image and pattern recognition. Remote sensing images differ from ordinary images taken with conventional cameras. Remote sensing images are captured from satellite photos taken far above the Earth's surface. As a result, objects in satellite images appear small and have low resolution when enlarged. This condition makes it difficult to detect and recognize objects in remote-sensing images. However, detecting and recognizing objects in these images is crucial for various aspects of human life. This paper aims to address the problem of remote sensing image quality. The method used is a convolutional neural network. Our proposed method consists of two main parts: the first part focuses on feature extraction, and the second part is dedicated to image reconstruction. The feature extraction component includes 25 convolutional layers, whereas the reconstruction component comprises 75 convolutional layers. To validate the effectiveness of our proposed method, we employed the Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) as evaluation metrics. The test datasets consisted of Landsat-8 images, which were segmented into three Regions of Interest (ROI) of sizes 16x16 pixels, 24x24 pixels, and 32x32 pixels. The experimental results demonstrate that the PSNR/SSIM values achieved were 28.94/0.822, 30.24/0.089, and 33.24/0.925 for each respective ROI. These results indicate that the proposed method outperforms several state-of-the-art techniques in terms of PSNR and SSIM.

Keywords: remote sensing, convolutional neural network, image enhancement, deep learning, object recognition.

I. INTRODUCTION

Artificial Intelligence (AI) primarily focuses on developing computerized systems that enable software to work like living creatures in solving problems. Regarding decision-making techniques, AI algorithms can be divided into two broad categories: algorithms that imitate animal behavior [1] and algorithms based on human thinking [2]. The first group includes Ant Colony Optimization [3], Particle Swarm Optimization [4], Genetic Algorithms [5], Bee Colony Optimization [6], and others. Meanwhile, algorithms that imitate humans in solving problems include fuzzy logic[7], Support Vector Machines (SVM) [8], Expert Systems [9], Artificial Neural Networks (ANNs) [10][11], and more.

One branch of AI that has developed rapidly in the past decade is Deep Learning (DL), which is an extension of ANNs [12]. This field gained significant attention following the success of several ANN models in the ILSVRC competition, including AlexNet (2012) [13], Clarifai (2013) [14], GoogLeNet (2014) [15], and ResNet (2015) [16]. Building on this success, deep learning has been widely applied in various fields, such as classification, forecasting, image enhancement, remote sensing, and more.

On the other hand, the problem of detecting and recognizing objects in remote-sensing images has been a major focus for researchers over the last three decades. The main goal of object detection and recognition in remote-sensing images is to quickly and accurately locate and identify objects of interest to survey within the vast expanse of remote-sensing images.

Remote sensing technology has advanced significantly, enabling the capture of intricate details such as contours, colors, textures, and other distinctive attributes [17]. Nevertheless, object detection algorithms face numerous formidable challenges. This complexity arises from the differences in acquisition methods employed for remote optical sensing imagery compared to those used for natural imagery. Remote sensing imagery utilizes sensors, including optical, microwave, or laser devices, to gather data about the Earth's surface by detecting and recording radiation or reflections across various spectral ranges. In contrast, natural images are captured using electronic devices, such as cameras, or sensors that capture visible light, infrared radiation, and other forms of radiation present in the natural environment to obtain everyday image data. Unlike natural images captured horizontally by ground cameras, satellite images are obtained from an aerial perspective, providing extensive imaging coverage and comprehensive information about the Earth's surface in the areas where the images are acquired.

Given those characteristics, detecting and recognizing objects in remote-sensing images represents one of the most complex tasks in pattern recognition. This is due to the satellite's distant position, causing the object to appear very small. Despite efforts that have been made to enlarge the remote sensing image, the resulting image of the object still has low resolution. These low-resolution object images present a challenge in object detection and recognition based on remote sensing images. This is because a subtle difference between pixels in low-resolution images makes it difficult for computers to distinguish between individual objects effectively.

This study aims to improve the quality of object images in remote sensing images. Improving image quality is essential for addressing the challenges associated with object detection in remote-sensing images. This enhancement is typically evaluated using two standard metrics in image processing: Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM). In this context, higher PSNR and SSIM values indicate superior image quality.

Several methods, including bicubic interpolation, SRCNN, and DCSCN, have been proposed to address the problem of increasing image resolution. However, the results still require improvement, especially when dealing with extremely low-resolution images, such as object images in remote sensing data.

The main contribution of this research is a relatively simple Convolutional Neural Network (CNN) architecture that uses convolutional layers to improve the quality of remote sensing images. This architecture can be combined with various architectures to recognize objects in remote-sensing images.

The rest of this paper is structured as follows. Section 1 introduces the introduction and the motivation. Section 2 discusses the proposed method in detail. Section 3 presents the experiments, and the final section provides the concluding remarks.

