TOSHIBA

Leading Innovation

Texture Analysis using Markov Random Fields

Elizabeth Vargas Vargas

supervised by

Keith Goatman

June 2015

Made for Life™

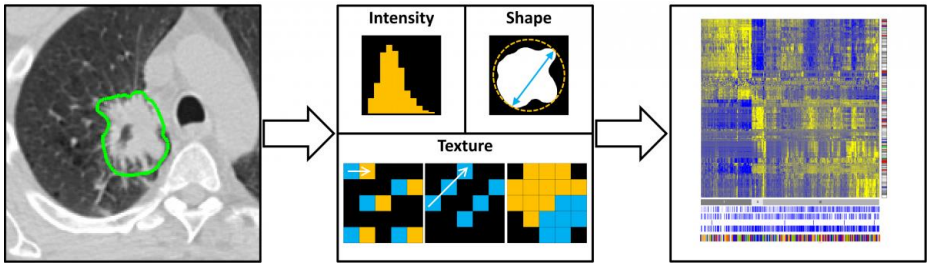
TOSHIBA MEDICAL SYSTEMS CORPORATION

Outline

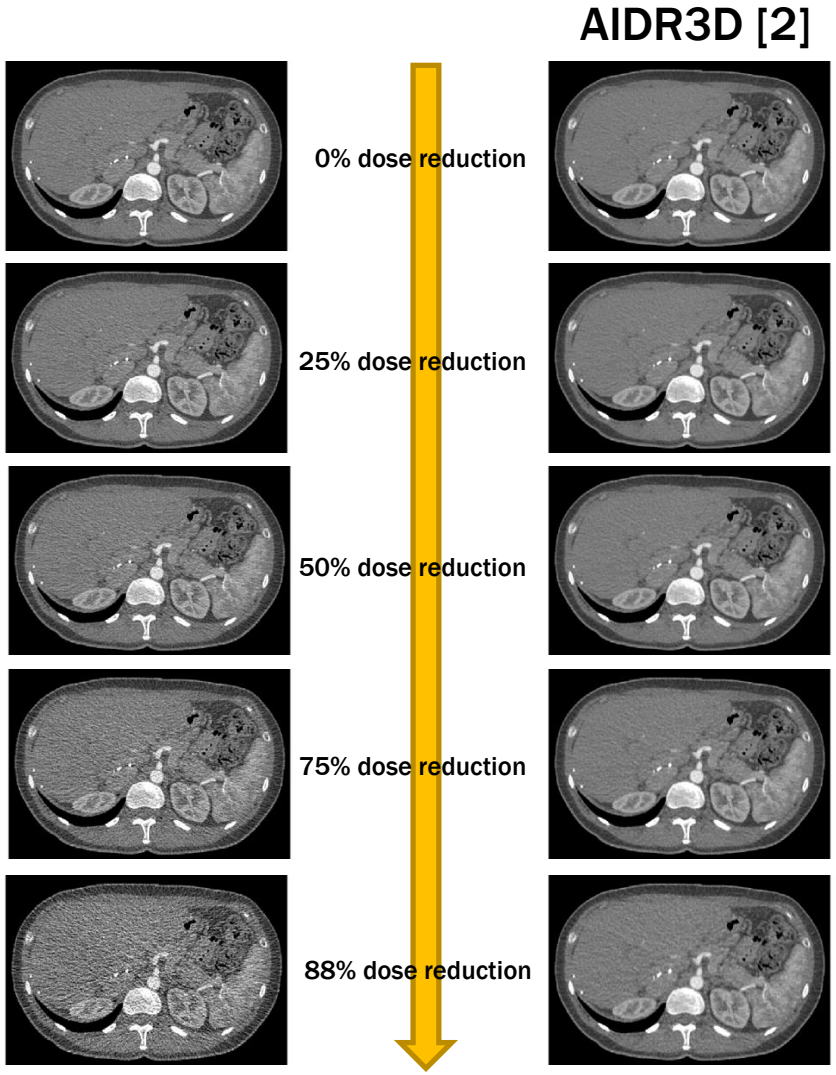
1. Motivation
2. Aims
3. Problem
4. State of the Art
5. Markov Random Fields
6. Classification
   - 6.1 Methodology
   - 6.2 Results
7. Segmentation
   - 7.1 Methodology
   - 7.2 Results
8. Conclusions
9. Future Work
10. Bibliography

1. Motivation

Radiomics



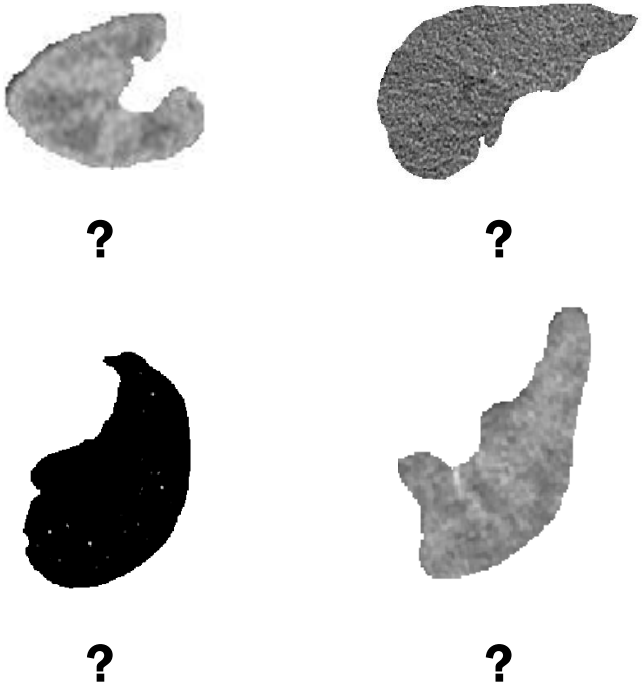
Given an image and a region of interest, measure lots and lots of things in and about the ROI, e.g. volume, shape, texture [1]



