IMAGE RESIZING USING THIN-PLATE SPLINE

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To my beloved father and mother

for their endless support and encouragement.

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ABSTRACT

Interpolation of scattered data refers to the problem of passing a smooth surface through a non-uniform distribution of data samples. In many science and engineering fields, where data are often generated or measured at few and irregular positions, this problem is of practical importance. Over the past decades, different methods have been used to yield solutions to the multi-variate scattered data interpolation problem. One of the popular methods that is commonly used is Thin-Plate Spline (TPS). A thin-plate spline is a physically inspired two-dimensional interpolation structure for randomly spaced tabulated data$(x_i, y_i, f(x_i, y_i))$. TPS is the generalization of the natural cubic spline in one dimension. The spline surface represents a thin sheet of metal that is limited not to move at the grid points. Such surfaces are preferred for various modeling and design applications. For decades, TPS had been used in mechanics and engineering, and they were initiated to image analysis community by Bookstein. TPS is practically one of the most frequently used transformation function in non-rigid image registration. In this project, TPS is used for the image resizing purpose and its result shows around 12% improvement in terms of quality compared with Bicubic interpolation method. Furthermore, an approach is proposed to reduce the computational cost drastically for large scale images. The results show that this method speeds up the evaluation of TPS interpolation function up to 16 times, compared with direct evaluation. This approach involves windowing the image in order to implement TPS on smaller data sets rather than applying it to the whole image at once.

ABSTRAK

Interpolasi bagi data tidak tersusun merujuk kepada permasalahan yang terjadi apabila melalui permukaan yang sekata pada titik-titik data yang tidak seragam. Di dalam bidang sains dan kejuruteraan, data-data yang diperoleh selalunya sedikit atau pada kedudukan janggal dan merupakan permasalahan praktik. Kebelakangan ini, pelbagai cara telah digunakan untuk mendapatkan penyelesaian pada permasalahan interpolasi data tidak seragam. Salah satu penyelesaian yang masyhur ialah menggunakan Splin Plat-Nipis(TPS). Splin Plat-Nipis secara fizikal telah di inspirasi kan daripada struktur interpolasi dua dimensi untuk data rawak $(x_i, y_i, f(x_i, y_i))$. TPS terbina daripada splin kiub asli dalam satu dimensi. Permukaan splin adalah satu lapisan metal yang nipis dan pergerakannya terbatas pada satu-satu titik grid. Permukaan sebegini menjadi pilihan untuk model pelbagai dan juga aplikasi rekaan. Sebelum ini, TPS digunakan dalam bidang mekanik dan kejuruteraan dan Bookstein memulakan pengunaakn TPS dalam konteks analisis imej. TPS juga merupakan kaedah lazim yang selalu digunakan untuk fungsi transformasi pada pendafttaran imej tidak tetap. Dalam projek ini, TPS digunakan pada imej untuk tujuan pensaizan semula dan keputusan yang diperoleh menunjukkan peningkatan kualiti sebanyak 12% berbanding dengan kaedah konvensional. Tambahan pula, kaedah ini dicadangkan untuk mengurangkan kadar kerumitan pada imej berskala besar secara mendadak. Kaedah ini meningkatkan tahap kelajuan sehingga 16 kali untuk penilaian interpolasi menggunakan kaedah TPS berbanding penilaian terus. Kaedah ini melibatkan cara membahagikan imej kepada tetingkap-tetingkap lebih kecil untuk perlaksanaan TPS pada set data yg lebih kecil berbanding kepada keseluruhan imej sekaligus.