II. PROPOSED METHOD

2.1. Datasets

The datasets used in this study are of two types, training data and testing data. Data for training comes from Yang et al. [18] and the Berkeley Segmentation Database [19]. Both databases contain high-resolution images, and the data sizes vary. Both databases are commonly used in image resolution improvement research, such as in [20][21][22].

The next data set is for testing. It is obtained from remote sensing images produced by the Lansat 8 Satellite, downloaded from the official website of GIS Geography (https://gisgeography.com/landsat/). The illustration of the image for the dataset is shown in Figure 1.

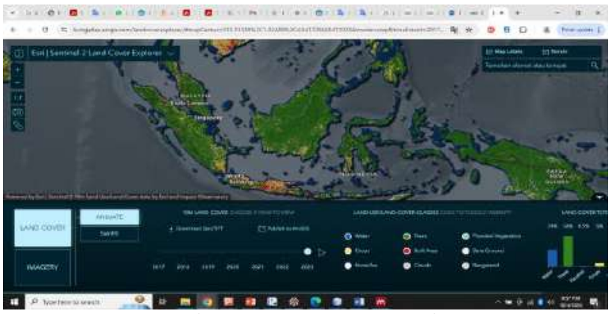

Figure 1. Capture of the remote sensing image from Landsat 8

The image can be downloaded by following these steps:

Step 1. Set your area of interest in the "Search Criteria" tab

Step 2. Select your data to download in the "Datasets" tab

Step 3. Filter your data in the "Additional Criteria" tab

Step 4. Download free Landsat imagery in the "Results" tab.

2.2. Architecture of Proposed Method

To solve the challenge of detecting small objects in remote sensing images, Gan et al. [23] proposed a method that employed a novel edge-enhanced super-resolution GAN (EESRGAN) to enhance the quality of remote sensing images. The method integrated various detector networks in an end-to-end approach. The detector loss was backpropagated into the EESRGAN to optimize detection performance. Furthermore, Zhao et al. [24] proposed a method consisting of two parts of architecture: a degraded reconstruction-assisted enhancement branch and a detection branch. Hereinafter, Chung et al [25] proposed a method using bicubic and generative adversarial network (BLG-GAN).

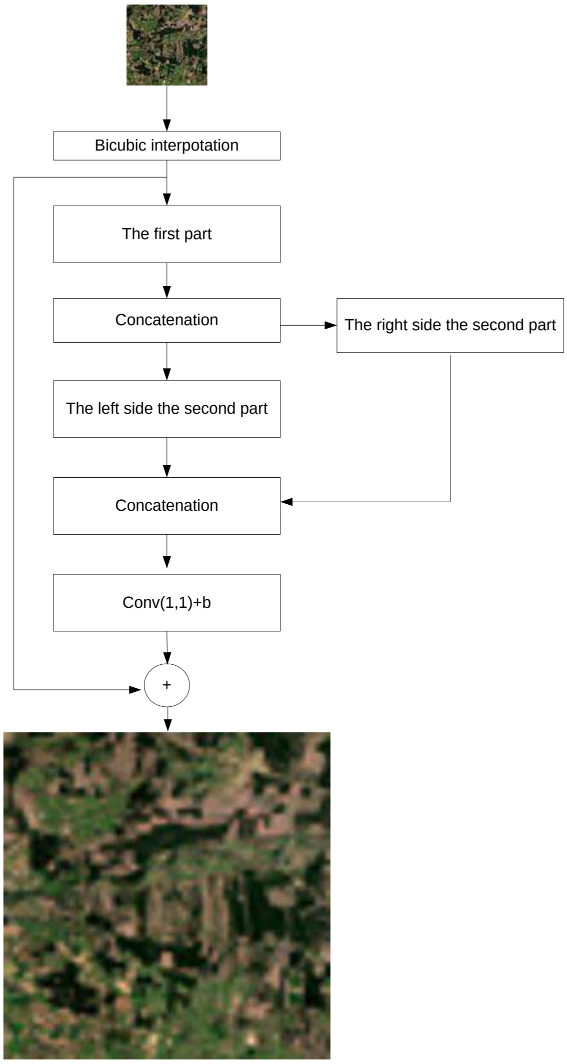

Figure 2. Framework of the enhancing remote sensing image resolution using CNN

In this research, we propose a method consisting of two main parts: feature extraction and reconstruction.

Both parts consist of deeply convolutional layers. The purpose of the feature extraction network is to extract the most relevant features of the image, while the reconstruction network aims to enhance image resolution through deconvolution. Overall, Figure 2 shows the framework of the proposed method, with details of the first and second parts shown in Figures 3 and 4, respectively.

