האוניברסיטה העברית בירושלים
The Hebrew University of Jerusalem

Towards Content-Based Image Retrieval: From Computer Generated Features to Semantic Descriptions of Liver CT Scans

Assaf B. Spanier and Leo Joskowicz

The Rachel and Selim Benin School of Computer Science and Engineering
The Hebrew University of Jerusalem, Israel.
{assaf.spanier,leo.josko}@mail.huji.ac.il
http://www.cs.huji.ac.il/~caslab/site/

CLEF Sheffield 2014

Computer Aided Surgery Medical Image & Processing Laboratory

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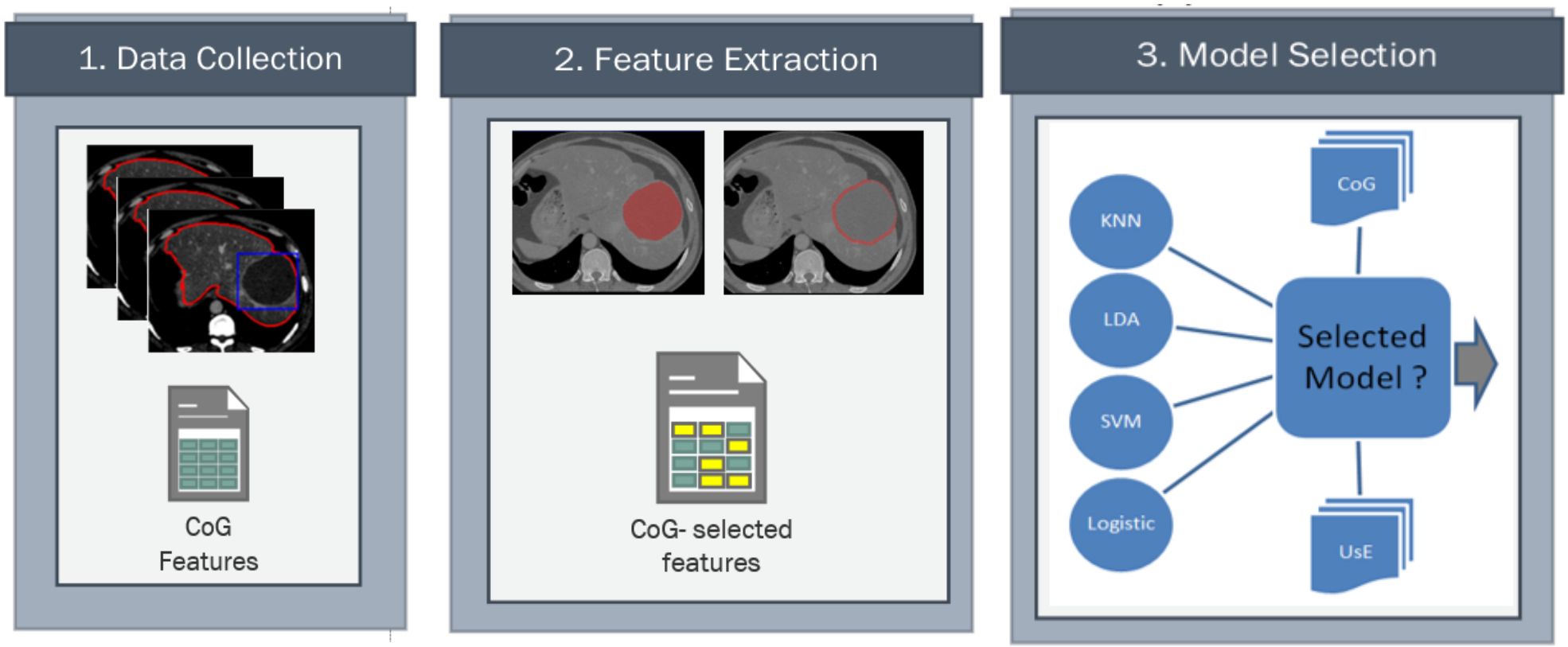
ImageCLEF - Image Retrieval in CLEF

