Tricolor Attenuation-Based Shadow Detection and Removal Using Feature Descriptors

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Abstract:
The suggested work presents TAM-FD, a creative extension of the tricolor attenuation model designed to tackle the difficult problem of shadow detection in pictures. Using restricted contextual reasoning via pair wise potentials in Conditional Random Fields, conventional shadow detection techniques often emphasize examining the local appearance of shadow areas. The suggested method, on the other hand, captures global scene features and higher-level relationships. The shadow detector has been trained to operate as a generator of a conditional TAM (Type Attention Model) with an aim to improve shadow detection accuracy by combining the usual TAM loss with another data loss term based on feature descriptors. Shadows occur as a result of certain objects blocking direct illumination which usually comes from the sun. They are divided into cast shadows which are created by projections from an object toward a light source, and self shadows which form parts of the object not directly illuminated. Cast shadows can be sub-divided into umbra which is the region of total blockade of light and penumbra which is a region of partial blockade of light resulting in blurred boundaries between shadowed and non-shadowed areas. Shadowed regions encompass a loss of irradiance, and amplify the difficulty of imaging tasks such as interpretation, object detection and recognition, and change detection due to the loss of information presented. In all cases evaluated for performance, the proposed method yielded improvements in quantifiable indices such as 1.76% in the shadow detection index SDI, 9.75% in the color component index for preserving color contrast during shadow removal, and an increase of 1.89% in the normalized saturation value detection index NSVDI which indicates precision in recognizing shadow regions.

Keywords: Shadow Detection, TAM, TAM-FD, Cast Shadow, SDI, NSVDI.

1. Introduction

1.1 Shadow Detection and Removal in High-Resolution Panchromatic Satellite Images:

High-resolution satellite imagery (0.5–2 m) provides detailed information useful for object detection, urban planning, and 3D modeling. However, shadows—especially in urban environments—pose a significant challenge by obscuring details and reducing image clarity. Shadowed areas can cause partial or complete loss of brightness, making object extraction difficult. Therefore, shadow detection and removal is a critical preprocessing step in remote sensing applications.

While effective methods exist for multispectral and natural images, panchromatic imagery still lacks advanced shadow removal techniques despite offering superior spatial resolution. This work addresses the challenge by analyzing shadow characteristics in urban scenes and aims to reconstruct clear, shadow-free images.

1.2 Shadow Detection Techniques:

Traditional methods rely on features like low intensity and bimodal histogram distributions. Shadows are generally detected using threshold-based segmentation. However, binary masks from hard thresholding often fail in complex urban scenes. To address this, recent studies combine bimodal thresholding with image matting to achieve soft shadow detection, assigning probabilities rather than binary values.

1.3 Shadow Removal Techniques:

Three major enhancement methods are used:

a. Gamma Correction
b. Histogram Matching
c. Linear Correlation

To handle non-uniform shadows, spatially adaptive non-local regularized operators have been introduced, allowing better control over brightness and smoothness. This paper proposes the Spatially Adaptive Nonlocal Sparse (SANS) model, which combines sparse modeling and radiometric correction for noise reduction and brightness uniformity. It uses improved thresholding for different shadow types. Such as:

Self Shadow: From object surfaces not facing light directly.

Cast Shadow: Caused by objects blocking light, with types like umbra (completely dark) and penumbra (partially dark).

1.4 Detection Approach:

Hard shadow detection uses bimodal histogram segmentation, targeting large shadow areas first. Soft detection refines these results by identifying transitional regions like penumbra. This multi-step approach enhances accuracy and supports better image reconstruction.

2. Experimental Set Up and Result

Shadows are a fundamental component in high-resolution remotely sensed imagery. However, they often obscure critical features, thereby affecting various image processing tasks such as object recognition, change detection, and scene matching. Consequently, shadow detection and compensation are of significant research interest.

2.1 EXPERIMENTAL SET UP

The proposed programmed shadow recognition and pay calculations were executed in MATLAB programs under Microsoft Windows 10 condition. We chose the satellite picture of Houston/Texas of USA to test the calculations depicted in the past part.

Presently portray the strategies for shadow identification and pay in high goals satellite picture dependent on the Tricolor Attenuation Model with Feature Descriptor calculation. The properties of highlight descriptor give us a prompt to identify and expel shadows. So we use TAM (Tricolor Attenuation Model) change to change the information direct RGB picture into a different shading differences portrayal. The histogram limit method is utilized to identify shadow locales in RGB channel, and the other two chrominance channels are unaltered. Rather than applying Retinex on R, G, B channels, the proposed strategy is utilized to improve the picture just in luminance channel to make up for shadows after shadow recognition.