2. Aims

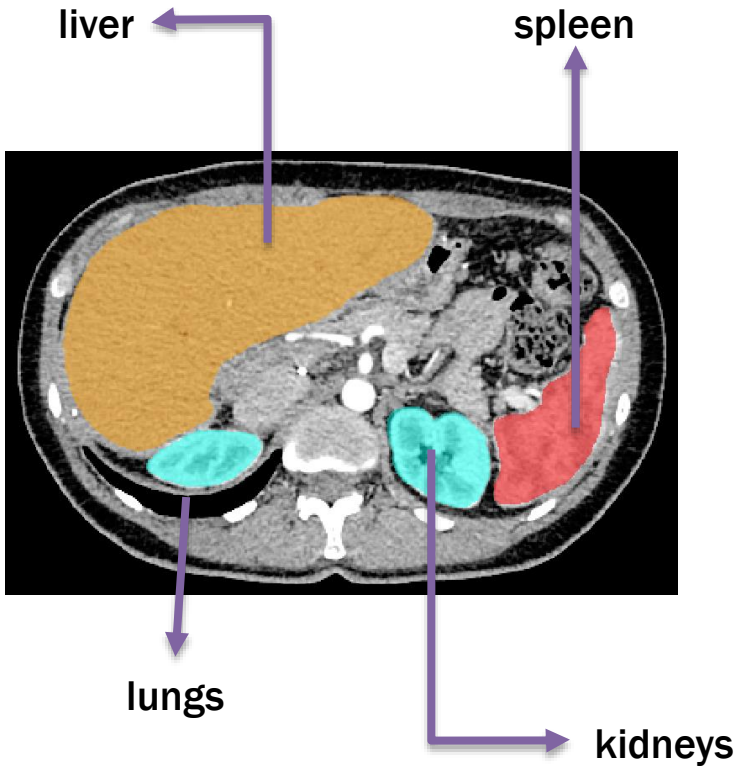
Classification

Classify 2D masks into different tissues:
kidneys, liver, lungs and spleen



Region classification

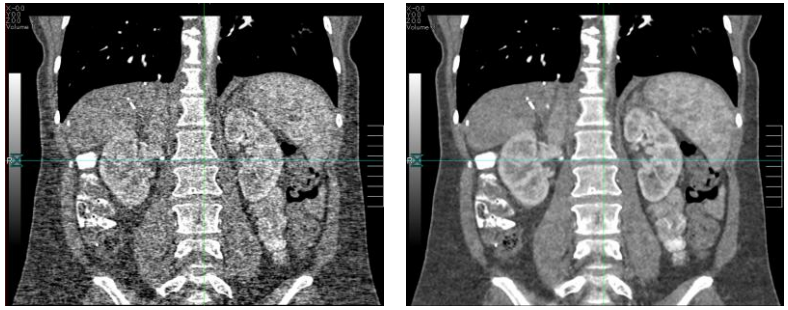
Segmentation



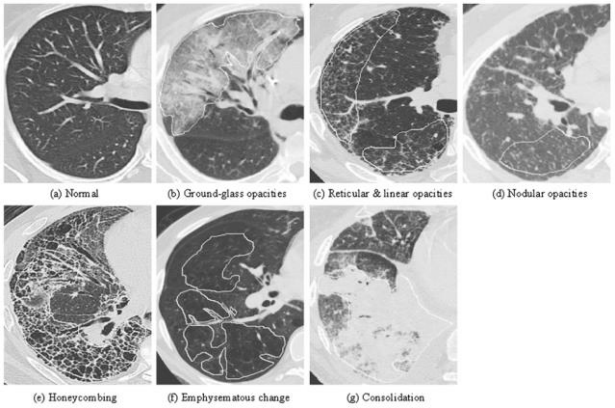
Pixel classification

3. Problem

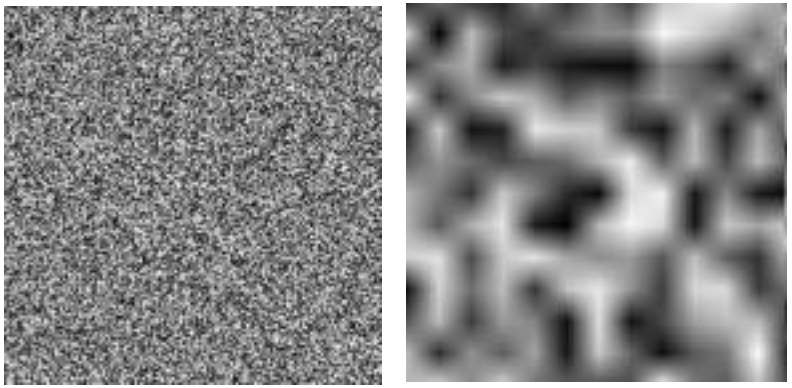
Wide Dynamic Range



Noise

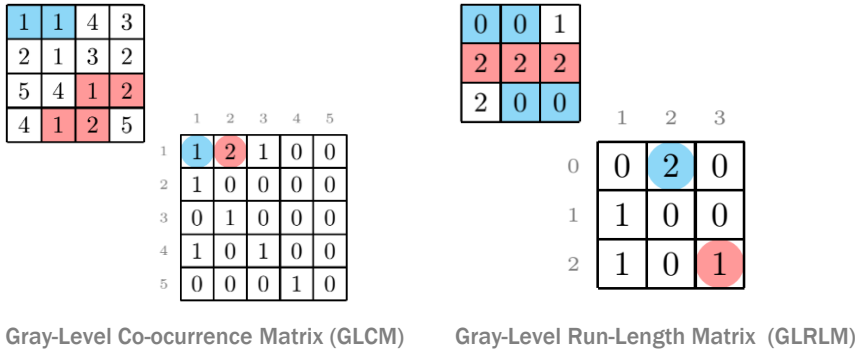


Texture Inhomogeneity [3]



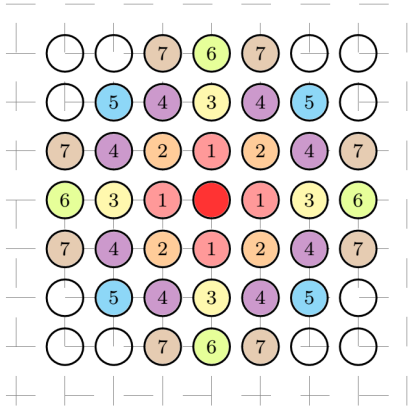
Scale

4. State of the Art



Gray-Level Co-ocurrence Matrix (GLCM) Gray-Level Run-Length Matrix (GLRLM)

Baseline: Statistical Methods



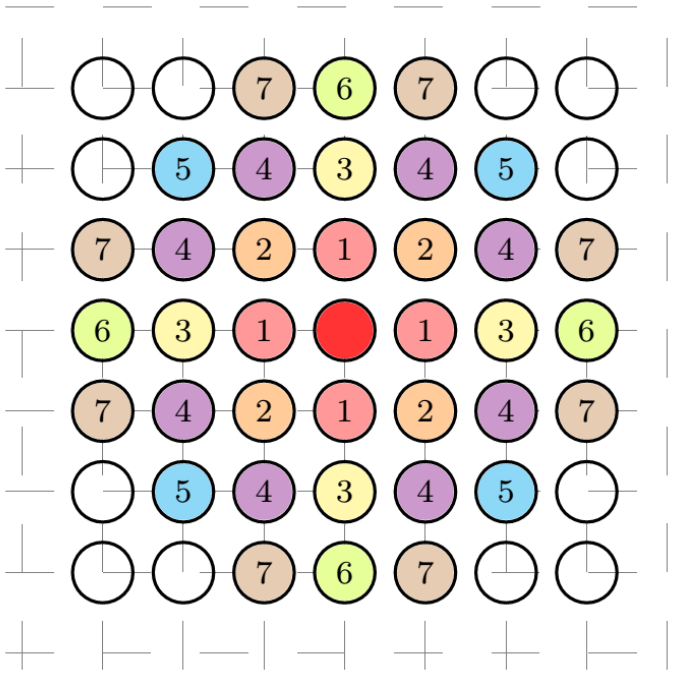
Markov Random Fields

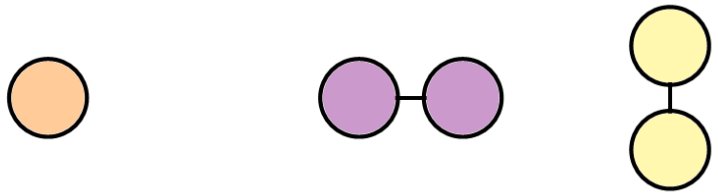
Model-based Methods

5.1 Parametric Markov Random Fields

MRF characterize mutual influences among pixels using conditional MRF distributions, that is to say, they derive the joint distribution from conditional distributions

$$p(I(x_c)|I(x), \forall x \neq x_c) = p(I(x_c)|I(x), x \in \mathcal{N}(x_c))$$





cliques

$$l* = \arg\max_l P(l|x) = \arg\min_l E(l;x)$$

5.2 Non-parametric Markov Random Fields

Varma and Zisserman [4] proposed a non-parametric Markov Random Field, based on a two dimensional histogram

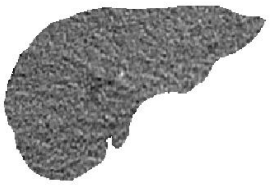
- High accuracies on challenging datasets
- The method relies on fewer prior assumptions, such as the form of the distribution.

6. Classification

Classification

Classify 2D masks into different tissues: kidneys, liver, lungs and spleen

?

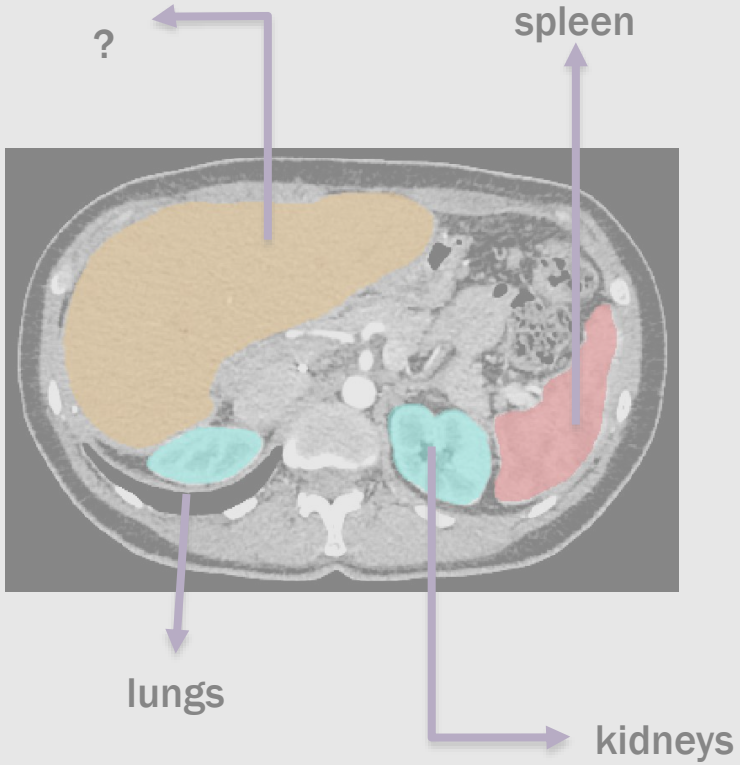


?

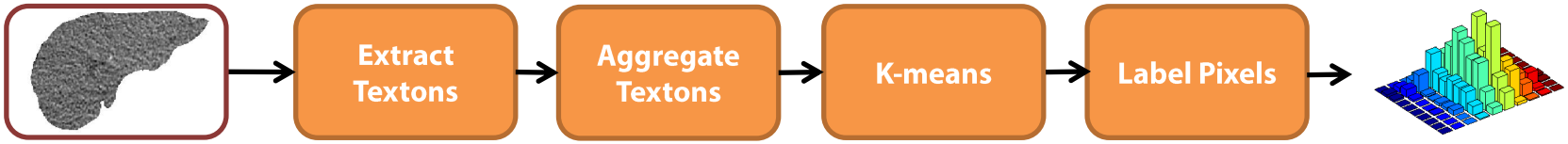
?

