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PDE-based Specular Highlight Elimination

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ABSTRACT

Dealing with reflections in images captured through glass would be real headache, as they can obscure the important stuff behind the glass and make the whole image look messy. This is a major problem in many computer vision tasks.Early studies reported that a popular way to tackle the challenge of removing reflections from [1] single images in deep learning. In this article, we take a deep dive into the research on this topic from 2015 to 2021, focusing on how deep learning is being used for [5] single-image reflection removal [4].We searched through a bunch of important online databases and libraries, like IEEE Xplore, Google Scholar, ScienceDirect, SpringerLink, and ACM Digital Library, to find relevant research papers. After carefully going through them, we picked out 25 papers [9] that fit the criteria for our review.We analyzed these papers to answer seven major questions about how deep learning and [3] neural networks are being used for [6] single-image reflection removal. This will hopefully give future researchers a good understanding of what's been done in this area and help them build on that knowledge.The review also highlights the important challenges that data scientists are facing in this area, and also some promising directions for future research. . And importantly, it provides a list of useful datasets that data scientists can use to benchmark their own deep learning techniques against other studies. Whether you're a researcher hungry for the next challenge or just someone who wants to understand how it all works, this review will equip you with the knowledge and inspiration to delve deeper into this fascinating field.

Key words: Anisotropic diffusion, boundary constraints, diffusion coefficients, image inpainting, non-local methods, partial differential equations (PDEs), specular highlight modeling, texture preservation ,Variational Framework

1. INTRODUCTION

Isolating reflections in images is tricky, especially for diverse materials like plastics, leaves, wood, and skin. This separation matters because the final image is a blend of specular (mirror-like) and diffuse (rough) reflections, weighted by the material's inherent reflectivity. Breaking down an image into these parts unlocks several benefits.

The Lambertian model perfectly captures diffuse reflection, making it a powerful tool for real-world 3D scene analysis and object recognition, even when surfaces aren't perfectly Lambertian.

Specular reflections, besides influencing our perception, are crucial for certain computer vision algorithms. Furthermore, separating specular and diffuse components is vital in 3D modeling and photo editing, allowing independent manipulation and recombination of these layers. This paper tackles the challenge of separating reflection components in diverse images, potentially including textured surfaces. It focuses on surfaces accurately described by Shafer's dichromatic reflectance model, where specular reflections match the light source's color, and diffuse reflections depend on the material's properties[10] . The goal is to split an RGB image into an RGB "diffuse image" and a black and white specular layer. This is quite challenging, especially if the light source color is unknown. Existing methods handle this by combining color information across the image, differentiating between global and local approaches [40] . Global methods, like those by Klinker et al. and Tan and Ikeuchi, rely on explicit segmentation or known light source color. Local methods, on the other hand, focus solely on local interactions, assuming known light source color. Examples include iteratively reducing the specular component by analyzing neighboring pixels and minimizing an error function based on local variations.

This paper introduces a general framework using continuous-domain partial differential equations (PDEs) to formalize the concept of "local interactions" for specular/diffuse separation. [11] This method selectively shares color information between nearby image points through multi-scale erosion, adapting to both textured and untextured surfaces. The framework is extended to videos, incorporating motion information as an additional clue.

In practical applications, the paper showcases results on high-resolution lab images and 8-bit internet images, demonstrating robustness to artifacts like low dynamic range, JPEG compression, and unknown light source color. Results on videos highlight [8] the adaptability of the proposed

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