Lehrstuhl für Bildverarbeitung

RWTH AACHEN UNIVERSITY

Master-Thesis

Superpixel-Based Downsampling with Fixed Region Constraints and Adaptive Compactness

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Background

The semantic information of an image essentially answers the question, "What is depicted in the image?" In image processing, comparing semantic content is crucial—be it in super-resolution, where low-resolution images are transformed into high-resolution versions, or in visual aid applications. Traditional downsampling methods like bilinear or bicubic interpolation were originally designed for upsampling. However, when applied without a preceding low-pass filter, aliasing effects can distort key image details. An innovative approach to enhancing this process is the use of superpixels. Instead of uniformly reducing an image, it is partitioned into homogeneous, semantically meaningful regions. Specifying a fixed number k of superpixels allows for controlled and consistent data reduction that better preserves both global and local structures.

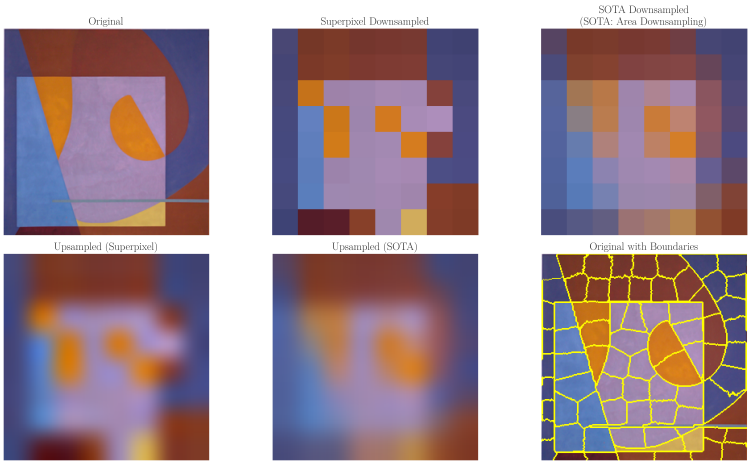

Figure 1: Prototype results of the pipeline. The novel Downsampling

A central focus of this work is the investigation and selection of the optimal superpixel algorithm. Classical methods such as SLIC, SEEDS, or watershed-based approaches will be compared with modern, deep-learning-based techniques. A key aspect is the automatic determination of the compactness parameter, which regulates the balance between uniformity within a superpixel and its spatial regularity. An adaptive adjustment of this parameter, based on the image content, promises to maintain semantic integrity even in images with diverse structures.

The goal of this research is to systematically compare existing methods and develop a novel approach that enables content-dependent adaptation of compactness. In doing so, the work aims to strike the ideal balance between preserving semantic image content and achieving effective data reduction.

Tasks

- Literature Research. An overview of existing methods for superpixel-based downsampling, focusing on fixed superpixel count and adaptive compactness.
- Analysis and Comparison. Examination of classical algorithms (e.g., SLIC, SEEDS, Watershed) versus deep learning-based approaches regarding their suitability for a fixed pixel approach
- Proof-of-Concept Implementation. Development of a prototype that adaptively determines the compactness parameter based on local image content.

Your Profile

- Experience with programming languages, ideally Python
- Structured approach to work
- Strong mathematical background

Interested?

- Write me an E-Mail to konermann@lfb.rwth-aachen.de. In a personal conversation, we can get to know each other and, if necessary, discuss the details or **alternative research questions.**