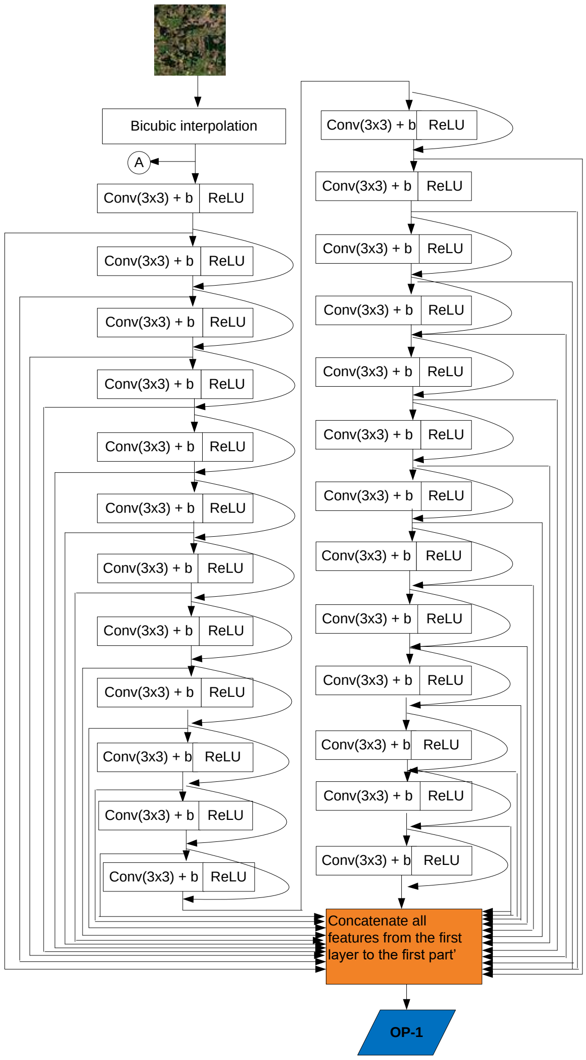

Figure 3. The architecture of CNN in the first part of the proposed method. OP-1 is output from the feature extraction layer.

A. Bicubic Interpolation

Bicubic interpolation is employed to enlarge an image by a specified scale factor prior to its processing by a CNN. For instance, a low-resolution image can be upsampled to a higher resolution using this method. This step provides the CNN with a larger input image, allowing it to concentrate on enhancing the details and overall quality of the interpolated image.

In cases where a low-resolution image is directly input into the CNN without prior interpolation, the network may require additional layers or greater complexity to effectively learn from the data and produce a high-resolution output. Bicubic interpolation alleviates this challenge by offering an image with an initially higher resolution, thus enabling the CNN to focus on refining quality aspects, such as texture details and object edges, rather than merely enlarging the image.

In summary, the function of bicubic interpolation is to furnish a larger image as a foundation, thereby allowing CNN to prioritize the improvement of image quality over simple image enlargement.

B. Feature Extraction Layers

The feature extraction network consists of 25 convolutional layers. Each layer employs a kernel size of 3x3, but the number of kernels per layer varies. Specifically, the first layer contains 139 kernels, and each subsequent layer decreases by 3 kernels. Table 1 shows the kernel and bias used on feature extraction layers, and Figure 3 shows the architecture of CNN in the first part of the proposed method.

TABLE 1. DETAILED CONVOLUTIONAL LAYER ON FEATURE EXTRACTION NETWORK

No. Layers	Size of Kernel	Number of Kernels	Number of Biases
1	*3x3*	139	139
2	*3x3*	136	136
3	*3x3*	133	133
4	*3x3*	130	130
5	*3x3*	127	127
6	*3x3*	124	124
7	*3x3*	121	121
8	*3x3*	118	118
9	*3x3*	115	115
10	*3x3*	112	112
11	*3x3*	109	109
12	*3x3*	106	106
13	*3x3*	103	103
14	*3x3*	100	100
15	*3x3*	97	97
16	*3x3*	94	94
17	*3x3*	91	91
18	*3x3*	88	88
19	*3x3*	85	85
20	*3x3*	82	82
21	*3x3*	79	79
22	*3x3*	76	76
23	*3x3*	73	73
24	*3x3*	70	70
25	*3x3*	67	67

C. Reconstruction Layer

In the reconstruction network, the feature maps generated in the first part are manipulated to enhance image resolution. See Figure 4, which comprises two convolutional neural network segments: the first segment (the left segment) contains a single convolutional layer, while the second segment (the right segment) consists of seventy-five convolutional layers. Additionally, the second segment concludes with a convolutional layer featuring a 1x1 kernel size. The architecture of the CNN in the second part of the proposed method is detailed in Figure 4. Here, OP-1 is output from the feature extraction layer. Table 2 shows the kernel and bias used in feature extraction part.

TABLE 2. THE DETAILED KERNEL SIZE OF CONVOLUTIONAL LAYER ON RECONSTRUCTION NETWORKS.

