Table of Contents

Chapter 1: Introduction

1.1 Premise .................................................1
1.2 Geometric Distortions in Satellite Imagery ..........1
1.3 Problem Statement and Research Objectives .........3
1.4 Contribution of This Research .......................5
1.5 Outline of the Thesis ................................6

Chapter 2: Ortho-Rectification Using Geo-referencing

2.1 Introduction .........................................8
2.2 Computing the Parameters of a Two-dimensional Coordinate Transformations ..9
2.3 Filling an Array Aligned with the Ground Coordinate System ..........10
2.4 Mathematical Relationship between Coordinate Systems ..........12
2.5 Selection of Ground Control Points ..................16
2.6 Summary .............................................17

Chapter 3: Formulation of Pixel Projection Model

3.1 Introduction .........................................18
3.2 FORMOSAT-2 Satellite ................................19
3.2.1 Remote Sensing Instrument (RSI) ..................19
3.2.2 Daily Revisit Orbit ................................20
3.3 Factors Affecting Satellite Image Geometry ..........22
3.3.1 Parameters of Orbit Model .......................23
3.3.2 Earth Model .......................................23
3.4 Pixel Projection Modeling ................................24
3.5 Mathematical Formulation of PPM .................25
3.5.1 Position and Information of Satellite .........26
3.5.2 Rotation Matrix (RM) and Euler Angles ..........27
3.5.3 Pixel Line-of-Sight (LOS) Vector from Recording Platform (Body) to ECF ..........................................................29
3.5.4 Intersection of Recording Platform LOS Vector and the Geodetic Surface ..........32
3.6 Summary .............................................36

Chapter 4: Level-3 Geometric Correction of FORMOSAT-2 Images

4.1 Introduction .........................................37
4.2 Test Images and Ancillary Data ......................38
Chapter 5: Experimental Results

5.1 Introduction 54
5.2 Residual Analysis 54
5.2.1 Image Matching 55
5.2.2 Point to Point Error Estimation 56
5.3 Image Resampling 59
5.3.1 Applying Different Approximations for Pixel Transformations 60
5.3.1.1 Nearest Neighbor (NN) 60
5.3.1.2 Bilinear Interpolation (BI) 60
5.3.1.3 Cubic Convolution (CC) 60
5.3.1.4 Comparison of Resampling Methods 61
5.3.1.5 Discussion on Resampling Methods Result 63
5.3.2 Wavelet Based Resampling Algorithm for Image Transformation 65
5.3.2.1 Daubechies 4 (D-4) Wavelet Filter 67
5.3.2.2 Results of D-4 Wavelet Based Resampling 68
5.3.2.3 Analysis of D-4 Wavelet Based Resampling 68
5.3.2.3.1 Complexity of Algorithm 70
5.3.2.3.2 RMS Analysis in Case of D-4 72
5.3.2.3.3 Execution Time 73
5.4 Application to Disaster Investigation 74
5.5 Summary 77

Chapter 6: Conclusions and Recommendations

6.1 Overview 79
6.2 Achievements and Applications 80
6.3 Limitations 82
6.4 Recommendations and Future Research 83
6.4.1 Specific to FORMOSAT-2 Imagery 83
6.4.1.1 Band to Band Co-registration 83
6.4.1.2 Digitized Map of Pakistan 84
6.4.1.3 Other Causes of Geometric Distortions 84
6.4.2 Other Remote Sensing Satellites and Challenges to Image Processing and Analysis 85
6.4.2.1 Different Resolutions 85
6.4.2.2 Techniques for Machine Assisted Interpretation 86
6.4.2.3 Multi-source and Multi-sensor Images 86
6.5 Summary 87

Appendices

A. Two-dimensional Coordinate Transformations 89
B. Digital Resampling 92
C. Systematic Formulation of Normal Equations into Matrix Notation 95

References 98