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LIST OF ABBREVIATIONS

2D	-	Two-Dimensional
3D	-	Three-Dimensional
A-Bilinear	-	Advanced Bilinear
CIM	-	Curvature Interpolation Method
DAP	-	Difference of Adjacent Pixels
dB	-	decibel
DFT	-	Discrete Fourier Transform
FFT	-	Fast Fourier Transform
IEEE	-	Institute of Electrical and Electronics Engineers
LMS	-	least mean square
MATLAB	-	Matrix Laboratory
MSE	-	Mean Squared Error
PDE	-	Partial Differential Equation
PSNR	-	Peak Signal to Noise Ratio
RLS	-	Recursive Least Square
TPS	-	Thin-Plate Spline

CHAPTER 1

INTRODUCTION

1.1 Introduction

Due to the development of modern information technology, image processing is becoming more and more important in our life. Digital image processing has demonstrated an extraordinary evolution in the past decades, in terms of both applications and theoretical development. It is practically a leading technology in several vital areas, such as Internet-based services, digital telecommunications, broadcasting, multimedia systems and medical imaging. Among all the technologies that digital image processing provides, image resizing is a remarkably important technology, due to its wide applications in different fields such as, scientific imaging, graphic design, multimedia communication, medical imaging, police security, etc. In order to have better and fine images for users, images are regularly required to be resized or reproduced to different resolutions.

1.2 Background

Technically, resizing whether implies enlargement of an image for a better view of it, or implies image reduction to reproduce the smaller size of it for applications that size and speed are the main concern. Image resizing is referred to inserting new pixels into the image in order to expand the size or removing pixels to reduce the size.

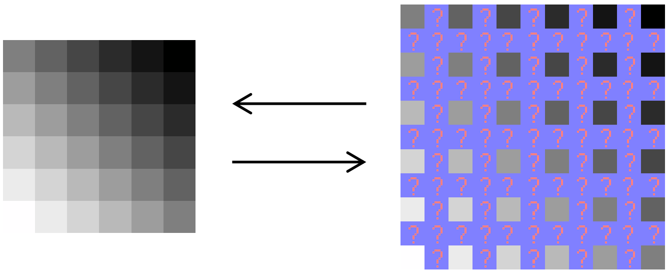

Figure 1.1 Image resizing

The major task is the interpolation of the new pixels from the surrounding original pixels. Interpolation is a method of constructing new data points within the range of a discrete set of known data points. In other words, interpolation works by using known data to estimate values at unknown points. In image resizing, interpolation is used to find the value of unknown pixels with the help of known pixel values. Basically, it turns a discrete image into a continuous function, which is essential for various geometric transform of discrete images.

Various interpolation methods have been developed during the last few decades. Some of the basic interpolations that are commonly used in image resizing are Nearest neighbor interpolation, Bilinear interpolation and Bicubic interpolation.

1.3 Problem Statement

When resizing is performed on an image, the result can vary significantly depending on the interpolation algorithm. Unfortunately, the methods mentioned previously have one or more undesirable artifacts. Edge halos, blurring and aliasing, as shown in Figure 1.2, are some of these artifacts that usually appear in the image when resizing is applied, especially when the image is resized by a large factor.

(a) (b) (c)

Figure 1.2 Undesirable artifacts a) Edge halos b) Blurred c) Aliased

Another parameter that varies in different image interpolation methods is the processing time. Depending on the method's complexity, the processing time differs. The low order interpolation methods, like Nearest neighbor, require less computation at the expense of degrading the quality of the resized image. On the other hand, the higher interpolation methods, like Bicubic, offer resized image of better quality, but more complex computation cannot be avoided in them.

The main problem in image resizing is finding the method which contributes to the best performance, in terms of quality, timing and computational cost.

1.4 Objective of the study

This project focuses on image resizing using another interpolation method called Thin-plate spline. The performance and the result of implementing this method will be analyzed and compared with conventional methods. The main objective is to improve the quality of images using Thin Plate Spline interpolation when resizing is performed, and reducing the computational cost and processing time of it as possible.

1.5 Scope of the study

The scope of study is listed as below:

- This project focuses only on still images rather than videos.
- This project uses grayscale images for the experimental result.
- Thin-plate spline interpolation will be studied and implemented on different sample images using MATLAB software.

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