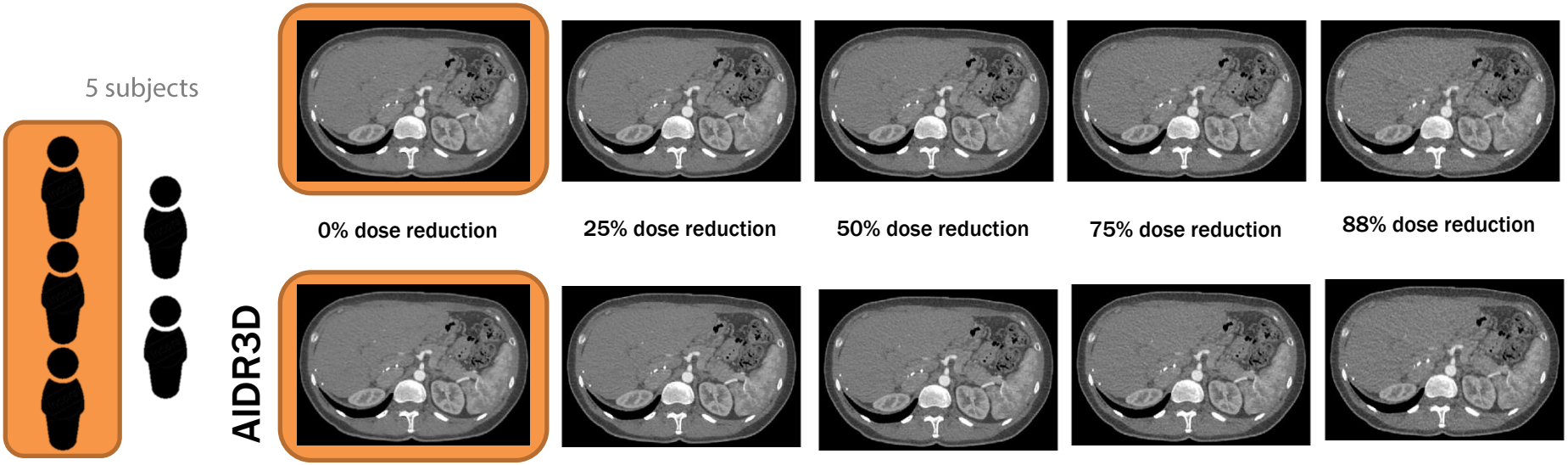
?