Layers	**L1**	**R1**	**R2**	**…**	**R75**	**L2**
Size of Kernel	1x1	1x1	3x3	…	3x3	1x1
Number of Kernels	32	32	32	…	32	1
Number of Biases	32	32	32	…	32	0

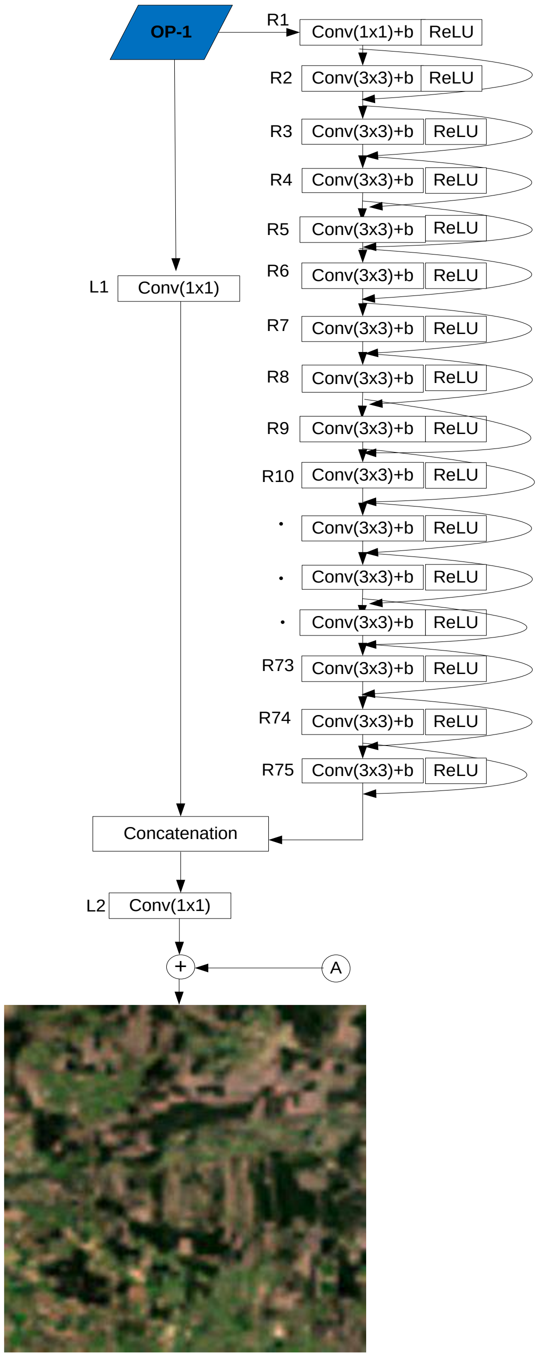

Figure 4. The architecture of CNN in the second part of the proposed method

Furthermore, the detailed steps of the proposed method are outlined in Algorithm 1.

Algorithm 1:

Step 1: Input Image Enlargement: Enlarge the small input image using the bicubic interpolation method based on the desired scale.

Step 2: Perform feature extraction by running all convolution operations in the first part of the architecture.

Step 3: Combine all features generated by all channels through a concatenation operation to form a single image.

Step 4:(a) Run convolution operations on the left segment of the image in the second part of the architecture.
(b) Run convolution operations on the right segment of the image in the second part of the architecture.

Step 5: Combine the results of the left and right segment operations into a single image.

Step 6. Apply a 1x1 convolution to transform the combined output image from the second part of the architecture.

Step 7. Add the initial bicubic interpolation image to the transformed image from Step 6 to finalize the image reconstruction.

D. Convolution Layer

Let I be the input of the convolution layer, K the kernel, and B the bias. The output of the convolution layer $l+1$ can be calculated using Equation (1) and (2) [11]:

$$Y_{r,s}^{(l)} = B^{(l)} + \sum_{u=-H_1}^{H_1} \sum_{v=-H_2}^{H_2} \sum_{d=0}^{D} K_{u,v}^{(l)} * I_{r+u,s+v}^{(l)} \quad (1)$$

$$I_{r,s}^{(l+1)} = \varphi(Y_{r,s}^{(l)}). \quad (2)$$

where H_1 and H_2 are the sizes of the kernel K, D is the number of kernels K, $r=0, 1,..., m$ and $s=0, 1,..., n$, and φ is the sigmoid function, defined as: $\varphi(x) = \frac{1}{1+e^{-x}}$.

E. Pooling Layer

A pooling layer (a subsampling layer) aims to reduce the feature resolution make the features more resistant to noise and distortion. There are two primary methods of pooling: maximum pooling and average pooling. Both methods start by dividing the pixel matrix into several two-dimensional matrices (see Figure 5). Maximum pooling selects the highest value from each region, whereas average pooling computes the average value from each region [11].

