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OVERVIEW OF APPROACHES TO SOFTWARE IMPLEMENTATION SUPER-RESOLUTION

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Abstract

These theses provide an overview of various approaches to the software implementation of super-resolution, focusing on algorithms used in digital image processing, such as interpolation-based, reconstruction-based, and learning-based algorithms. They discuss the advantages and limitations of each approach, highlighting their impact on image quality and computational efficiency. Additionally, the theses explore recent advancements and trends in super-resolution techniques, offering insights into potential future developments in this field.

Keywords: software implementation, super-resolution, digital image processing.

Introduction

Most of the information that people perceive is presented in some way in a visual form, from text to images or videos. Observing the trends in the media sphere, the hypothesis is confirmed that the share of such information will grow, and the methods of displaying it will evolve along with it. Therefore, there is a need both to adapt outdated low-resolution images for modern screens and to acquire new ones without relying solely on the capture device.

Modern super-resolution technology solves some of the problems in the field of image enhancement and computer vision. It involves increasing the resolution of an image or video by generating the missing details of high quality from a low-resolution input image, while preserving its content and structure [1]. To date, super-resolution technology has demonstrated great potential in many areas, including medical image processing, remote sensors, high-quality digital television, and video surveillance.

There are several approaches to implementing super-resolution. They are classified by the amount of input data and the principles of further processing.

Depending on the specifics of the task at hand, in some cases it is advisable to use methods that require several or a single image.

But in many practical scenarios, it is quite difficult to obtain a sequence of images of the same object. In addition, most super-resolution algorithms based on multiple images are extensions of algorithms based on a single image [1].

According to the processing principles, the methods can be divided into those based on reconstruction, interpolation, or machine learning.

Reconstruction-based algorithms assume that there is a target high-resolution image, and its low-resolution variations have some relative geometric shifts from the target high-resolution image. One of the most striking examples of a reconstruction method is the degradation model of an image (Fig. 1). It operates on the parameters of image deformation, optical blurring, and down sampling. In fact, super-resolution is an inverse process.

The above degradation process can be represented as the following equation:

$$Yk = DFkNX + Vk \quad (1)$$

where X is a high quality image, Yk is the k-th low-resolution image.

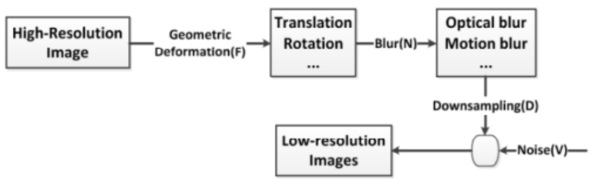

Figure 1. Schematic of the degradation model

Interpolation methods are one of the simplest and fastest options for implementing super-resolution. Their principle is to determine the position and characteristics of new pixels by interpolating already known pixels. Compared to other approaches, the interpolation-based method provides the simplest calculation procedure and minimal computational complexity. Image interpolation is an important technique in the field of image processing, which is mainly used to resize an image when quality does not play a big role.

For example, the bilinear interpolation algorithm (Figure 2) consists of performing linear interpolation in both the horizontal and vertical directions. This method estimates the value of the pixel to be interpolated by bilinearly interpolating the values of its surrounding pixels.

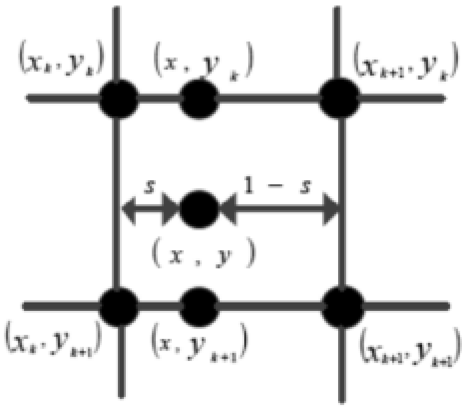

Figure 2. Bilinear interpolation

Machine learning methods are quite easy to solve image processing problems and are therefore often used in super-resolution. The basic idea of this method is to learn the relationship between a low-resolution image and a high-resolution image, and then reconstruct the target image using this relationship [1].

Convolutional neural networks are most often used in the field of image processing (Fig. 3). For super-resolution, the receptive field of a convolutional network determines the amount of contextual information that can be used to reconstruct missing high-frequency components.

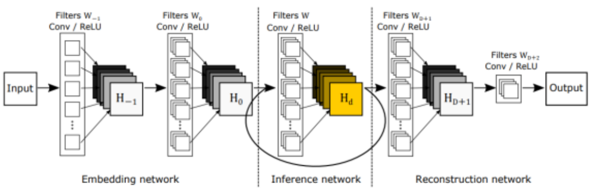

Figure 3. Convolutional Neural Network Architecture for Image

Processing Since increasing resolution is an ill-defined inverse problem, collecting and analysing more neighbouring pixels can provide more indications of what may have been lost in the quality loss [2]. For example, if the receptive field contains a pattern with blurred edges, it is likely that the pattern will be recognised and the edges will be reproduced accordingly

Conclusions

Thus, based on the review of approaches to super-resolution, we can conclude that each method has its own field of application. Interpolation methods are convenient when the goal is image processing speed, but they can leave artefacts after execution. Reconstruction and machine learning-based methods can produce a defect-free target image, but their preparation and execution require significant resources.

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