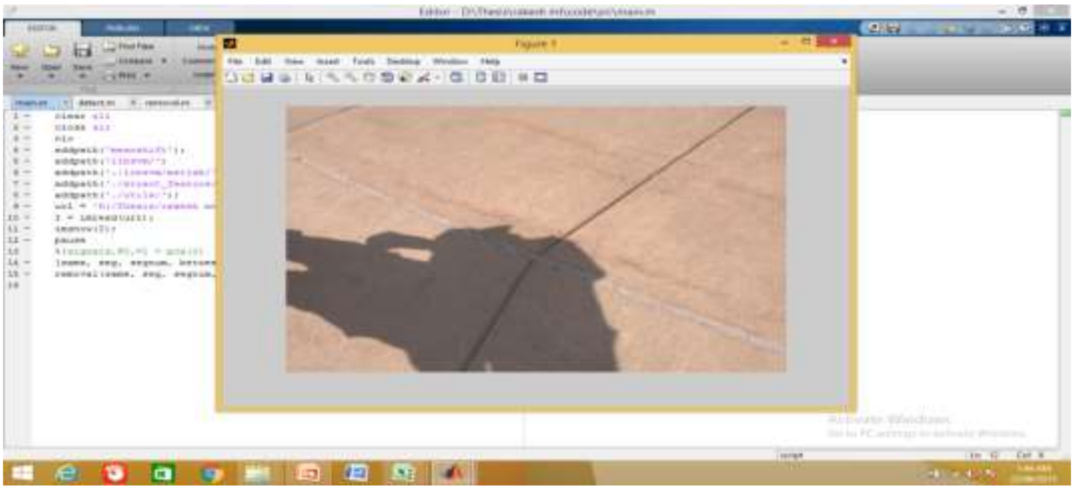

Figure 2.1: Snapshot of input sample shadow image

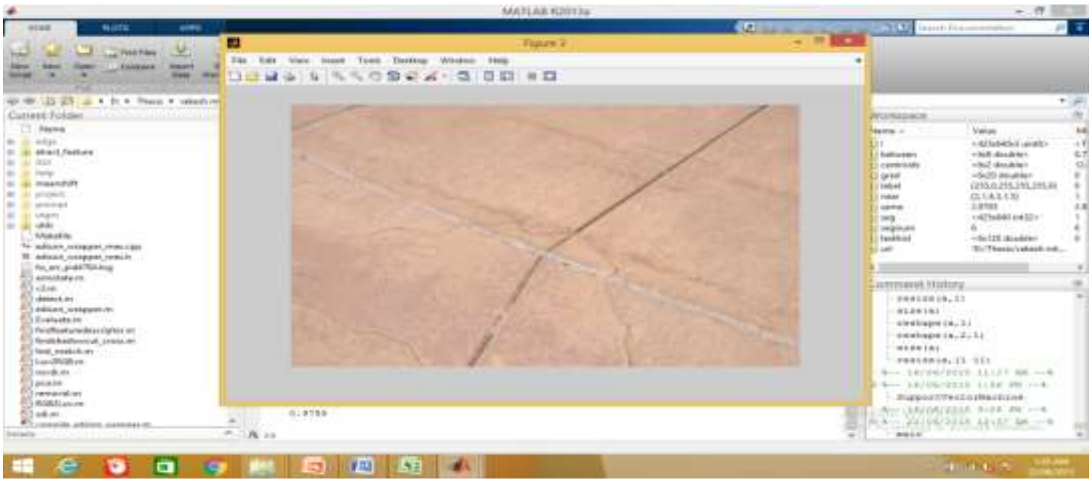

Figure 2.2: Snapshot of output non-shadow image

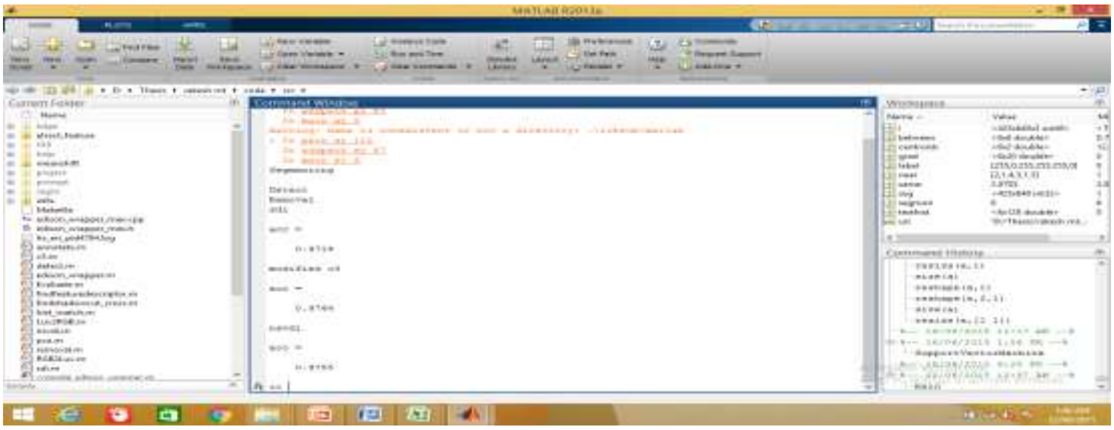

Figure 2.3: Snapshot of value of parameters

2.2 COMPARATIVE ANALYSIS

In spite of the fact that our past shadow evacuation technique can recuperate the surface detail well by and large, for some amazingly convoluted cases, where the shadowed locales are excessively dull and have overwhelming commotion, or the edges data and surface detail in the shadowed areas have been debilitated genuinely because of the brightening impeding, our past strategy may not function admirably. We present a Tricolor Attenuation Model with Feature Descriptor strategy to address these issues. We deteriorate the picture in a multi-scale detail levels utilizing an edge-protecting channel, and expel the shadow in each dimension, at that point consolidate the shadow evacuation results into the last outcomes in a spatially shifting way utilizing the weighted normal. This methodology can get increasingly loyal outcomes.

