Motion Picture Restoration

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Digital Algorithms for Artefact Suppression in Degraded Motion Picture Film and Video

Springer

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ISBN 978-1-4471-3487-9 ISBN 978-1-4471-3485-5 (eBook)
DOI 10.1007/978-1-4471-3485-5

British Library Cataloguing in Publication Data
Kokaram, Anil. C.
Motion picture restoration : digital algorithms for artefact suppression in degraded motion picture film and video
1.Motion pictures - Conservation and restoration 2.Image processing - Digital techniques 3.Image reconstruction
I.Title
621.3'67
ISBN 978-1-4471-3487-9

Library of Congress Cataloging-in-Publication Data
Kokaram, A. C., 1967-
Motion picture restoration : digital algorithms for artefact suppression in degraded motion picture film and video / A.C. Kokaram.
p. cm.
Includes bibliographical references.
ISBN 978-1-4471-3487-9
1. Motion picture film--Conservation and restoration. 2. Image processing--Digital techniques. 3. Signal processing--Digital techniques.
I. Title.
TR886.3.K65 1998
778.5'3'0288--dc21 98-4855

Originally published by Springer-Verlag Berlin Heidelberg New York in 1998

Typesetting: Camera ready by author
Printed and bound at The Cromwell Press, Trowbridge, Wiltshire, England
34/3830-543210 Printed on acid-free paper

To my wife, Stefanie

Preface

The manipulation of pictures and video in digital form has been an established research activity for more than twenty years. It is only recently, however, that digital image and video processing equipment has been accessible to the general public. This is due in part to the rapidly growing economy of the home computer. A major contributing factor has been the marked rise in the presence of the non-academic user on the internet, particularly the World Wide Web (WWW). Manipulating digital imagery has become synonymous with the WWW. It is the drive to present audio and visual media to the home user in an interactive form and to increase the available range of choices, which has encouraged agreements to begin digital video television broadcasting before the turn of the century. With the increased demand for video material, there is a perceived increase in demand for material from archive sources and this has fuelled commercial interest in automatic digital restoration processes. Furthermore there is a continuing effort to design techniques for correcting errors in received compressed video bit streams for the purposes of live communications links over noisy channels e.g. mobile telephones and the internet.

This book introduces the reader to a range of digital restoration activities beyond the well traversed areas of noise reduction and deblurring. It describes a number of problems associated with archived film and video. Particular attention is given to missing data since that applies equally well to correcting packet loss in coded video bit streams. The book should appeal both to those in industry and to academic researchers.

In many ways the book is a culmination of eight years work in the area of video reconstruction. This began in 1989 when I was a Ph.D student in the Signal Processing Laboratory at the Cambridge University Engineering Department and continued as a post-doctoral fellow from 1993–1998. I am grateful for

the financial support of Cambridge University, the British Library and Cable and Wireless during the early years and the European Union restoration project AURORA[1] during the last three years.

Many exceptional people influenced my thinking in this time and this book would be incomplete without suitable acknowledgement. I wish to thank Dr. Simon Godsill for many educational discussions about the Bayesian paradigm which led to the design of the JOMBADI algorithm. Much of the research performed would not have been possible were it not for the Ph.D students who gave of their time to help maintain the laboratory network: Pete Wilson, Dr. Adam Tibbalds, Ray Auchterlounie, Dr. Robert Young, Ian Calderbank, Dr. Robin Morris and Dr. M. Lai. I am grateful for many enlightening conversations with Dr. Joan Lasenby, Dr. Bill Fitzgerald, David Elias, Ben Bradshaw, Dr. Julian Magarey, Dr. Adam Tibbalds, Dr. Robin Morris, Dr. Nick Kingsbury and of course my Ph.D supervisor Dr. Peter Rayner who also arranged funding in the early years. The work of many willing proofreaders was essential in creating a coherent manuscript: Steve Armstrong, Adam Tibbalds, Ben Bradshaw, Rebecca Moore (of Springer-Verlag) and my wife, Stefanie. I am especially grateful for helpful comments from Prof. Petar M. Djurić during his short stay at Cambridge. I wish to thank every one of my colleagues in the laboratory for creating a very pleasant atmosphere for interaction.

Thanks are due to several members of the AURORA project for valuable discussions about restoration during my last few years as a post-doctoral fellow: Louis Laborelli and Jean-Hugues Chenot of I.N.A.; John Drewery, Jim Easterbrook and Theodore Vlachos at the BBC; Martin Weston and Stuart Sommerville of Snell and Wilcox and Peter van Roosmalen at Delft University. I am also grateful for the help of David Throup at Quantel (U.K.), Wolfgang Lempp and Amit Gupta at the Computer Film Company, London, for providing source material. Some of the pictures used in Chapters 5 and 8 are provided by INA, Paris, through the help of Jean-Hugues Chenot and I must also thank João Sequeira of RTP (Raotelevisão Portuguesa) for readily providing some of the material used in Chapters 8, 9 and 10.

Finally, I must thank my family in Trinidad for their constant support over the years. I am indebted to my wife for her encouragement, punctuation and patience while my world-view narrowed to these three hundred pages in the last few months.

I am currently in-between worlds as I take up a Lectureship in the Electrical Engineering Dept. of Trinity College, Dublin, Ireland. There I shall continue the work started in this book.

Anil Kokaram
Cambridge
January 1998

[1] **AU**tomatic **R**estoration of **OR**iginal **A**rchives, European Union ACTS Project AC072.

Glossary

2D	Two Dimensional
3D	Three Dimensional
AR	Autoregressive
BBC	British Broadcasting Corporation
ARMA	Autoregressive Moving Average
2DAR	Two Dimensional AR Model
3DAR	Three Dimensional AR Model
WBME	Wiener Based Motion Estimator
MWBME	Multiresolution Wiener Based Motion Estimator
AWBME	Adaptive Wiener Based Motion Estimator
BM	Block Matching
BBM	Boyce Block Matching
MRF	Markov Random Field
JOMBADI	Joint Model Based Detection and Interpolation
MCMC	Markov Chain Monte Carlo
MPEG	Motion Picture Experts Group
pdf	Probability Distribution Function
cdf	Cumulative Distribution Function
ML	Maximum Likelihood
MAP	Maximum a Posteriori
MBD	Model Based Detection
MBI	Model Based Interpolation
LS	Least Squares
SNR	Signal to Noise Ratio
MSE	Mean Square Error
MMSE	Minimum Mean Square Error
MAE	Mean Absolute Error
DFD	Displaced Frame Difference
DPD	Displaced Pixel Difference
ICM	Iterated Conditional Modes
SA	Simulated Annealing
VZO	Temporal zero-order hold interpolation for motion
Pel	Pixel
RMS	Root Mean Squared
SDI	Spike Detection Index
ROD	Rank Order Detector
ROC	Receiver Operating Characteristic
PMSE	Percentage Mean Squared Error
PIMSE	Percentage Improvement in Mean Squared Error
MMF	Multilevel Median Filter
DFT	Discrete Fourier Transform
FFT	Fast Fourier Transform
IDFT	Inverse Discrete Fourier Transform

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