UNIVERSITAS
GADJAH MADA
FEATURE EXTRACTION AND CLASSIFICATION OF KIDNEY STONE IN 3D CT IMAGES
Nilar Thein, Teguh Bharata Adji, S.T., M.T., M. Eng., Ph.D; Hanung Adi Nugroho, S.T., M.E.,Ph.D
Universitas Gadjah Mada, 2019 | Diunduh dari http://etd.repository.ugm.ac.id/

CONTENT

CONTENT ..... **i**
LIST OF FIGURE ..... **vi**
LIST OF TABLES ..... **vii**
LIST OF ABBREVIATIONS ..... **ix**
CHAPTER I **1**
INTRODUCTION **1**
1.1 Background of Research 1
1.1.1 Epidemiology of Kidney Stone Disease 1
1.1.2 Medical imaging and Diagnostic techniques of kidney stone 2
1.2 Problem Statement 7
1.3 Research Objective 8
1.4 Benefits of Research 8
1.5 Research Contribution 10
1.6 An Overview of Thesis structure 11
CHAPTER II **13**
LITERATURE REVIEW AND THEORETICAL BACKGROUND **13**
2.1 Complication of Kidney Stone on CT Imaging 13
2.1.1 Related Works of Kidney Stones Diagnosis on CT Imaging 15
2.2 3D Image Segmentation 17
2.2.1 Comparative Study on Kidney Stone Segmentation 17
2.2.2 Image Segmentation 20
2.2.3 Thresholding and Otsu's Method 22
2.2.4 Morphological Operation 24
2.3 3D Feature Extraction 24
2.3.1 Comparative Study of Feature Extraction on CT imaging 25
2.3.2 Geometric Feature Extraction 27

UNIVERSITAS
GADJAH MADA
FEATURE EXTRACTION AND CLASSIFICATION OF KIDNEY STONE IN 3D CT IMAGES
Nilar Thein, Teguh Bharata Adji, S.T., M.T., M. Eng., Ph.D; Hanung Adi Nugroho, S.T., M.E.,Ph.D
Universitas Gadjah Mada, 2019 | Diunduh dari http://etd.repository.ugm.ac.id/

2.3.3 Shape Features Extraction....30
2.3.4 First Order Statistical Feature Extraction....31
2.3.5 3D Gray Level Co-occurrence Matrix (3D GLCM) 33
2.3.6 3D Gray-Level Run-Length Matrix (3D GLRLM)....35
2.3.7 3D Gray-Level Size Zone Matrix (3D GLSZM) 38
2.4 Feature Selection....40
2.4.1 Comparative Study of Feature Selection on CT imaging 41
2.4.2 Feature Selection by Feature Weighting....42
2.4.3 Weight by Correlation....44
2.4.4 Threshold using Arithmetic Value....44
2.4.5 Min-max Normalization....45
2.5 Classification....45
2.5.1 Naïve Bayes....46
2.5.1 K-Nearest Neighbor (KNN)....46
2.5.1 SVM (Support Vector Machine)....47
2.5.1 Random Forest Classifier....48
2.5.1 Decision Tree....50
2.5.2 Information Gain....51
2.5.3 K-Fold Cross Validation....53
2.5.4 Performance Computation....55
2.6 Research Questions....56
CHAPTER III....57
METHODOLOGY AND IMPLEMENTATION....57
3.1 Research Methodology....57
3.1.1 Preprocessing (segmentation)....57
3.1.2 Feature Extraction....66

UNIVERSITAS
GADJAH MADA
FEATURE EXTRACTION AND CLASSIFICATION OF KIDNEY STONE IN 3D CT IMAGES
Nilar Thein, Teguh Bharata Adji, S.T., M.T., M. Eng., Ph.D; Hanung Adi Nugroho, S.T., M.E.,Ph.D
Universitas Gadjah Mada, 2019 | Diunduh dari http://etd.repository.ugm.ac.id/

3.1.3 Feature Selection....71
3.1.2 Classification....73
3.2 System Design....74
3.3 System Implementation....75
CHAPTER IV....79
PREPROCESSING OF KIDNEY STONE CLASSIFICATION USING 3D IMAGE SEGMENTATION....79
4.1 Introduction....79
4.2 Data Collection....81
4.3 Evaluation of Kidney Stone Segmentation on CT Imaging....82
4.3.1 Soft-organ removal....83
4.3.2 Bed mat removal....84
4.3.3 Noise reduction....85
4.4 Results and Analysis....86
4.4.1 3D Visualization....86
4.4.2 Performance Evaluation of Proposed Preprocessing Scheme....88
4.4.3 Comparative Study....90
4.5 Summary....94
CHAPTER V....96
3D FEATURE EXTRACTION....96
5.1 Introduction....96
5.2 Data Analysis and Data Augmentation....97
5.3 Implementation of Feature Extraction....99
5.4 Results and Analysis....102
5.4.1 3D Geometric Feature Extraction....102
5.4.2 Shape Feature Extraction....103
5.4.3 First Order Statistical Feature Extraction....105
5.4.4 3D GLCM Feature Extraction....106

UNIVERSITAS
GADJAH MADA
FEATURE EXTRACTION AND CLASSIFICATION OF KIDNEY STONE IN 3D CT IMAGES
Nilar Thein, Teguh Bharata Adji, S.T., M.T., M. Eng., Ph.D; Hanung Adi Nugroho, S.T., M.E.,Ph.D
Universitas Gadjah Mada, 2019 | Diunduh dari http://etd.repository.ugm.ac.id/

5.3.5 3D GLRLM Feature Extraction 107
5.3.6 3D GLSZM Feature Extraction 108
5.5 Performance Evaluation 109
5.5.1 Execution Time and Feature Dimensionality for Feature Extraction 109
5.5.2 Performance Comparison of Feature Extraction across Five Classifiers 110
5.5.3 Statistical Testing for Performance of Proposed Feature Extraction across Five Classifiers 111
5.5.4 Performance Comparison of Six Feature Extraction across RF Classifiers 112
5.5. Summary 113
CHAPTER VI 115
FEATURE SELECTION AND CLASSIFICATION 115
6.1 Introduction 115
6.2 Implementation of a feature selection and classification scheme 116
6.2.1 Feature Selection 116
6.2.2 Classification 118
6.3 Results and Analysis 120
6.3.1 Feature Selection Using Weight by Correlation 120
6.3.2 Evaluation of Feature Quality by 17 Feature Weighting Algorithms 122
6.4 Performance Evaluation 126
6.4.1 Comparative analysis of Feature Selections by Feature Dimensionality 126
6.4.2 Performance Comparison of Feature Selection by Feature Weighting Methods 127

UNIVERSITAS
GADJAH MADA
FEATURE EXTRACTION AND CLASSIFICATION OF KIDNEY STONE IN 3D CT IMAGES
Nilar Thein, Teguh Bharata Adji, S.T., M.T., M. Eng., Ph.D; Hanung Adi Nugroho, S.T., M.E.,Ph.D
Universitas Gadjah Mada, 2019 | Diunduh dari http://etd.repository.ugm.ac.id/

6.4.3 Statistical Testing for Performance of Proposed Feature Selection methods 128
6.4.4 Performance Evaluation of proposed optimized and modified features for feature selection 130
6.4.5 Analysis of the parameters for classification 131
6.5 Summary 134
CHAPTER VII 137
CONCLUSION 137
7.1 Discussion 137
7.2 Limitation and Future Works 142
REFERENCES 143