As the shadow limits as a rule change more quickly than inside areas of the shadow, and the uniform direct enlightenment suspicion may not function admirably to create loyal outcomes along the limits. What's more, for muddled shadows, to precisely recognize the shadow limits is likewise a difficult work. Along these lines, we need to evacuate the shadow and light irregularities around the limits areas. We present an element descriptor shadow estimation way to deal with dispense with the shadows around the limits, and produce a reliable luminance progress between the recouped areas and the first lit districts.

Table 2.1: SDI analysis in between of ATI-LC[1] and TAM-FD(Proposed)

Images	ATI-LC[1]	TAM-FD(Proposed)
A	97.08	98.79
B	91.51	95.34
C	96.10	98.31
D	84.62	87.77

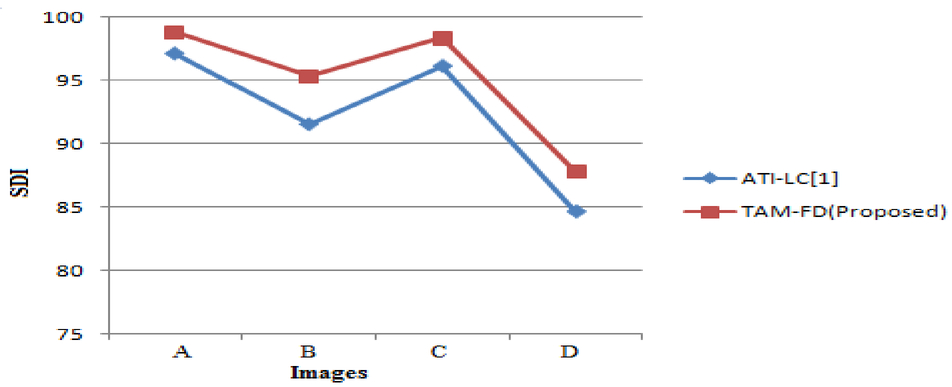

Figure 2.4: Graphical analysis of SDI in between of ATI-LC[1] and TAM-FD(Proposed)

In above figure and table are shows that shadow detection index is improve significantly for difference, hence observation non-shadow image much more effective then ATI-LC[1] (Automatic Threshold Identification with Linear Correlation).

Table 2.2: C_3* analysis in between of ATI-LC[1] and TAM-FD(Proposed)

Images	ATI-LC[1]	TAM-FD(Proposed)
A	81.92	89.91
B	75.67	83.71
C	89.84	96.14
D	58.91	62.11