Liver CT Annotation

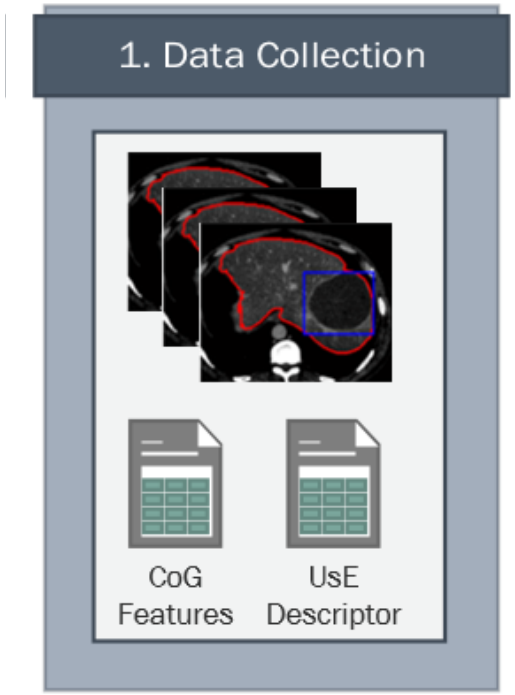
CLEF Sheffield 2014

Main steps in designing and building a machine learning algorithm



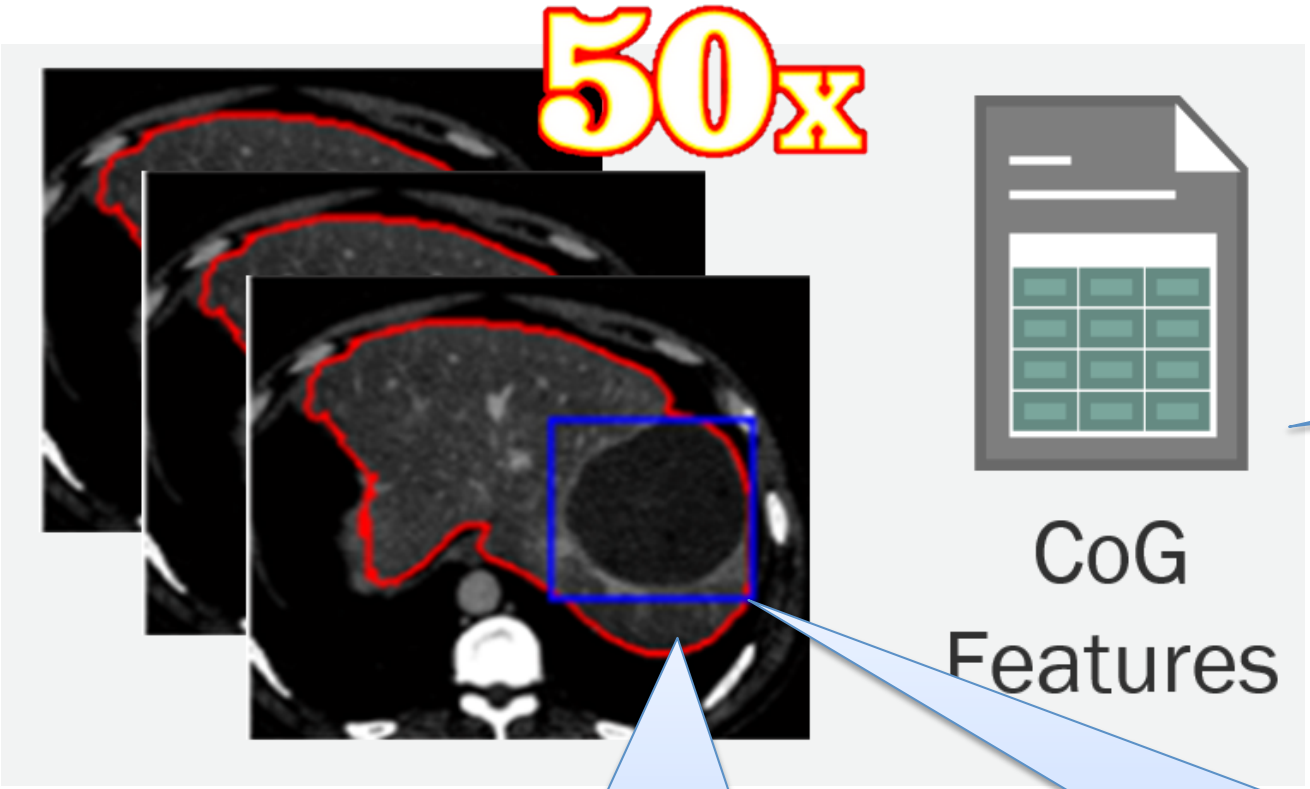
(c)