Segmentation

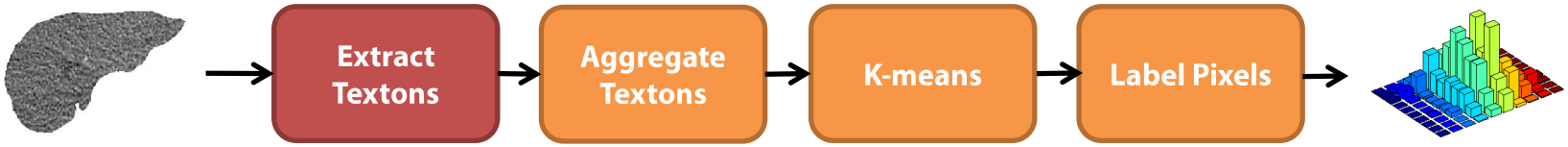


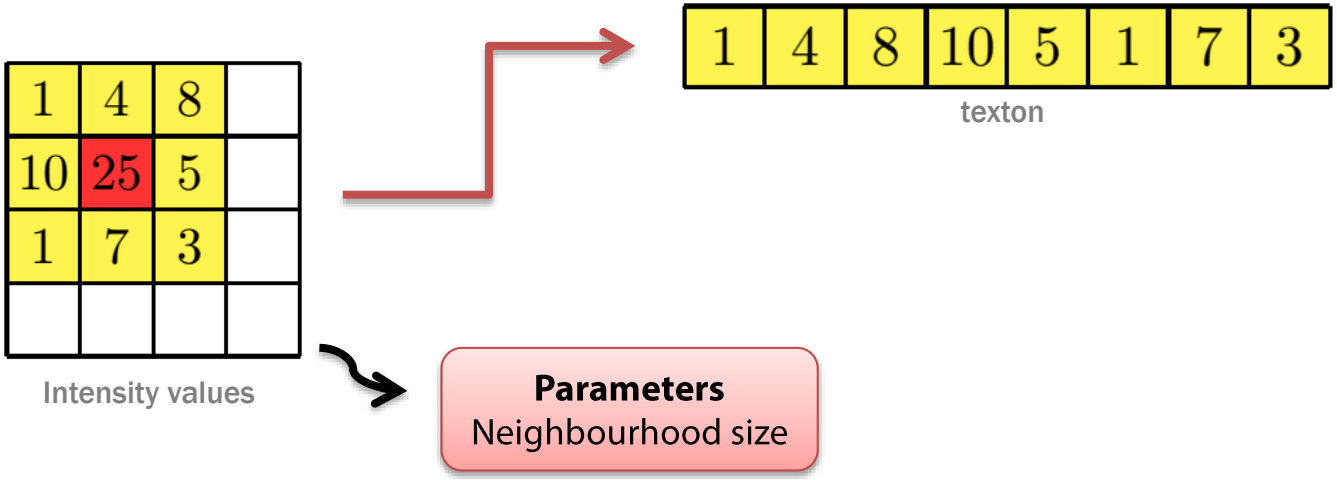
6.1 Classification: Methodology



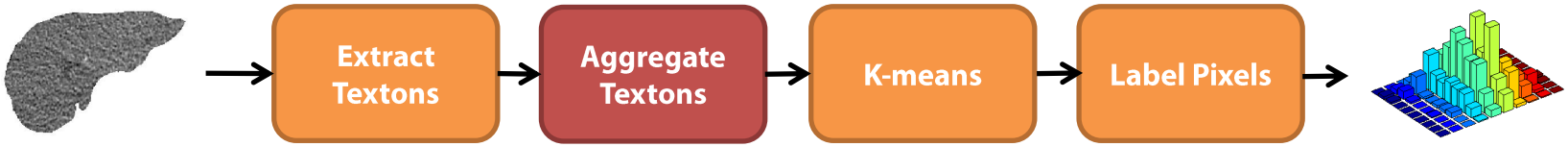


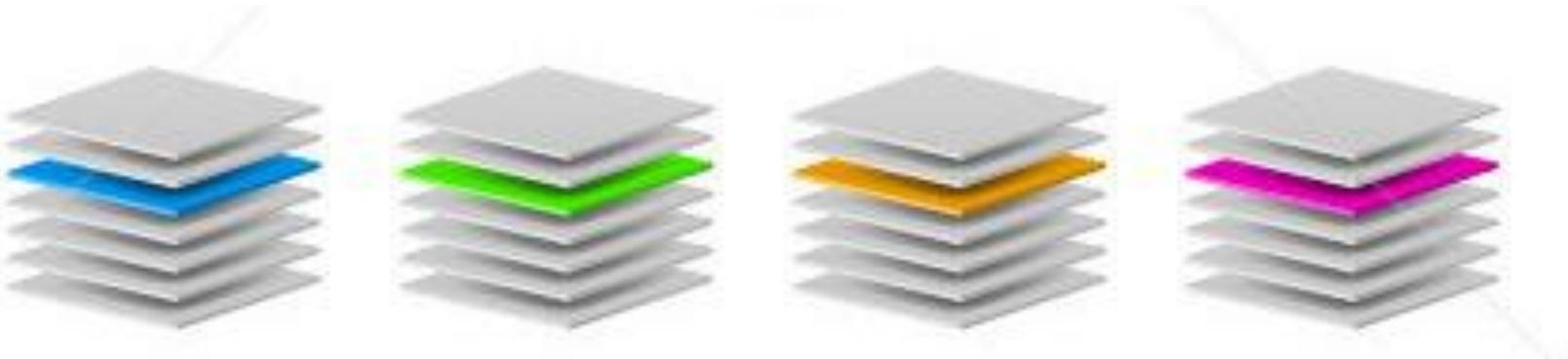
6.1 Classification: Methodology





6.1 Classification: Methodology

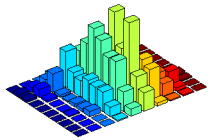


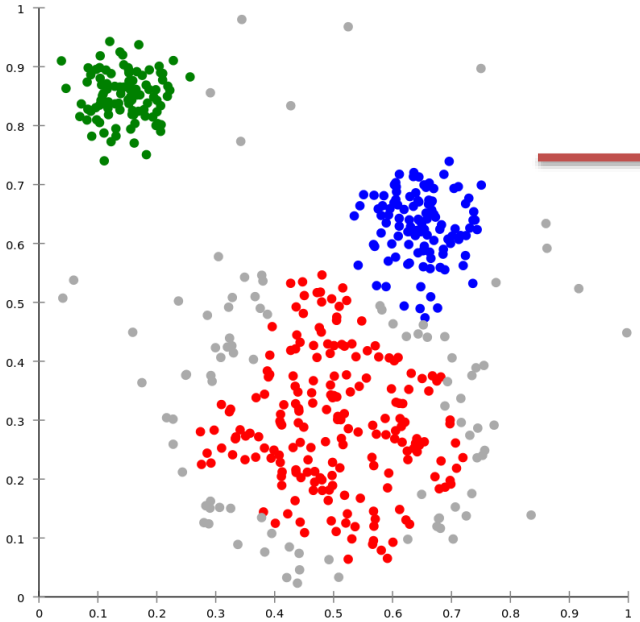


kidneys liver lungs spleen

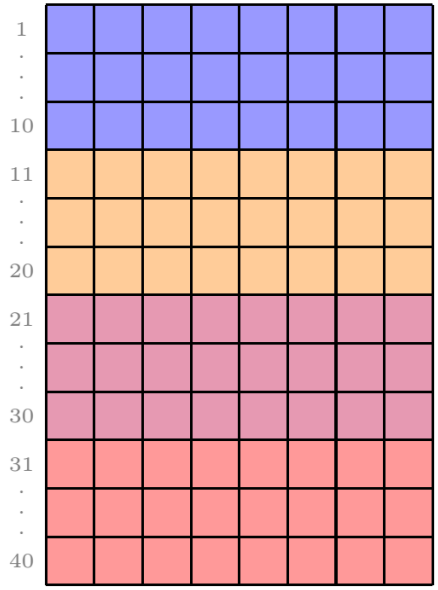
6.1 Classification: Methodology

Extract Textons → Aggregate Textons → K-means → Label Pixels



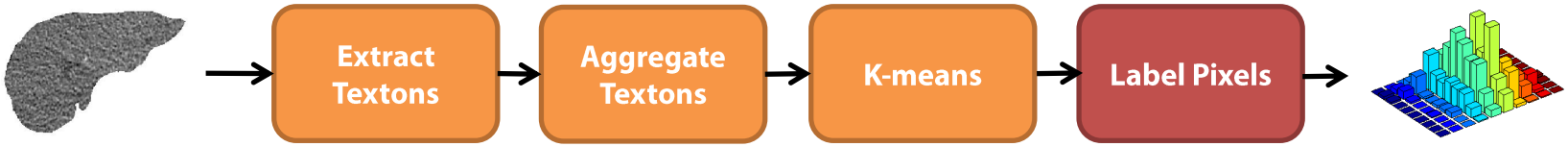


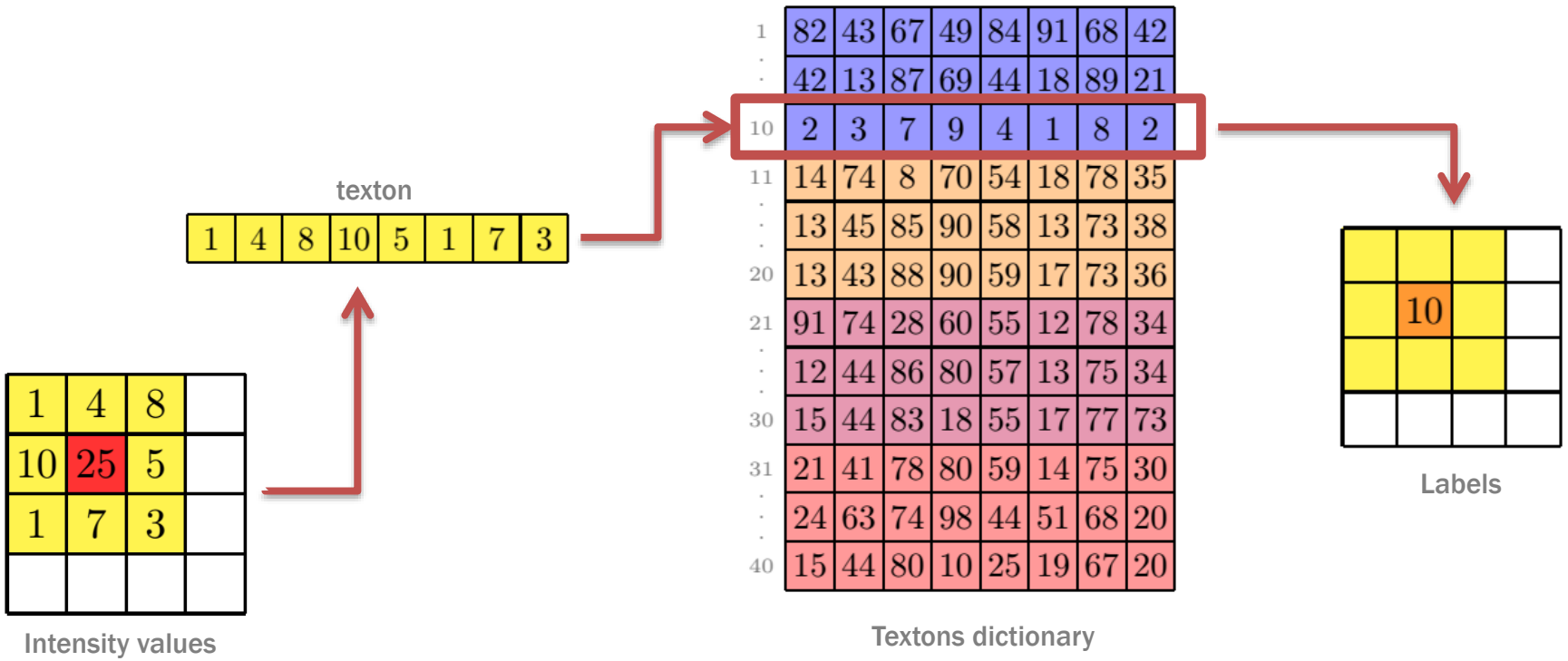
K-means per class



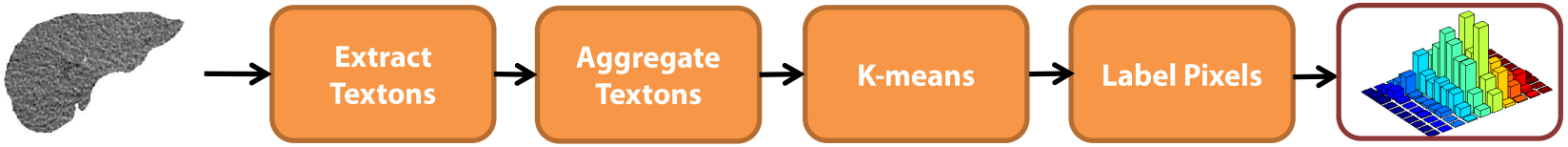
Parameters
Number of textons per class

6.1 Classification: Methodology





6.1 Classification: Methodology

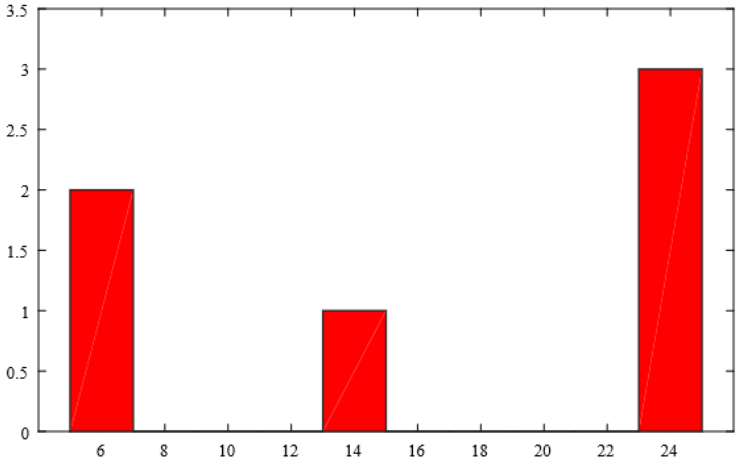


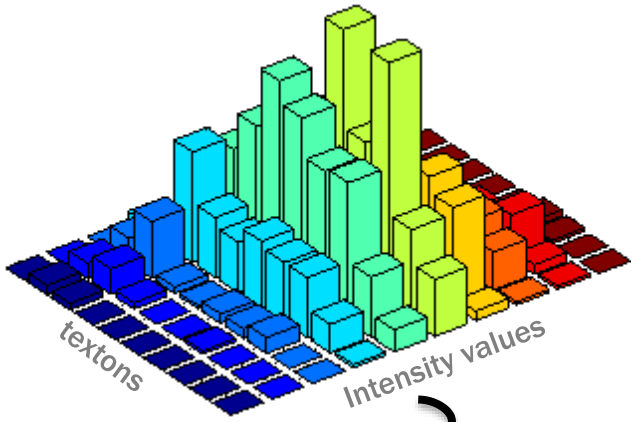
1	4	8	25
10	25	5	4
15	7	5	8
30	25	50	5

Intensity values

8	4	5	**10**
19	**10**	20	15
10	8	**10**	12
7	**10**	6	**10**

Labels

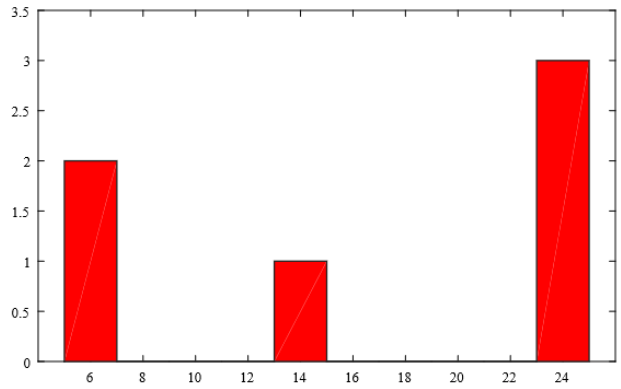




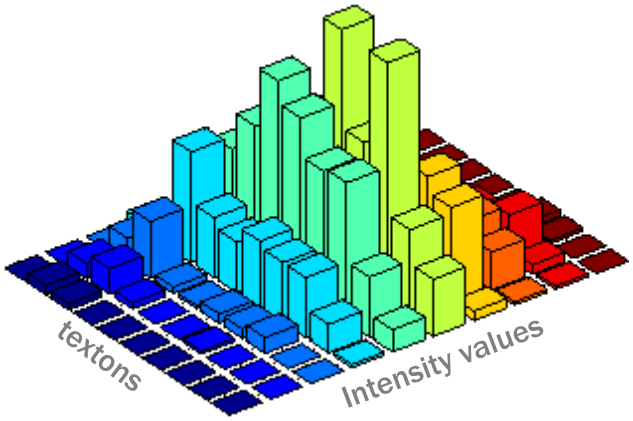
Parameter
Number of bins

6.1 Classification: Methodology

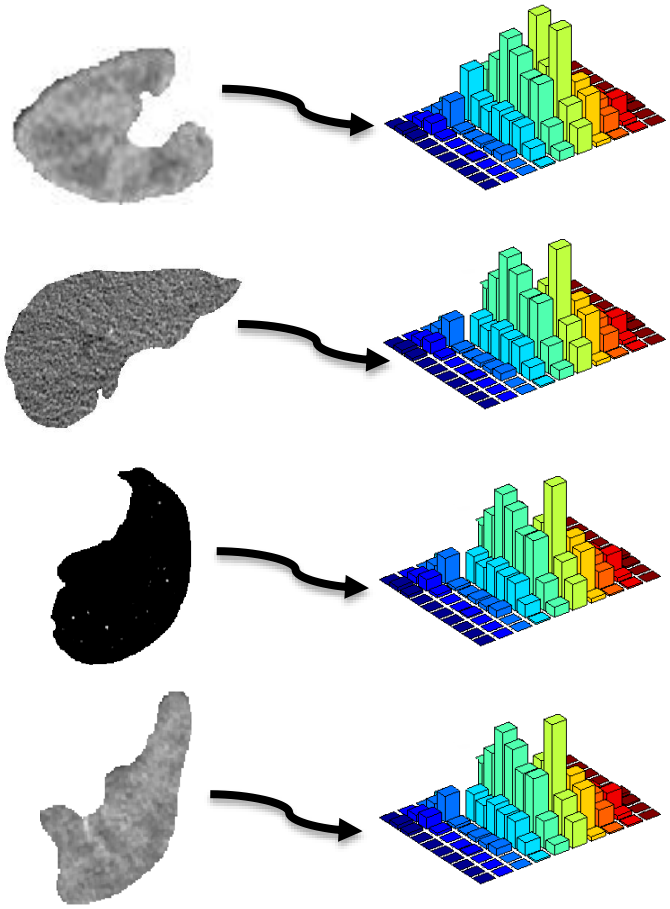