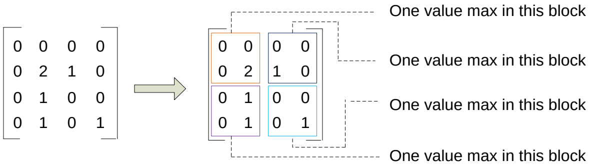

Figure 5. Illustration of max pooling

F. Training Phase

Training is a very crucial stage in deep learning. The purpose of training is to determine the best model to solve the problem. Training calculations are carried out by minimizing the loss function. In this study, to minimize the error in the training phase, we use the loss function L_2 as given by Equation (3):

$$\xi = \left(\sum_{i=1}^{n}\|h(x) - t(x)\|\right)^2, \quad (3)$$

where ξ is the loss function, *h(x)* is the image output from the network, and *t(x)* is ground truth images.

Hereafter, to optimize the training phase, we employed the Adam Optimizer with $\beta_1 = 0.9$, $\beta_2 = 0.999$, and $\in = 1\text{e} - 8$. The optimizer and RMSprop momentum were both set to a value of 0.9. The learning rate started at 0.002 and increased to 0.005. The training process would terminate upon reaching the final learning rate. If the loss remained constant for 10 consecutive epochs, we reduced the learning rate by a factor of 2 until the final learning rate was achieved. We implemented a technique to create high resolution based on instructional techniques, as referenced in [26][27]. This method aims to improve prediction accuracy [28]. Additionally, we applied the strategy proposed by Wang et al. in [29] to the self-ensemble. During this training phase, a cross-validation ensemble of five was utilized.

In addition, the calculation steps for each layer's feed-forward phase are derived from [30], and those for the feed-backward phase are derived from [31]. The weight update rule follows the classic backpropagation method [32] and employs the Adam Optimizer [33]. To mathematically update the weights *w* and bias *b* at time *t*, we use Equation (4) and (5), respectively [11]:

$$w(t+1) = w(t) - \alpha \frac{\hat{m}_{t_w}}{\sqrt{v_{t_w}} + \in}, \; for \in > 0 \quad (4)$$

$$b(t+1) = b(t) - \alpha \frac{\hat{m}_{t_b}}{\sqrt{v_{t_b}} + \in}, \; for \in > 0 \quad (5)$$

$$m_{t_w} = \beta_1 m_{t_w - 1} + (1 - \beta_1)\, g_{t_w}$$

$$m_{t_b} = \beta_1 m_{t_b - 1} + (1 - \beta_1)\, g_{t_b}$$

$$v_{t_w} = \beta_2 v_{t_w - 1} + (1 - \beta_2)\, g_{t_w}^2$$

$$v_{t_b} = \beta_2 v_{t_b - 1} + (1 - \beta_2) g_b^2$$

$$\hat{m}_{t_w} = \frac{m_{t_w}}{(1-\beta_1^t)}; \; \hat{m}_{t_b} = \frac{m_{t_b}}{(1-\beta_1^t)}$$

$$\hat{v}_{t_w} = \frac{v_{t_w}}{(1-\beta_2^t)}; \; \hat{v}_{t_b} = \frac{v_{t_b}}{(1-\beta_2^t)}$$

where m_{t_w} is the first moment of weight *w*, v_{t_w} is the second raw moment of weight *w*, m_{t_b} is the 1st moment of bias *b*, v_{t_b} is 2nd raw-moment of bias *b*, $\hat{m}_{t_w}$ is the weight-corrected 1st moment, $\hat{v}_{t_w}$ is the weight-corrected 2nd raw moment, $\hat{m}_{t_b}$ is the bias-corrected 1st moment, $\hat{v}_{t_b}$ is the bias-corrected 2nd raw-moment, α is learning rate, β_1 *and* β_2 are hyperparameters, $g_{t_w} = \frac{\partial \mathcal{L}}{\partial w}$ is the partial derivative of the loss function with respect to *w*, and $g_{t_b} = \frac{\partial \mathcal{L}}{\partial b}$ is the partial derivative of the loss function with respect to *b*.

G. Measurement and Validation

To measure the effectiveness of the proposed method, we employ standard metrics commonly used to assess the quality of transformed images, specifically the Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM) [34]. PSNR compares the maximum signal level of the original image with the noise that appears after the transformation process (output image). Meanwhile, SSIM evaluates the structural and visual information between the output and original images. Mathematically, PSNR is calculated using Equation 6, while SSIM is determined by Equation 8.

$$PSNR = 20\, Log_{10}\left(\frac{Max_f}{\sqrt{MSE}}\right) \quad (6)$$

$$MSE = \frac{1}{mn} \sum_0^{m-1} \sum_0^{n-1} \|f(i,j) - g(i,j)\|^2 \quad (7)$$

Here, f denotes the pixel matrix of the original image, while g represents the pixel matrix of the resulting image. The variable m indicates the number of rows of pixels in the images, with i as the index of a specific row. Additionally, n signifies the number of columns of pixels in the image, and j represents the index of a specific column. Furthermore, Max_f represents the maximum signal value present in the original image.

$$SSIM_{(x,y)} = \frac{(2\mu_x\mu_y + C_1)(2\tau_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\tau_x^2 + \tau_y^2 + C_2)} \quad (8)$$

Where μ_x and μ_y are the average brightness of images *x* and *y*, τ_x^2 and τ_y^2 are the variants of image *x* and image *y* that is contrast, τ_{xy} covariance of image *x* and image *y* that is structure measure, and C_1 and C_2 are small constants to stabilization numerical.