1. Data Collection



(a)

1. Data Collection



CoG image features (with a total dimensionality of 458)

volumes cropped to the region around the liver

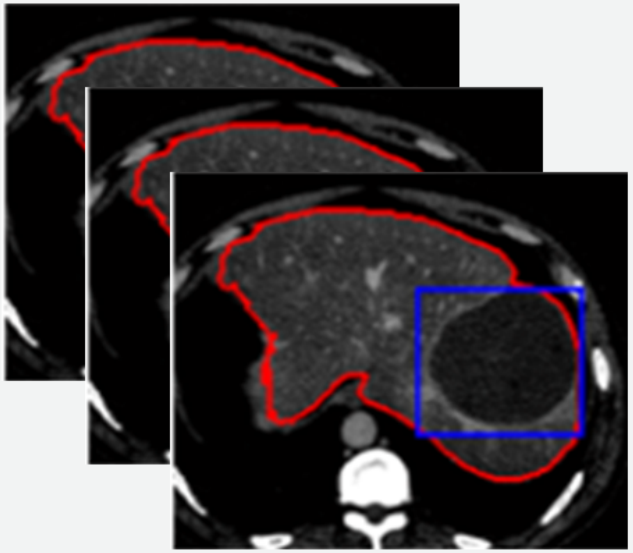
A mask of the liver and the bounding box for a selected lesion

1. Data Collection

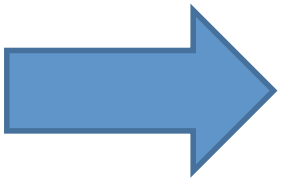
- Computer Generated features (CoG) features

Group	Name	Description	#
Liver	LiverVolume	Liver volume(mm)	1
	LiverMean	Liver's mean intensity value	1
	LiverVariance	Liver's variance intensity value	1
Vessel	VesselRatio	|vessel's voxels|/ |liver's voxels|	1
	VesselVolume	Vessel volume (mm)	1
AllLesions	NumberofLesions	Number of lesions in the liver.	1
	MinLesionVolume	Smallest lesion's volume (mm)	1
	MaxLesionVolume	Biggest lesion's volume (mm)	1
	LesionRatio	|lesions' voxels|/ |liver's voxels|	1
	HistogramOfAllLesions	Histogram of all lesions intensity values.	67
	Mean	Lesions' mean intensity	1
	Variance	Lesions' variance intensity	1
	Skewness	Lesions' skewness	1
	Kurtosis	Lesions' kurtosis	1
	Energy	Lesions' energy	1
	Entropy	Lesions' entropy	1
	Smoothness	Lesions' smoothness	1
	Abscissa	Bin of histogram peak	1
Lesion	AspectRatio	Ratio of max lesion to min lesion radios(mm).	1
	Sphericity	Sphericity of lesion in mm	1

1. Data Collection



CoG Features



UsE Descriptor

1. Data Collection

- User Express (UsE) annotations

Lesion	Lesion	Cluster Size	1(1), 2(2), 3(3), 4(4), 5(5), multiple(6) For simple cases this value shows number of lesions inside the ROI, but in case of having more than one lesions of a certain type, the biggest lesion is annotated as a sample of that cluster and number of lesions with same properties is written here
		Contrast Uptake	NA(-1), dense(0), heterogeneous(1), homogeneous(2), minimal(3), moderate(4), other(5)
		Contrast Pattern	NA(-1), central(0), early uptake then wash out(1), fixing contrast in late phase(2), heterogeneous(3), homogeneous(4), peripheric(5), peripheric nodular(6), spokes wheel(7), undecided(8), other(9)
		Lesion Composition	SolidCycsticMix(0), Solid(1), SolidWithCystic(2), PureSolid(3), PredominantSolid(4), Cystic(5), PureCystic(6), PredominantCystic(7), CysticWithSolidComponent(8), CysticWithDebris(9), Abcess(10)
		is Leveling Observed?	True(1),False(0)
		Leveling Type	NA(-1), fluid fluid(0), fluid gas(1), fluid solid(2), gas solid(3), other(4)
		is Debris observed?	True(1),False(0),NA(-1)
		Debris Location	NA(-1), floating inside(0), located on dependent position(1),other(2)