Varma and Zisserman proposed to model an MRF as a 2D histogram



Probability density function



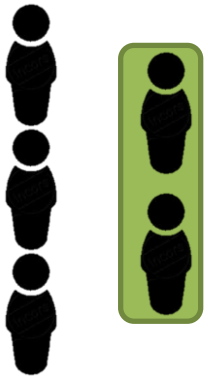
Joint pdf



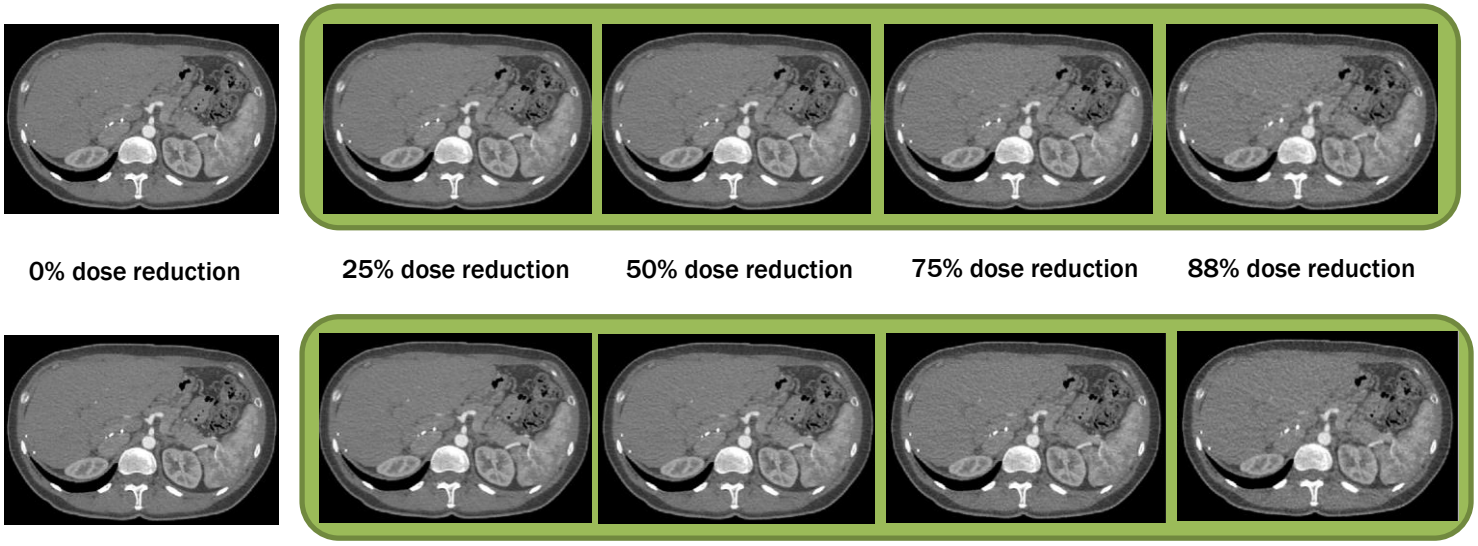
6.1 Classification: Methodology

Extract Textons → Label Pixels → 2D Histogram → KNN → ROI CLASS

5 subjects



AIDR3D



0% dose reduction | 25% dose reduction | 50% dose reduction | 75% dose reduction | 88% dose reduction

6.1 Classification: Methodology

Extract Textons → Label Pixels → 2D Histogram → KNN → ROI CLASS

1	4	8	
10	25	5	
1	7	3	

Intensity values

1	4	8	10	5	1	7	3

texton

6.1 Classification: Methodology

Extract Textons → Label Pixels → 2D Histogram → KNN → ROI CLASS

texton

1	4	8	10	5	1	7	3

1	4	8	
10	25	5	
1	7	3	

Intensity values

1	82	43	67	49	84	91	68	42
.	42	13	87	69	44	18	89	21
10	2	3	7	9	4	1	8	2
11	14	74	8	70	54	18	78	35
.	13	45	85	90	58	13	73	38
20	13	43	88	90	59	17	73	36
21	91	74	28	60	55	12	78	34
.	12	44	86	80	57	13	75	34
30	15	44	83	18	55	17	77	73
31	21	41	78	80	59	14	75	30
.	24	63	74	98	44	51	68	20
40	15	44	80	10	25	19	67	20

Textons dictionary

	10		

Labels

6.1 Classification: Methodology

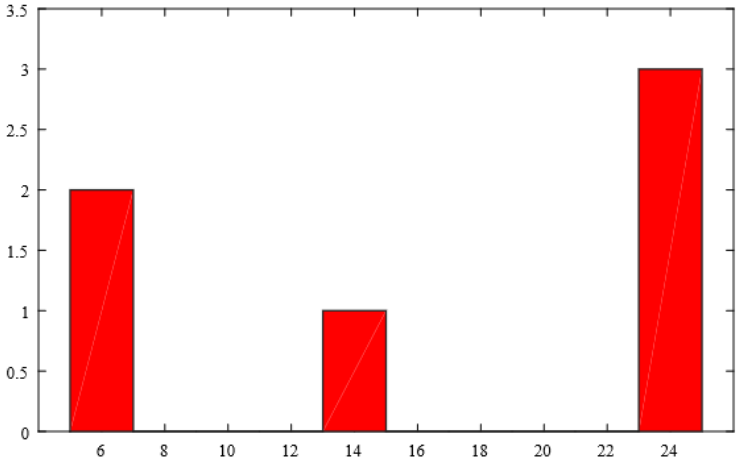
Extract Textons → Label Pixels → 2D Histogram → KNN → ROI CLASS

