

Contents

1	Introduction	1
	References	3
2	Review: Prediction of Respiratory Motion	7
2.1	Tools for Measuring Target Position During Radiotherapy	7
2.1.1	Radiographs	8
2.1.2	Fiducial Markers	8
2.1.3	Fluoroscopy	8
2.1.4	Computed Tomography	8
2.1.5	Magnetic Resonance Imaging	9
2.1.6	Optical Imaging	9
2.2	Tracking-Based Delivery Systems	10
2.2.1	Linear Accelerator	10
2.2.2	Multileaf Collimator	11
2.2.3	Robotic Couch	12
2.3	Prediction Algorithms for Respiratory Motion	13
2.3.1	Model-Based Prediction Algorithms	14
2.3.2	Model-Free Prediction Algorithms	22
2.3.3	Hybrid Prediction Algorithms	25
2.4	Open Questions for Prediction of Respiratory Motion	30
2.4.1	Changes of Respiratory Patterns	31
2.4.2	Tumor Deformation and Target Dosimetry	31
2.4.3	Irregular Pattern Detection	31
2.5	Summary	31
	References	32
3	Phantom: Prediction of Human Motion with Distributed Body Sensors	39
3.1	Introduction	39
3.2	Related Work	41
3.2.1	Kalman Filter	41
3.2.2	Interacting Multiple Model Framework	42
3.2.3	Cluster Number Selection Using Gaussian Mixture Model and Expectation-Maximization Algorithm	43

3.3	Proposed Grouping Criteria with Distributed Sensors	45
3.3.1	Collaborative Grouping with Distributed Body Sensors	45
3.3.2	Estimated Parameters Used for Interacting Multiple Model Estimator	47
3.4	Sensors Multi-Channel IMME: Proposed System Design	48
3.4.1	MC Mixed Initial Condition and the Associated Covariance	49
3.4.2	MC Likelihood Update	50
3.4.3	Switching Probability Update	50
3.4.4	Feedback from Switching Probability Update to Stage 1 for Grouping Criteria with Distributed Sensors	50
3.4.5	Combination of MC Conditioned Estimates and Covariance	51
3.4.6	Computational Time	51
3.5	Experimental Results	52
3.5.1	Motion Data	53
3.5.2	Collaborative Grouping Initialization	53
3.5.3	Comparison of Grouping Methods with Other Techniques	57
3.5.4	Multi-Channel IMME	58
3.5.5	Prediction Overshoot	61
3.5.6	Computational Time	62
3.6	Summary	64
	References	64
4	Respiratory Motion Estimation with Hybrid Implementation	67
4.1	Introduction	67
4.2	Related Work	69
4.2.1	Recurrent Neural Network	69
4.2.2	Extended Kalman Filter for Recurrent Neural Networks	71
4.3	Multi-Channel Coupled EKF-RNN	72
4.3.1	Decoupled Extended Kalman Filter	72
4.3.2	Hybrid Estimation Based on EKF for Neural Network	74
4.3.3	Optimized Group Number for Recurrent Multilayer Perceptron	75
4.3.4	Prediction Overshoot Analysis	77
4.3.5	Comparisons on Computational Complexity and Storage Requirement	78
4.4	Experimental Results	79
4.4.1	Motion Data Captured	79
4.4.2	Optimized Group Number for RMLP	80

4.4.3	Prediction Overshoot Analysis	81
4.4.4	Comparison on Estimation Performance.	82
4.4.5	Error Performance Over Prediction Time Horizon.	84
4.4.6	Comparisons on Computational Complexity.	84
4.5	Summary	86
	References	87
5	Customized Prediction of Respiratory Motion.	91
5.1	Introduction	91
5.2	Prediction Process for Each Patient	92
5.3	Proposed Filter Design for Multiple Patients.	94
5.3.1	Grouping Breathing Pattern for Prediction Process	95
5.3.2	Neuron Number Selection	97
5.4	Experimental Results	98
5.4.1	Breathing Motion Data	98
5.4.2	Feature Selection Metrics.	98
5.4.3	Comparison on Estimation Performance.	99
5.4.4	Prediction Accuracy with Time Horizontal Window	100
5.4.5	Prediction Overshoot Analysis	102
5.4.6	Comparisons on Computational Complexity.	104
5.5	Summary	104
	References	105
6	Irregular Breathing Classification from Multiple Patient Datasets.	109
6.1	Introduction	109
6.2	Related Work	111
6.2.1	Expectation–Maximization Based on Gaussian Mixture Model	111
6.2.2	Neural Network	112
6.3	Proposed Algorithms on Irregular Breathing Classifier.	113
6.3.1	Feature Extraction from Breathing Analysis	113
6.3.2	Clustering of Respiratory Patterns Based on EM.	115
6.3.3	Reconstruction Error for Each Cluster Using NN	116
6.3.4	Detection of Irregularity Based on Reconstruction Error.	117
6.4	Evaluation Criteria for Irregular Breathing Classifier.	119
6.4.1	Sensitivity and Specificity	119
6.4.2	Receiver Operating Characteristics	120
6.5	Experimental Results	121
6.5.1	Breathing Motion Data	121
6.5.2	Selection of the Estimated Feature Metrics (\hat{x})	122
6.5.3	Clustering of Respiratory Patterns Based on EM.	123
6.5.4	Breathing Pattern Analysis to Detect Irregular Pattern.	123

6.5.5	Classifier Performance	127
6.6	Summary	130
	References	131
7	Conclusions and Contributions	135
7.1	Conclusions	135
7.1.1	Hybrid Implementation of Extended Kalman Filter	135
7.1.2	Customized Prediction of Respiratory Motion with Clustering	135
7.1.3	Irregular Breathing Classification from Multiple Patient Datasets	136
7.2	Contributions	136
	Appendix A.	139
	Appendix B.	145

Prediction and Classification of Respiratory Motion

Lee, S.J.; Motai, Y.

2014, IX, 167 p. 67 illus., 65 illus. in color., Hardcover

ISBN: 978-3-642-41508-1