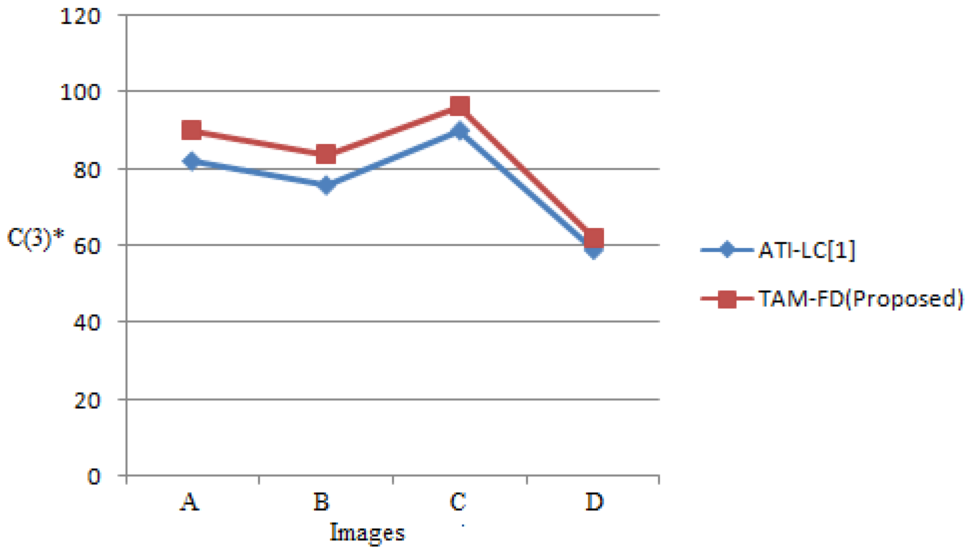

Figure 2.5: Graphical analysis of C_3* in between of ATI-LC[1] and TAM-FD(Proposed)

In above figure and table are shows that color index is improve significantly for difference, hence observation non-shadow image much more effective then ATI-LC[1] (Automatic Threshold Identification with Linear Correlation).

Table 2.3: NSVDI analysis in between of ATI-LC[1] and TAM-FD(Proposed)

Images	**ATI-LC[1]**	**TAM-FD(Proposed)**
A	96.93	98.77
B	82.78	86.91
C	96.78	98.13
D	94.48	97.83

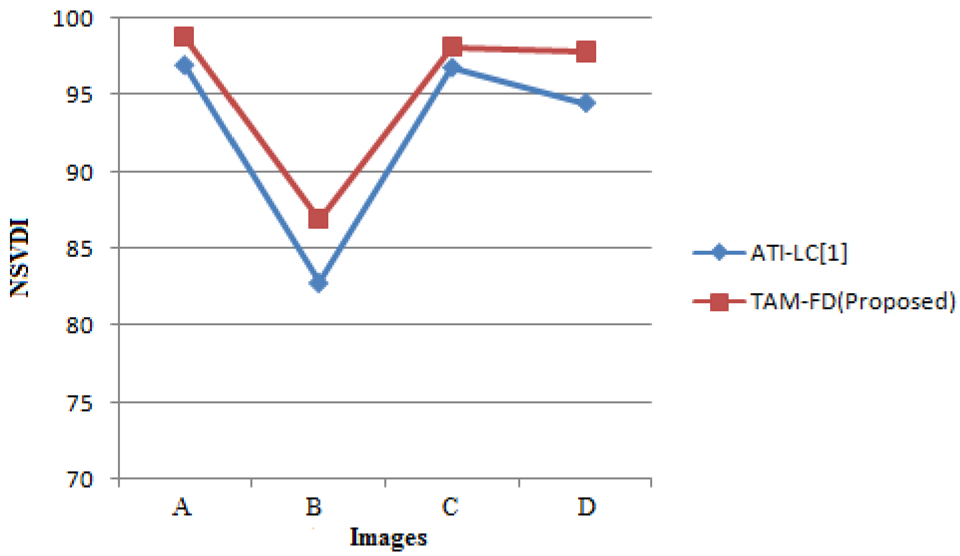

Figure 2.6: Graphical analysis of NSVDI in between of ATI-LC[1] and TAM-FD(Proposed)

In above figure and table are shows that NSVDI is improve significantly for difference, hence observation non-shadow image much more effective then ATI-LC[1] (Automatic Threshold Identification with Linear Correlation).

By correlation of the first picture, the upgraded picture and the shadow location picture, every one of the pixels in shadow locales of the first picture are supplanted by improved picture utilizing TAM-FD. Investigation results demonstrate that the technique is viable and offers the accompanying advantages:
(a) The technique can recognize the greenish articles from shadows, and the state of the portioned shadows is protected well including the exiguous shadow locales.
(b) The strategy can improve the perceivability of highlights in shadowed districts while holding non-shadowed areas unaffected. In any case, the normal tint of shadowed areas should be improved.