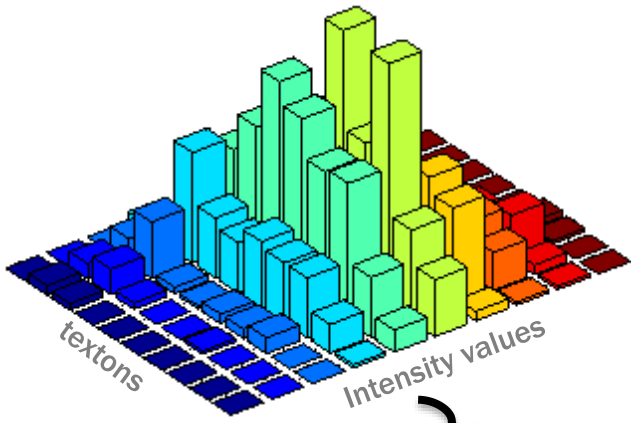
1	4	8	25
10	25	5	4
15	7	5	8
30	25	50	5

Intensity values

8	4	5	**10**
19	**10**	20	15
10	8	**10**	12
7	**10**	6	**10**

Labels





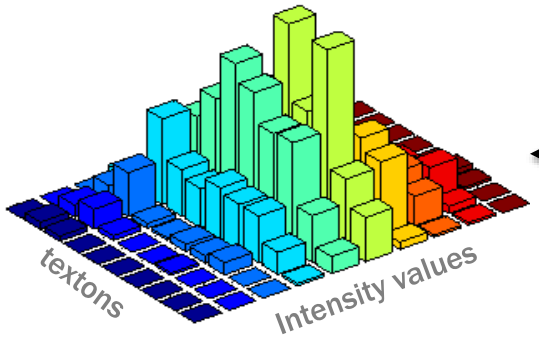
Parameter
Number of bins

6.1 Classification: Methodology

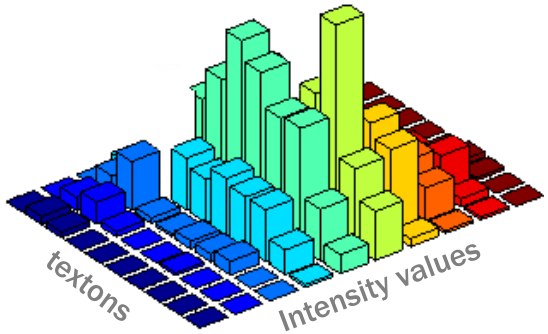
Extract Textons → Label Pixels → 2D Histogram → KNN → ROI CLASS

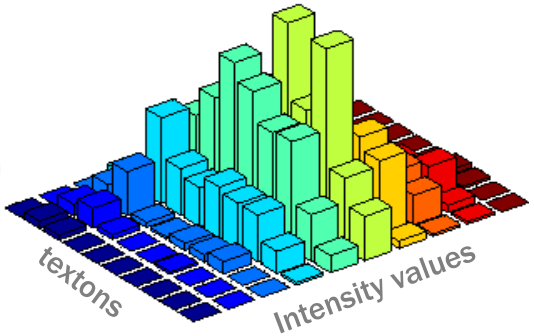
Metrics
- χ^2 distance
- Euclidean distance