III. RESULTS AND DISCUSSION

A. Training Model

For the training phase, we utilized databases commonly used to train CNN models for generating high-resolution images, i.e. the database from Yang et al. [18] and the Berkeley Segmentation Database [19]. The Yang database consists of 96 nature images, while the Berkeley database (BSD200) contains 200 images. An illustration of some images from the BSD200 database

[19] is shown in Figure 6. Furthermore, we initialized the weights using random numbers generated by a Gaussian distribution with a mean of zero and a standard deviation of 0.001, while setting the biases to zero for every part.

Figure 6. Sample images from Berkeley Segmentation [19].

In addition, the configuration of our training is divided into multiple scaling factors: 2, 4, 8, and 16. Each scale factor defines the desired improvement in image resolution. For instance, if the input image resolution is to be increased by a factor of 2, the training scale factor is 2; if the resolution is to be increased by a factor of 4, the training scale factor is 4; and so on.

B. Testing Model

To verify the proposed method, we used a dataset originating from Landsat 8 imagery, which was downloaded from the Google Earth Engine platform (https://developers.google.com/earth-engine/datasets/catalog/landsat-8).

As we know, remote sensing images are taken from distant locations and cover large areas. For example, the Landsat 8 satellite has an imaging area of 185 km^2. Despite its wide coverage, the objects in the image are tiny. Enlarging the entire image directly is not the best solution, as it requires large resources and high computational complexity.

To overcome this problem, this research applies a partition technique based on area. In this case, we experimented with three different partition sizes: 16×16 pixels, 24×24 pixels, and 32×32 pixels. Next, each partition is increased to 128×128 pixels. An illustration of the image partitioning process is presented in Figure 7.

In this experiment, we compare the result from our proposed method with previous methods widely used to improve the quality of low-resolution images, i.e. Bicubic, SRCNN [35], SRCNN-IBP [36], DRL [37], DCSCN [38]. These five methods are considered very good and are commonly used in the wider world. The results of the comparison obtained can be seen visually in Figure 8, while mathematically, the comparison of PSNR and SSIM from each method is presented in Table 3.

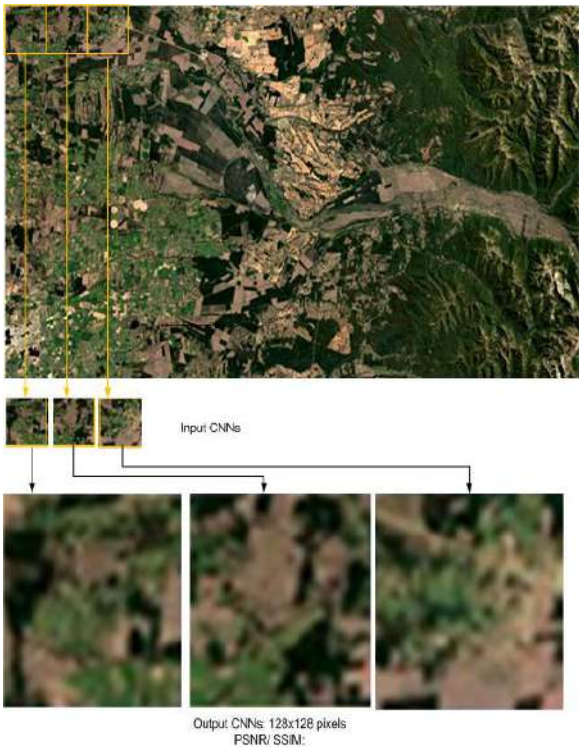

Figure 7. The Segmentation of image for input CNN process

TABLE 3. THE PSNR AND SSIM COMPARISON OF THE OUTPUT OF SOME STATE OF THE ART

Methods	**PSNR/SSIM**		
	16×16 pixels	**24×24 pixels**	**32×32 pixels**
Bicubic	26.45/0.520	27.16/0.721	29.75/0.831
SRCNN [35]	26.74/0.632	27.66/0.722	30.84/0.856
SRCNN-IBP [36]	27.78/0.641	28.87/0.746	30.90/0.859
DRL[37]	28.77/0.779	29.83/0.841	30.38/0.896
DCSCN [38]	28.66/0.790	29.88/0.861	32.93/0.910
Our Method	**28.94/0.822**	**30.24/0.089**	**33.24/0.925**

As illustrated in Figure 8, the images generated by our method exhibit superior visual quality compared to those produced by previously established methods. This observation is further substantiated by the quantitative results, specifically the SSIM and PSNR values presented in Table 3. The SSIM and PSNR values for all partition sizes (i.e. 16×16 pixels, 24×24 pixels, and 32×32 pixels) indicate that the quality of the images produced by the proposed method is consistently higher compared to existing methods. Accordingly, it can be concluded that the proposed method outperforms existing approaches.

