Corner Detection using Deep Learning

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***Abstract*— Corner detection is a fundamental task in computer vision that involves identifying and locating an image's corners or interest points. We can observe from multiple research papers that corner detection papers do not use pre-processing. This paper examines the effects of the Holistic Edge Detection (HED) as a preprocessing tool for corner detection. We examine if HED can yield better results. This can be observed by comparing side-by-side results of images that use HED and those that don't. By the end of the paper, we will conclude if HED can be used as a viable and robust tool for corner detection.**

I. Background

A given image is a collection of pixels, each of a different intensity value. At a corner, the intensity changes as you move along different directions. Corners are associated with high gradients in the image. The gradient represents the rate of change of intensity. At corners, this change is significant in more than one direction. However, a corner differs from an edge since an edge experiences a change in intensity along a linear path whereas it occurs over multiple directions in a corner. The detection of corners is a crucial step in many computer vision tasks, and various algorithms, both traditional and based on deep learning, have been developed to identify corners in images. An example of a traditional algorithm is the Harris Corner Detector, which computes the intensity gradients of the image in both the x and y directions. This is typically done using Sobel or Prewitt operators. An example of a deep learning model is the Harris CornerNet; inspired by the traditional Harris Corner Detector, this deep learning approach combines key-point detection with regression. It uses a fully convolutional network to predict corner locations and confidence scores. Today, a combination of traditional corner detection methods and deep learning approaches is often used based on the specific requirements of the task at hand. Corner detection remains a fundamental step in many computer vision applications, including image recognition, object tracking, and scene understanding.

II. Pre-requisite

This paper uses the BSDS-500 dataset. This dataset contains a plethora of images for edge detection learning. A large number of people have used this dataset to teach models for edge detection. The paper also uses Pytorch to teach models from the dataset. A type of edge detection neural network is used, called Holistic Edge Detection (HED). It uses a Convolutional Neural Network for image processing.

III. Literature Review

DeepCorners: Learning Representations for Corner Detection" (2017)
Authors: J. Kim, J. Choi, M. Kim, and J. Lee
Summary: This paper introduces DeepCorners, a convolutional neural network (CNN) based approach for corner detection. The network is trained to predict corner points directly, and the model outperforms traditional methods on various datasets.

"End-to-End Corner Detection and Classification With Deep Neural Networks" (2018)
Authors: A. Valada, and W. Burgard
Summary: The paper proposes an end-to-end trainable deep neural network for corner detection and classification. The model is capable of learning corner features from raw input data and achieves competitive results compared to classical methods.

"Fast Corner Detection Based on Deep Learning" (2019)
Authors: H. Kim, J. Kim, and S. Ahn
Summary: This work focuses on speed and efficiency in corner detection. The proposed model combines a deep learning approach with a traditional Harris corner detector, resulting in fast and accurate corner detection.

"CornerNet-Lite: Efficient Keypoint-Based Object Detection" (2019)
Authors: H. Law and J. Deng
Summary: Although primarily focused on object detection, CornerNet-Lite introduces an efficient keypoint-based detection mechanism that can be applied to corner detection tasks. The method demonstrates high accuracy in detecting corners in natural images.

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IV. Methodology

A combination of Holistic Edge Detection (HED) and corner detection is the approach used in this paper. Instead of directly passing the image into a corner detector, it is first passed into the HED model. The intermediate image from the HED model is passed into the corner detector for the final output image.

A. Image Format

We have used the Portable Network Graphics (PNG) format for consistency purposes. The input image must be formatted with a width 480 pixels and a height of 320 pixels.

B. HED Model

The input image passes the RGB values of each pixel into the HED model. The model uses Convolutional Neural Networks for image processing. The model architecture consists of 5 sequential layer and 1 side layer. The sequential layers consist of the first 2 layers of width 2 and the other 3 layers have width 3. This part of the neural network combines the output scores from different feature extraction stages. It applies a convolutional layer with one output channel and a sigmoid activation function. This final output represents the combined edge detection result.

C. Corner Detection

The output from the HED model is passed into the corner detector for a final output image. The corner detection uses first-order derivatives and applies Prewitt operator to detect corners. It can detect corners by identifying multiple locations of gradient change.

V. Observations

The results obtained from multiple test images show that the corner detection performs better on images with HED applied to them. The HED process can be thought of as a preprocessing step. The HED output images help the corner detector in examining corners by removing all irrelevant noise from the images. The convolution process seems to only focus on the edges, which helps in the final corner-detecting capabilities. The output image without HED misses essential features. In some cases, it cannot capture corners when many of the features are clustered or sparse. Moreover, each kernel used for convolution has a converging value for optimal results.

VI. Results

After passing multiple input images into the HED model and corner detection, results showed that passing the image through the HED model improved corner detection capabilities.

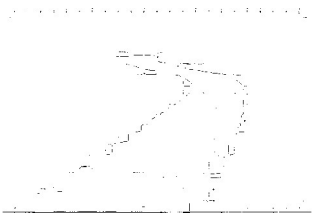
A. Input Image

Input Image 1

B. Intermediate Image of HED model.

HED Output 1

C. Final Image with HED



Final Output with HED 1

D. Final Image without HED

Final Output without HED 1

VII. Conclusions

From the above observations and results, using HED as a pre-processing step can help yield better results for corner detection. The corner detection can be extended to other algorithms like Harris corner detection for better results. Corner detection without HED results in improper feature extraction. Hence, corner detection should include HED as a tool for future analysis.

Acknowledgment

We want to express our sincere gratitude to the researchers and developers whose pioneering work in corner detection using deep learning has significantly influenced and enriched this project. The insights and innovations have been invaluable. This project wouldn't have been possible without the collaborative efforts and support from each of our team members.

References

[1] Kim, H., Kim, J., & Ahn, S. (2019). 'Fast Corner Detection Based on Deep Learning.'

[2] Law, H., & Deng, J. (2019). 'CornerNet-Lite: Efficient Keypoint-Based Object Detection.'

CV_FINAL_REPORT

by Gnanateja Reddy

General metrics

8,308	1,246	119	4 min 59 sec	9 min 35 sec
characters	words	sentences	reading time	speaking time

Score

86

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Writing Issues

45	8	37
Issues left	Critical	Advanced

Plagiarism

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