2. Feature Extraction

(b)

2. Feature Extraction

Descriptors type	Group	Name	Type	Value
Global	Liver	LiverVolume	double	12987.6
	Vessel	LiverVariance	double	297.683
	All Lesions	NumberofLesions	int	5
Pathology	Lesion	HaarWaveletCoef	VectorOfDouble	8.4, 3.9, 2.1,

Computer Generated features (CoG) features.

Descriptors Type	Group	Concept	Properties	Values	Indices
Global	Liver	Right Lob	Right Lobe Size Change	Normal	2
	Vessel	Hepatic Artery	Hepatic Artery Lumen Diameter	normal	2
Pathology	Lesion	Lesion	is Close to Vein	Other	8
	Lesion	Lesion	Segment	SegmentI, SegmentII	1,2
	Lesion	Capsule	Is Calcified?(Capsule)	True	1

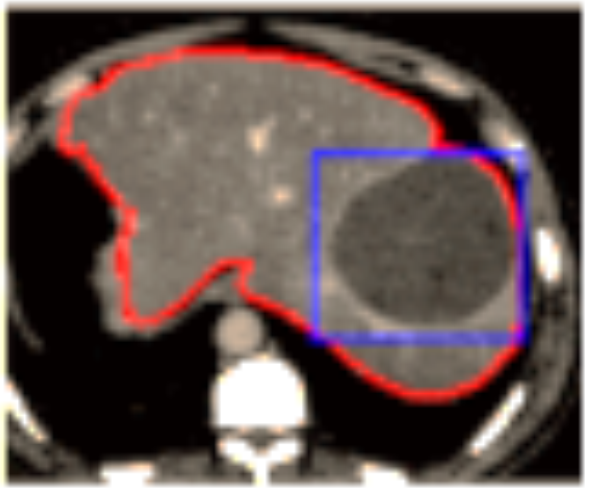
User Express (UsE) annotations

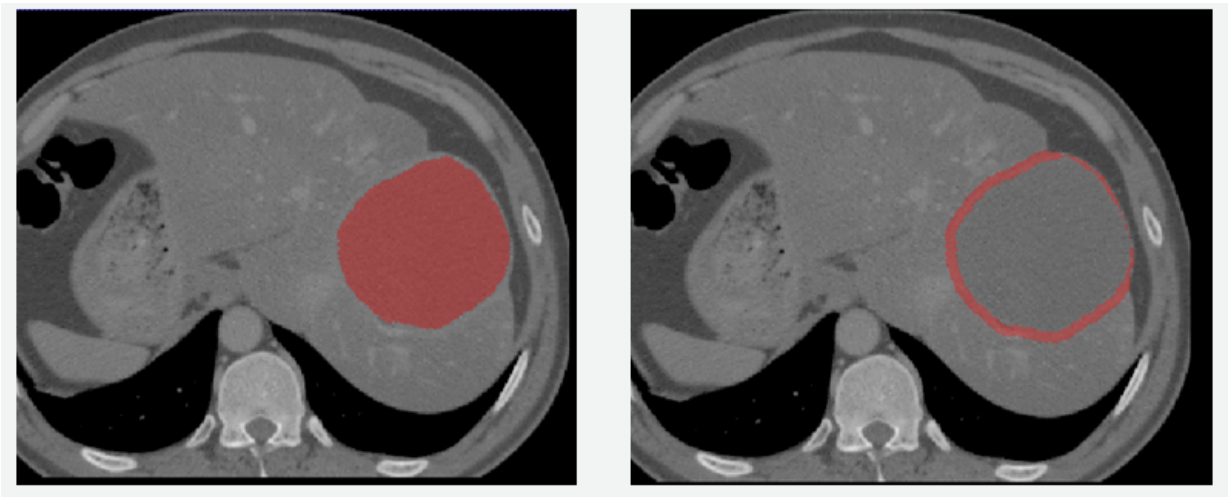
2. Feature Extraction

The 18 global CoG features are: *LiverVolume* , *LiverMean*, *LiverVariance*, *VesselRatio*, *VesselVolume*, *MinLesionVolume*, *MaxLesionVolume*, *LesionRatio*, *AllLesionsMean*, *AllLesionsVariance*, *AllLesionsSkewness*, *AllLesionsKurtosis*, *AllLesionsEnergy*, *AllLesionsSmoothness*, *AllLesionsAbcssia*, *AllLesionsropy*, *AllLesionsThreshold*, *NumberofLesions*

The 21 pathology related CoG features are: *LesionMean*, *LesionVariance*, *LesionSkewness*, *LesionKurtosis*, *Lesionnergy*, *Lesionmoothness*, *Lesionbcssia*, *LesionEntropy*, *LesionThreshold*, *Lesion2VesselMinDistance*, *Lesion2VesselTouchRatio*, *VesselTotalRatio*, *VesselLesionRatio*, *Volume*, *SurfaceArea*, *MaxExtent*, *AspectRatio*, *Sphericity*, *Compactness*, *Convexity*, *Solidity*

2. Feature Extraction



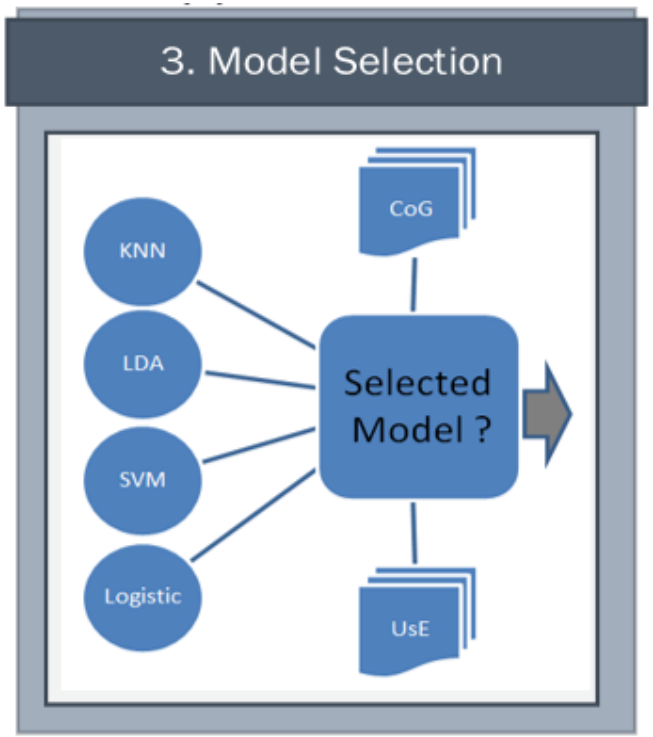