3. Conclusion:

The fundamental consequence of my exposition part-II errand is as per the following:
In view of the investigation of the properties of shadows, a handy technique that joins model and perception signals for exact shadow identification is proposed in this paper. In view of the first splendid channel earlier, we present another earlier for the shadow identification task. We additionally use NIR channel data (if the NIR channel is accessible) to recognize dim articles from shadows. Our technique is reasonable for both regular pictures and remote detecting pictures. Regardless of the effortlessness of the proposed strategy, high discovery exactness can be accomplished with no post-preparing stage. We approve the adequacy of the proposed splendid channel earlier and the perception prompts. Contrasted and the cutting edge strategies, our technique exhibited better precision and delivered shadow covers that are a lot nearer to the ground truth maps. Besides, the productivity of our strategy is likewise incredibly high, which is a significant factor for designing applications.

- SDI record improves by 1.76%.
- Color segment list for save shading change during expulsion of shadow procedure is improved by 9.75%.
- Normalize immersion esteem recognition file is improve by 1.89% for recognize shadow pixel.

4. SUGGESTIONS OF FUTURE WORK

The future work of present exposition part-II assignment is as per the following:
Besides, we propose another classifier to consequently recognize reasonable sets of lit-shadow districts. We exhibited that the iterative utilization of the proposed change in decidedly grouped sets of locales beats the cutting edge on the shadow evacuation benchmark dataset. Our outcomes are particularly precise in the center pixels of the shadow districts.

Reference:

1. Tomas F. Yago Vicente , Minh Hoai and Dimitris Samaras, “Leave-One-Out Kernel Optimization for Shadow Detection and Removal”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 40, No. 3, March 2018.
2. Vu Nguyen, Tomas F. Yago Vicente, Maozheng Zhao, Minh Hoai and Dimitris Samaras, “Shadow Detection with Conditional Generative Adversarial Networks”, IEEE International Conference on Computer Vision, 2017.
3. Yasser Mostafa and Ahmed Abdelhafiz, “Accurate Shadow Detection from High-Resolution Satellite Images”, IEEE Geo Science and Remote Sensing Letters, Vol. 14, No. 4, April 2017.
4. Jiayuan Li, Qingwu Hu and Mingyao Ai, “Joint Model and Observation Cues for Single-Image Shadow Detection”, MDPI Journal of Remote Sensing, 2016.

5. Nan Su, Ye Zhang, Shu Tian, Yiming Yan and Xinyuan Miao, "Shadow Detection and Removal for Occluded Object Information Recovery in Urban High-Resolution Panchromatic Satellite Images", IEEE Journal of Selected Topics in Applied Earth Observations And Remote Sensing, Vol. 9, No. 6, June 2016.
6. Huihui Song, Bo Huang, Associate Member, IEEE, and Kaihua Zhang, "Shadow Detection and Reconstruction in High-Resolution Satellite Images via Morphological Filtering and Example-Based Learning", IEEE Transactions on Geoscience and Remote Sensing, 2014.
7. Chunxia Xiao, Ruiyun She, Donglin Xiao and Kwan-Liu Ma, "Fast Shadow Removal Using Adaptive Multi-scale Illumination Transfer", COMPUTER GRAPHICS forum, 2013.
8. Tomás F. Yago Vicente, Chen-Ping Yu, Dimitris Samaras, "Single Image Shadow Detection using Multiple Cues in a Supermodular MRF", IEEE Access Journal, 2013.
9. Guangyao DUAN, Huili GONG, Wenji ZHAO, Xinming TANG, Beibei CHEN, "An Index-Based Shadow Extraction Approach On High-Resolution Images", Springer Journal of Image Processing, 2013.
10. Jiu-Lun Fan, Bo Lei, "A modified valley-emphasis method for automatic thresholding", Elsivier Journal of Pattern Recognition, 2012.
11. Q. YE, H. XIE, Q. XU, "Removing Shadows from High-Resolution Urban Aerial Images Based on Color Constancy", International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXIX-B3, 2012.
12. Jiejie Zhu, Kegan G.G. Samuel, Syed Z. Masood, Marshall F. Tappen, "Learning to Recognize Shadows in Monochromatic Natural Images", IEEE Journal of Image Processing, 2010.
13. Wen Liu and Fumio Yamazaki, "Shadow Extraction and Correction from Quickbird Images", IGARSS, 2010.
14. Lu Wang and Nelson H. C. Yung, "Extraction of Moving Objects From Their Background Based on Multiple Adaptive Thresholds and Boundary Evaluation", IEEE Transactions on Intelligent Transportation Systems, Vol. 11, No. 1, March 2010.
15. Fumio Yamazaki, Wen Liu and Makiko Takasaki, "Characteristics of Shadow And Removal of Its Effects for Remote Sensing Imagery", IGARSS, 2009.