liver



lungs

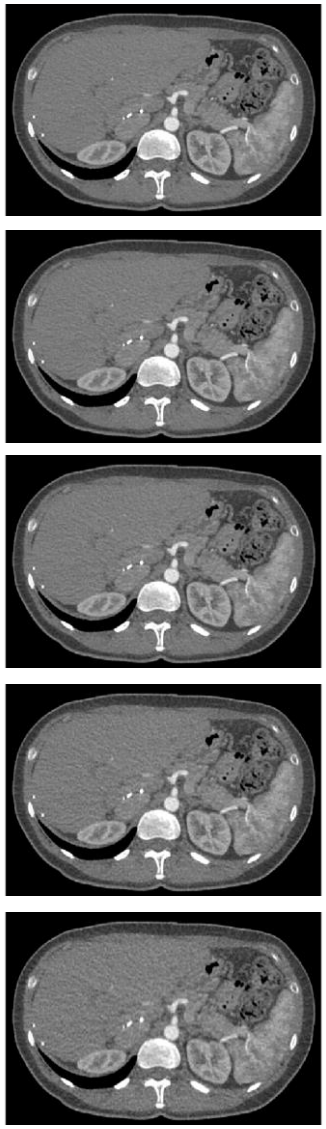


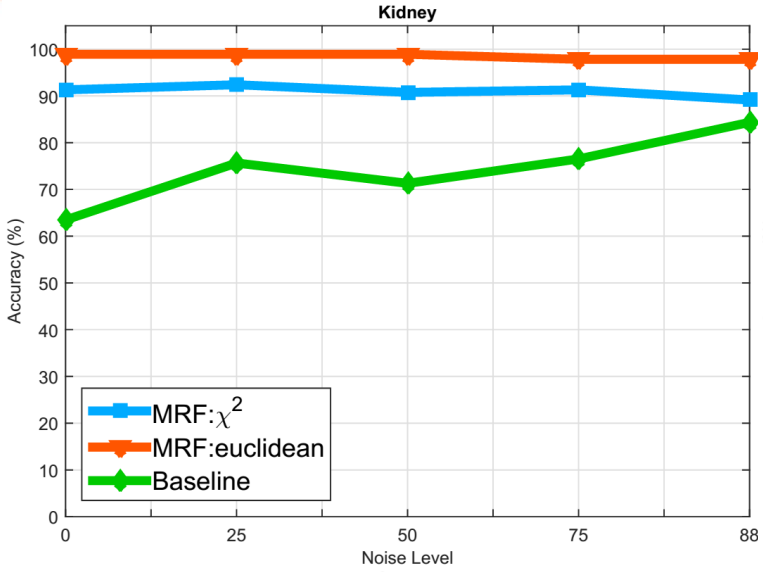


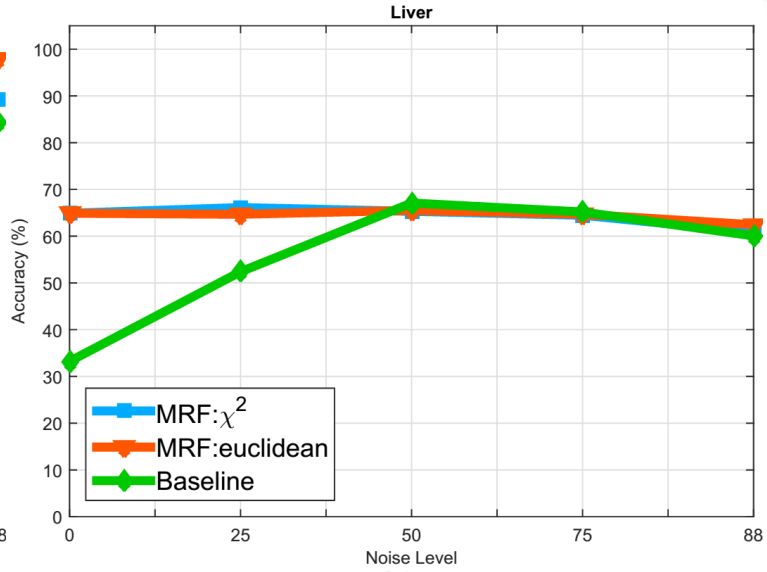
Train

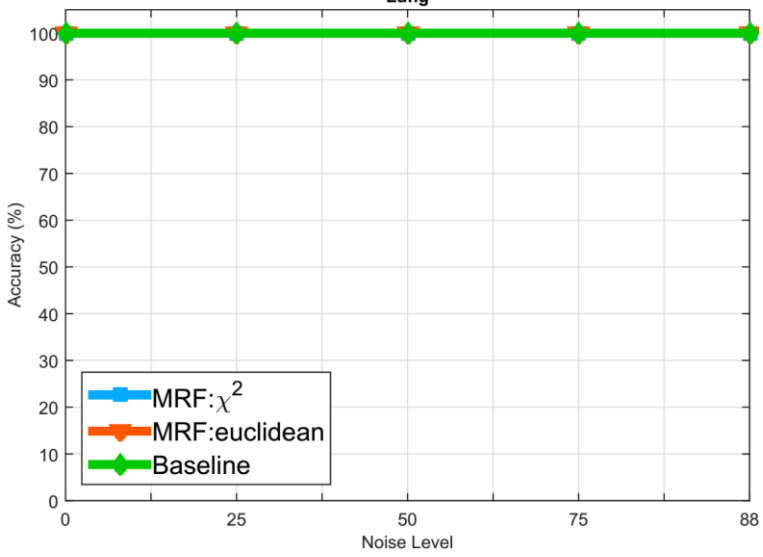
Test

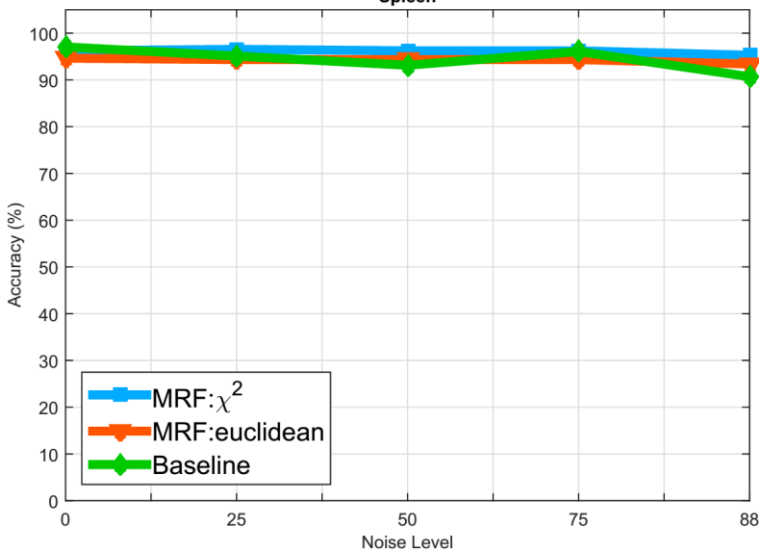
6.2 Classification: Results



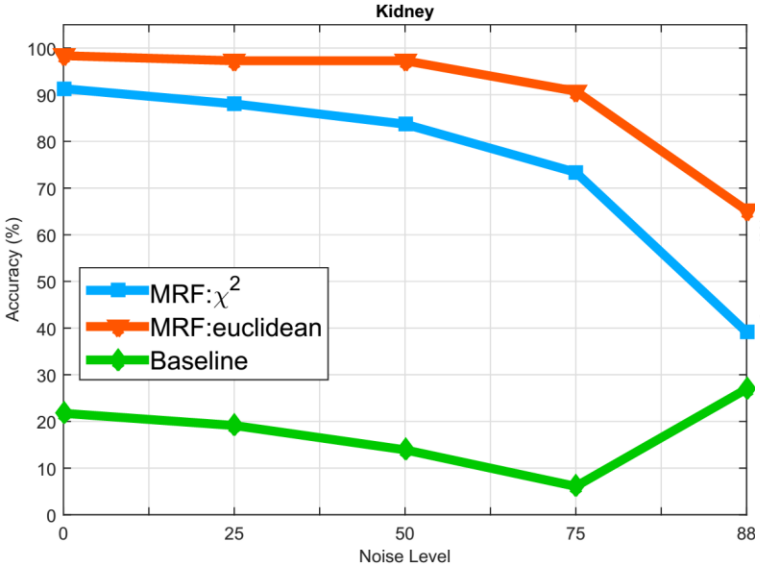


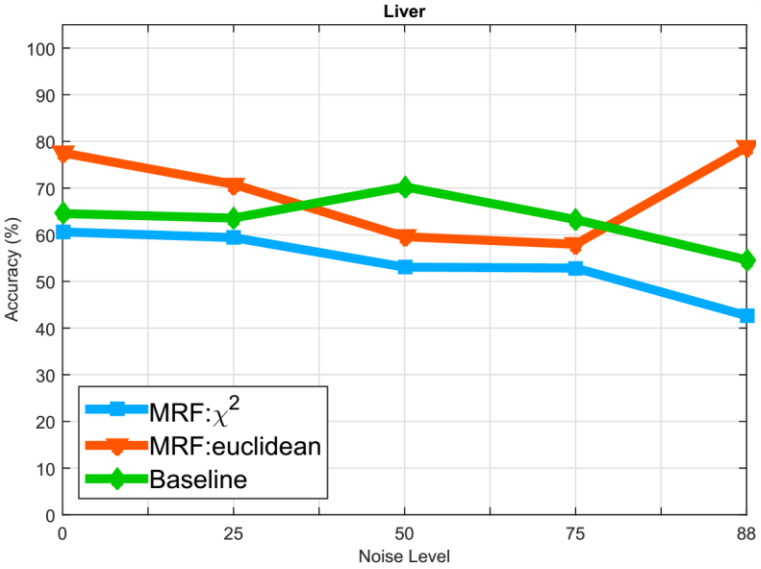


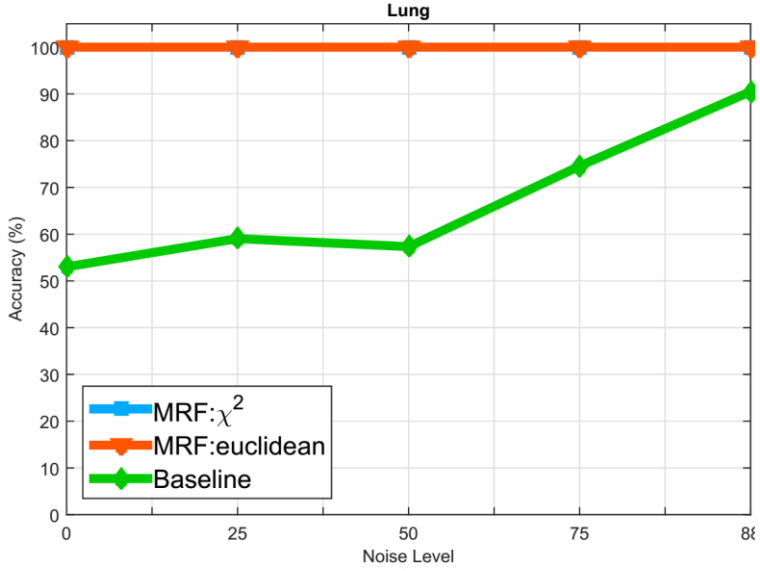


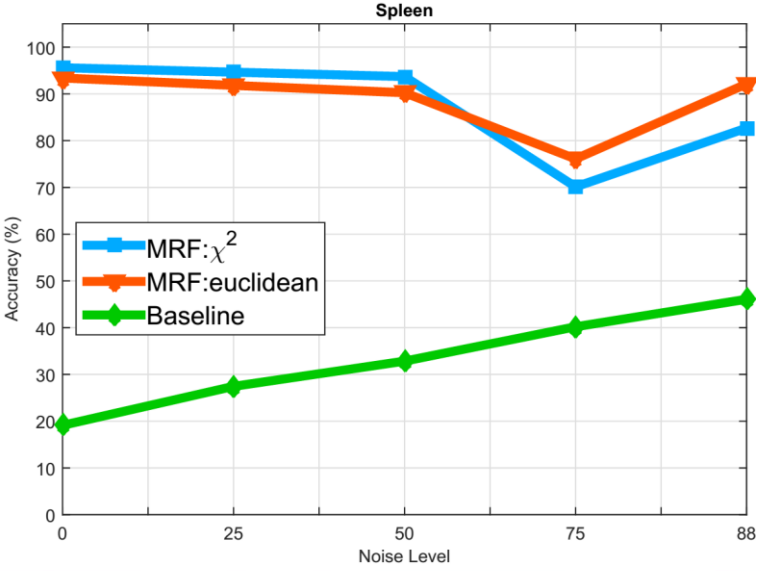


6.2 Classification: Results







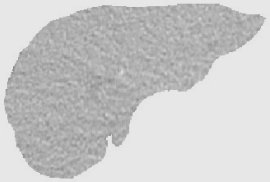


7. Segmentation

Classification

Classify 2D masks into different tissues: kidneys, liver, lungs and spleen

?

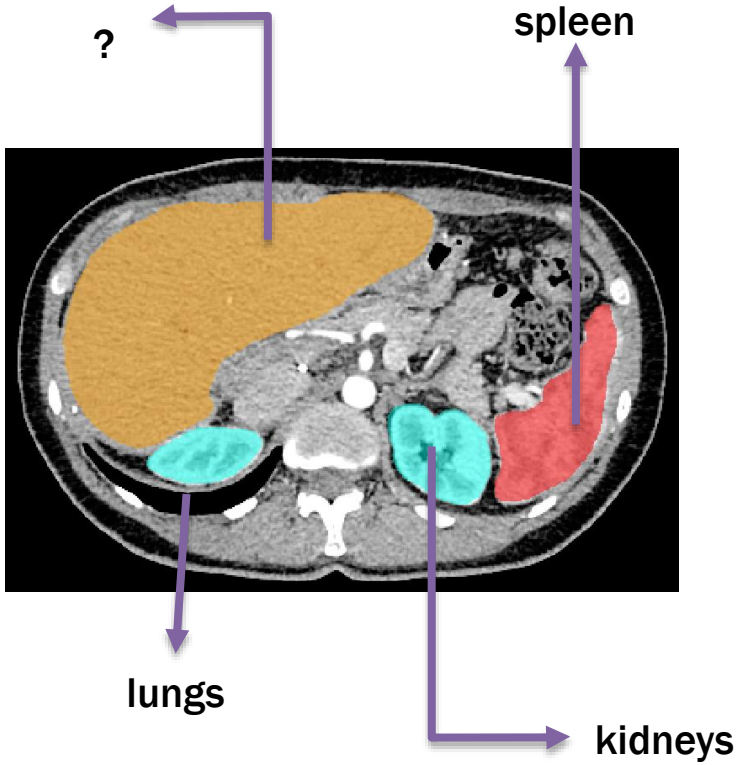


?