We added 9 features to pathology features

We added 9 features to pathology features

1. The average gray level intensity values of the healthy part of the liver. *(LiverGrayMean)*
2. The standard deviation of gray level intensity values of the healthy part of the liver. *(LiverGrayStd)*
3. The average gray level intensity values of the lesion. *(LesionGrayMean)*
4. The standard deviation of gray level intensity values of the lesion. *(LesionGrayStd)*
5. The lesion's contour mean gray levels. *(LesionBounderyGrayMean)*
6. The standard deviation of the lesion's contour gray levels. *(LesionBounderyGrayStd)*
7. The average gray level difference between the healthy part of the liver and the lesion. *(LesionLiverGrayDiff)*
8. The average gray level difference between the healthy part of the liver and the lesion' contour. *(BounderyLiverGrayDiff)*
9. The average gray level difference between the the lesion and its contour. *(lesionBounderyGrayDiff)*

3. Model Selection



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3. Model Selection

	Generative	Discriminative
Parametric	Linear Discriminant Analysis (LDA)	Logistic Regression (LR)
Non-Parametric	K-Nearest Neighbors (KNN),	Support Vector Machine (SVM)

- KNN: K=5, Distance: euclidean distance with no threshold for shrinking.
- LDA: Euclidean distance, regularization strength of 1.0.
- LR: L2 penalty, regularization strength of 1.0, tolerance for stopping criteria is 0.0001.
- SVM: Penalty parameter of 1.0, RBF kernel with degree of 3 and gamma of 0, tolerance for stopping criteria is 0.0001.