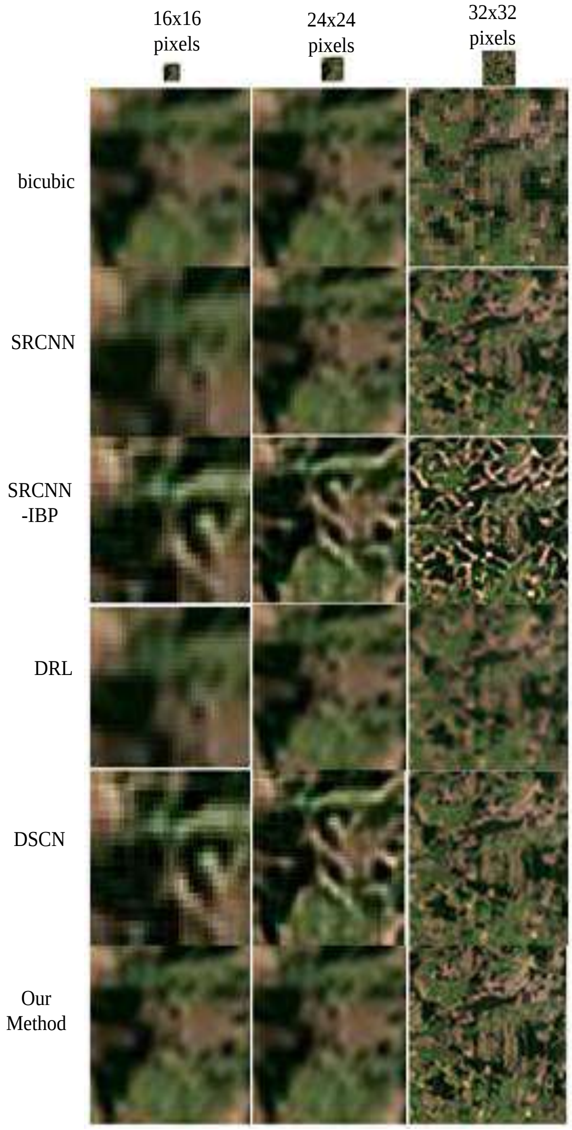

Figure 8. The comparison of some output from our proposed method with the existing methods for segment size areas 16×16 pixels, 24×24 pixels, and 32×32 pixels.

IV. CONCLUSION

This research has successfully developed an architecture for convolutional neural networks (CNNs) to enhance the quality of remote-sensing images. The architecture, classified as a deep-CNN model, incorporates over 75 convolutional layers. Moreover, the proposed method outperforms existing methods based on peak signal-to-noise ratio (PSNR) and structural similarity index measure (SSIM).

DECLARATIONS

Conflict of Interes

The authors have declared that there is no conflict of interest in this publication and research.

CRediT Authorship Contribution

Julian Supardi: Conceptualization, Methodology, Coding Software, Visualization, Investigation, Writing-Original draft preparation Writing-Reviewing and Editing; Samsuryadi: Data curation, Writing-Reviewing and Editing; Hadipurnawan Satria: Coding Software; Philip Alger M. Serrano: a review manuscript; Arnelawati: data colecting.

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Bukti Correspondence:

Judul Artikel: Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks

Authors: Julian Supardi, Samsuryadi Samsuryadi, Hadipurnawan Satria, Philip Alger M. Serrano, Arnelawati Arnelawati

Correspondence Author: Julian Supardi, email: julian@unsri.ac.id

#653 Summary

SUMMARY | REVIEW | EDITING

Submission

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Presentation and organization
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• Does the introductory section adequately explain the framework and problems of the research?
• Are the importance and usefulness of this research work clear?
• Were the methods adequately described and was the method appropriate to answer the question posed?
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:
This study explains how to improve the resolution of satellite-based data using the CNN algorithm. The writing is generally reasonable. However, this scientific paper has several things that need to be improved, such as the following points:
1. The abstract does not show concrete research results, such as the percentage of success of the method or the results of the evaluation matrix carried out
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Originality, scientific sound of the paper and its contribution to the field
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Upscaling techniques have been extensively explored, particularly in the field of super-resolution. However, there is always room for improvement in terms of performance. The paper surely offers a contribution to the field, however, the extent of its contribution to the field is somewhat limited (from reviewer point of view). With clearer explanations of the methodology, the paper has the potential to be scientifically sound. While the paper is lack of in-depth discussion of the results (which would enhance the paper's impact if its there), the sufficient information is presented.