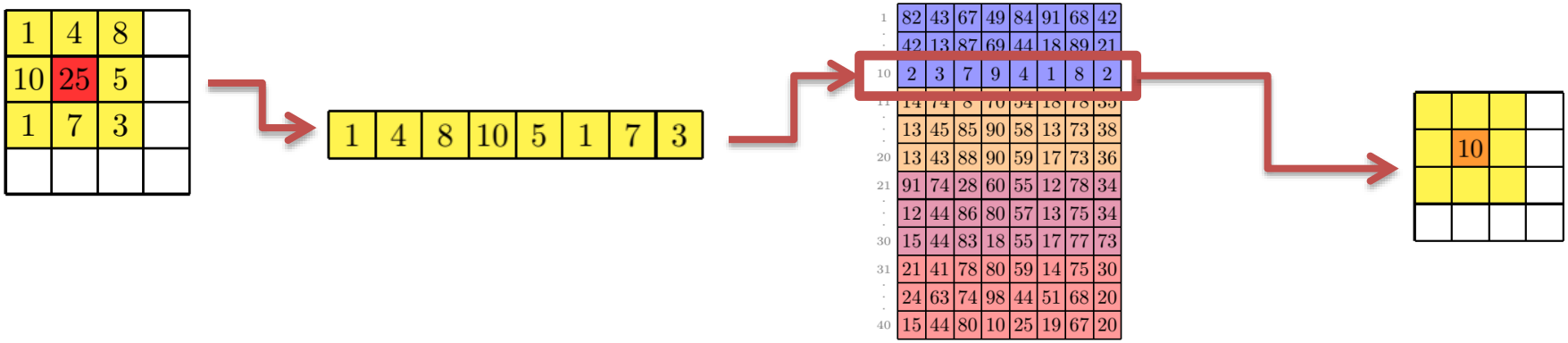
?

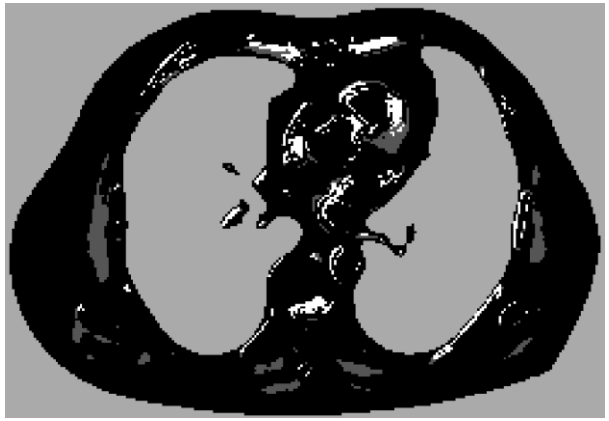
?

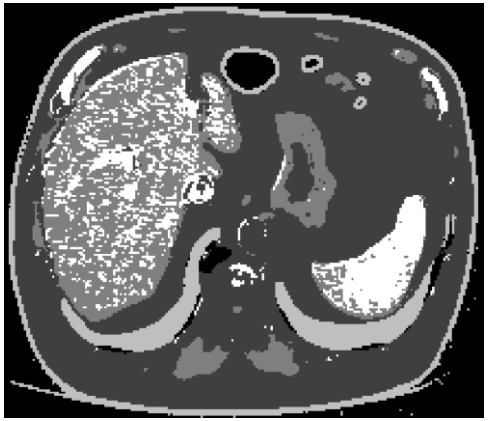
Segmentation



7.1 Segmentation: Methodology

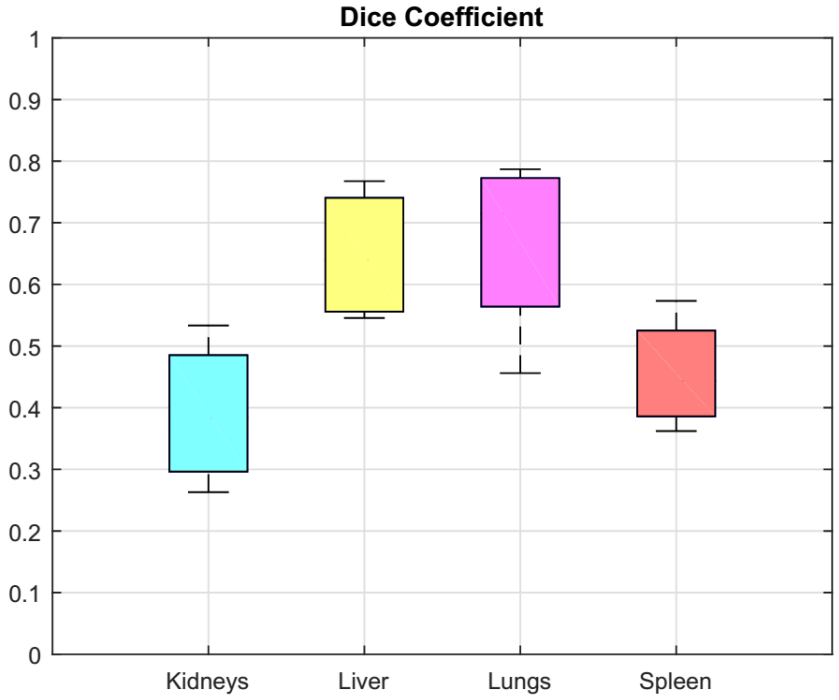


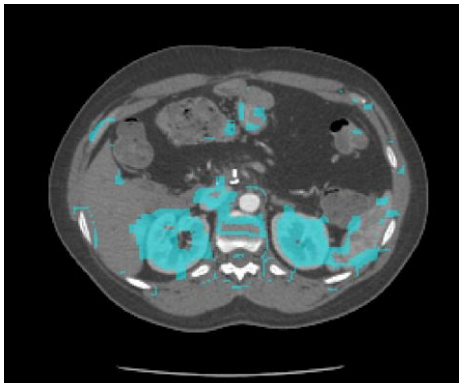




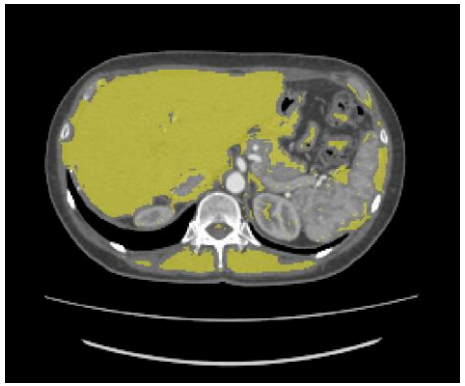
- Neighbourhood size
- Dictionary size
- Majority Voting Scheme
- Morphological Operations
- Adaptive Threshold
- Background Information

7.2 Segmentation: Results

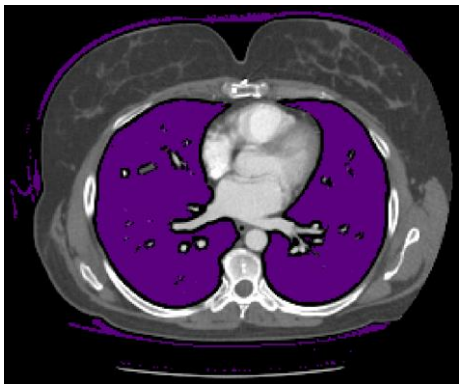




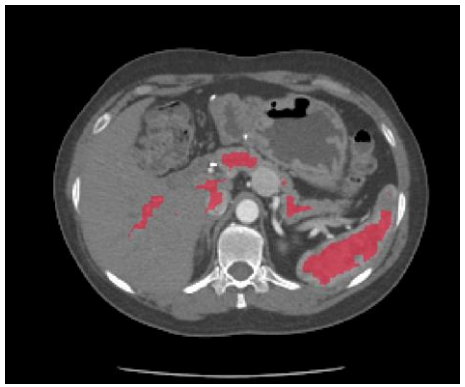
Background information and adaptive threshold of 605



Morphological operations and adaptive threshold of 605



Adaptive threshold of 1352



Threshold corresponding to the 25th percentile of the máximum distance per slice

8. Conclusions

- The implemented texture features were reassuringly robust to the noise level and AIDR3D noise reduction.
- These results were compared to the accuracy obtained using statistical texture methods. The results showed that our MRF-based method is more robust in noisy datasets.
- Our proposed Euclidean distance as metric to compared histograms performed consistently better on these datasets
- Classification of individual pixels had poorer performance than region classification. In general, the use of larger neighbourhoods, smaller dictionary sizes, morphological closing, and background textons presented the best results.

9. Future Work

- The first and most obvious step is the use of three-dimensional texton neighbourhoods.
- Another possible improvement is the inclusion of rotationally invariant features.
- A more complex addition might be the use of a sparse modelling approach to find representative objects
- Future work should evaluate the use of these features in differentiating healthy and unhealthy tissue

TOSHIBA
Leading Innovation

10. Bibliography

[1] Radiomics.org. About radiomics. http://www.radiomics.org/?q=node/4, 2015. Accessed: 2015-05-27.

[2] R Irwan, S Nakanishi, and Alain Blum. AIDR 3D - Reduces Dose and Simultaneously Improves Image Quality. Toshiba Medical Systems, pages 1–8, 2011.

[3] Yoshikazu Uchiyama, Shigehiko Katsuragawa, Hiroyuki Abe, Junji Shiraishi, Feng Li, Qiang Li, Chao-Tong Zhang, Kenji Suzuki, and Kunio Doi. Quantitative computerized analysis of diffuse lung disease in high-resolution computed tomography. Medical Physics, 30(9), 2003.

[4] Manik Varma and Andrew Zisserman. Texture classification: Are filter banks necessary? In Computer vision and pattern recognition, 2003. Proceedings. 2003 IEEE computer society conference on, volume 2, pages II–691. IEEE, 2003