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硕士学位论文

基于卷积神经网络的单幅图像去雨

Removing rain from a single image via Convolutional Neural Network

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摘 要

受恶劣天气的影响，室外视觉系统所获得的图像会劣化。雨是常见的恶劣天气之一，目前国内外关于去雨的问题已有一些解决的方案，但大多关注于视频去雨。由于该类方法是以丰富的时空相关信息为前提，因而并不适用于单幅图像去雨。近年来，单幅图像去雨的研究逐渐受到重视，然而现有方法需要在去雨效果和图像清晰度之间折中且计算效率低下，难以满足实际应用需求。

为此，本文针对单幅图像去雨，基于变分法和卷积神经网络提出三种新的单幅图像去雨算法，主要研究内容及成果如下：

1. 提出基于梯度 正则化的单幅图像去雨算法。首先设计一个引导 平滑滤波器实现初步去雨。该滤波器在保证输出图像与输入图像一致性的前提下，引入梯度正则项，使其根据引导图像的梯度大小平滑输出图像。而后在该初步去雨图像与有雨图像间取最小值，得到无雨图像。

2. 提出基于梯度修正的单幅图像去雨算法。该算法针对基于梯度 正则化的单幅图像去雨算法迭代过程中，引导图像细节丢失的问题，提出一个新的能量函数。该算法认为雨的信息基本包含在水平梯度中，因而求取水平梯度及垂直梯度后，运用引导滤波平滑水平梯度图，与垂直梯度相加，得到无雨的参考梯度图像。再以此无雨梯度图像作为先验，构造新的能量函数。最终通过变分法求解得到去雨图像。该算法保留了更多的背景信息。

3. 提出基于卷积神经网络的单幅图像去雨算法。现有的单幅图像去雨算法只能分析底层图像较小邻域内的特征，在清晰度与去雨间折中。深度学习能模仿人的大脑皮层，从底层图像中提取高层语义，并通过权重提取相应的特征，选取不同的形态成分。因而本文引入卷积神经网络，训练得到一个适用于去雨的滤波系统。该系统可以实现有雨图像到无雨图像的端到端的非线性映射，在去雨和保持图像清晰度方面达到了很好的综合效果。

4. 建立训练卷积神经网络的图像库。为了实现卷积神经网络的训练，本文通过screen blend model对干净的清晰图像人工加雨，形成相应的有雨图像与无雨图像对，建立了训练神经网络的图像库。相关实验表明，这种仿真获得的训练库训练所

得的卷积神经网络对于实际有雨图像雨线去除依然有效。

关键词：单幅图像去雨；变分法；卷积神经网络；深度学习

Abstract

Affected by the bad weather, the images obtained by outdoor visual systems always degrade. Rain is one of the common bad weather. At home and abroad, there are some solutions about removal of rain, but most of it aims to videos. It can't apply to single image since no temporal information can be obtained. Recently, the study of rain removal from a single image gradually receive more attention. However, the existing methods can't meet the demand of practical application. Because it makes a trade off between rain removal and image sharpness, and it has low computing efficiency.

Therefore, this paper proposes three new methods to remove the rain streaks in a single image based on variational method and convolutional neural network, the main study content and results are as follows:

1. Removing rain from a single image method via gradient regularization was proposed. A guided smoothing filter is designed, which can simply remove rain. The filter introduces gradient regularization, which make the filter smooth the input image according to the gradient magnitude of guided image. The final refined result is obtained by minimization operation between the input image and the coarse rain-free image.

2. Removing rain from a single image method via gradient modification is proposed. It puts forward a new energy function aiming the problem of loss information. The method assumes that rain is contained in horizontal gradient. So the sum of the vertical gradient and the smoothing horizontal gradient by guided filter can be a modified gradient. A new energy function is proposed using the modified gradient. The function can be solved with variational method, which can keep more details.

3. Removing rain from a single image method via CNN is proposed. The existing methods of single image rain removal only analyze the feature in a small

area. So it will make a trade off between keeping detail and rain removal. Deep learning can imitate human cerebral cortex. So it can extract high-level semantic from image, and extract corresponding feature according weight. As a result, this paper introduces convolutional neural network. It can get a filtering system which is suitable for removing rain by nonlinear mapping. This method can achieve good comprehensive effect in keeping detail and rain removal.

4. An image dataset is established to train convolutional neural network. In order to train convolutional neural network, artificial rain images are formed by screen blend model. And a dataset of clean/rain image pairs is established. The related experiments show that the network trained by this dataset is still valid for nature rain image.

Keywords: removing rain from single image; variational method; Convolutional Neural Network; deep learning

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