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• Are the results presented clearly and discussed satisfactorily?
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Abstract: The abstract is insufficiently detailed. It should clearly state the problem, provide a concise overview of the proposed method (beyond simply mentioning CNN), and include quantitative results (PSNR/SSIM values).
Introduction: While the introduction is well-written, it underemphasizes the importance of high PSNR/SSIM values. A stronger justification for pursuing these metrics is necessary.
Method: The method section is unclear and lacks essential details. Data preparation is not described, and the network architecture is inconsistent. The illustration should include all layers, and the role of the bicubic connection should be explained. Additionally, the concatenation block with only one input and the unconnected block require clarification. A flowchart would improve the overall understanding of the workflow.
Results: The presentation of both quantitative and qualitative results is effective.
Conclusion: The conclusion is well-supported by the results. Figures and data visualizations are clear and easy to interpret.
References: The reference list is adequate.

Reviewer D:

Presentation and organization
(Title, Abstract, Introduction, Method, Results and Discussion, Conclusion, Language)
• Is the paper well written enough for evaluation of technical content?
• Does the title reflect the contents of the paper?
• Does the abstract describe the essential information in the work?
• Does the introductory section adequately explain the framework and problems of the research?
• Are the importance and usefulness of this research work clear?
• Were the methods adequately described and was the method appropriate to answer the question posed?
• Are the results presented clearly and discussed satisfactorily?
• Are conclusions logically derived from the data presented? Are the figures and tables easily readable, correct and informative?
• Are sufficient references cited for providing a background to the research?
Please provide your detailed comments to the Author(s) on the following.
:
1. Regarding Figure 1, you don't need to put the image in the introduction section
2. Still related to the introduction too, you mention a lot of concepts without being based on citations, please pay attention and correct them.
3. You don't explain what kind of research gap you want to solve. Please fix it

Originality, scientific sound of the paper and its contribution to the field
• How original and creative are the idea and approach?
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• Have any parts of the paper already been published or considered for other publication?
• Is the paper scientifically sound and not misleading?
• Does it provide sufficient information and in-depth discussion?
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This paper has a good contribution to satellite image data processing.

Section Editor
2024-09-12 11:32 AM

Subject: [JET] Editor Decision

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The following message is being delivered on behalf of Jurnal Elektronika dan Telekomunikasi.

Dr. Julian Supardi:

Regarding our prior decision, which is "Revision Required", towards your submission to Jurnal Elektronika dan Telekomunikasi, "Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks"; we would like to inform you that we would appreciate a revision by 4 October 2024.

We look forward to receiving your revision.

Dr. Purnomo Husnul Khotimah
National Research and Innovation Agency
purn005@brin.go.id

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Author
2024-10-13 08:58 PM

Subject: Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks

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Dear Dr. Purnomo Husnul Khotimah and Dr. Marlin Ramadhan Baidillah,
We have completed the revision of the manuscript based on the point-to-point reviewer's comments. we hope that the responses given are in accordance with those suggested or asked by the reviewer.

Thank you very much for your help.

Best Regards

Julian Supardi, Ph.D

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Section Editor
2024-11-11 01:09 PM

Subject: [JET] Editor Decision (Revision required)

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Dr. Julian Supardi:

We have reached a decision regarding your submission to Jurnal Elektronika dan Telekomunikasi, "Enhancing Remote Sensing Image Resolution Using Convolutional Neural Networks".

Our decision is: Revisions Required (Minor revision at Round 2)

The author has to submit the revised manuscript along with a point-by-point response to the reviewer's comments. Please fill-up the form from the link below to explain your revisions and respond to the reviewers' and editor's comments.
For comments those you choose not to implement, please include a detailed reason why you think a change is inappropriate. Submit this form, along with your revised version of your manuscript once it finished. You can submit this form by click on ADD A SUPPLEMENTARY FILE on Summary Page.

Please submit your revision version through tab "REVIEW" > "editor decision"> "upload author version". We would appreciate a revision by 22 November 2024.

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All authors also should provide all references as a single BibTex file, then upload them as a supplementary file.

I look forward to receiving your revision.

Marlin Ramadhan Baidillah
National Research and Innovation Agency (BRIN)

Review comments from Section Editor:
1. In figure 3 and 4, define clearly each variable. Also, the bias symbol is not consistence, I found it is as "b" in other parts it is as "B". please check the consistency of all variables.

2. Usually variables in bold type is for vector. use consistency the font type of all variables.

3. The figure size of figure 5 is not proportional. make it more better.

4. The discussion part should consider the different or comparison accuracy results between this study and the published studies.

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Section Editor
2024-11-21 09:22 AM

Subject: [JET] Editor Decision

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Dr. Julian Supardi:

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Our decision is to: Accept Submission

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marlin.ramadhan.baidillah@brin.go.id

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