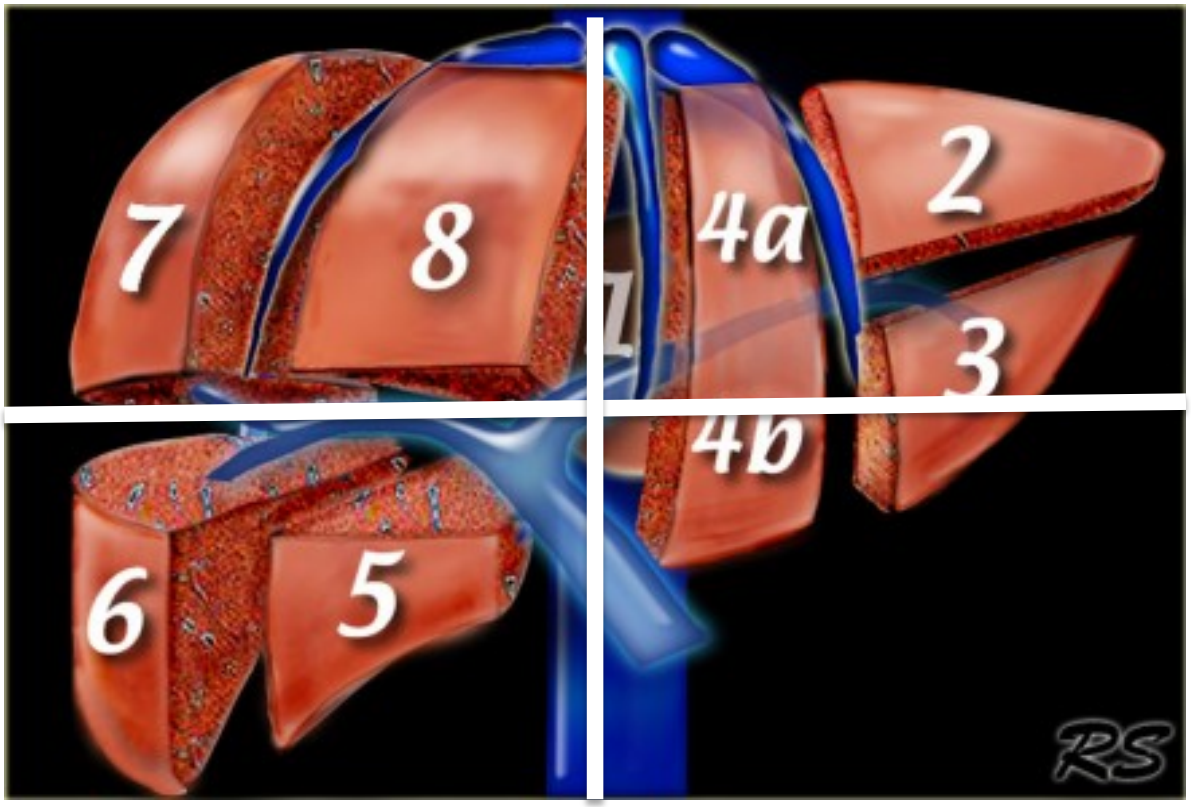
3. Model Selection

Group	UsE Annotations	**KNN**	**LR**	**LDA**	**SVM**	**Average**
Liver	All	0.92	0.92	0.92	0.92	0.92
Vessel	All	1	1	1	1	1
Lesion-Lesion	Contrast Uptake	0.7	0.62	**0.79**	0.66	0.8
Lesion-Lesion	Contrast Pattern	**0.75**	0.7	0.58	0.67	
Lesion-Lesion	Others	0.92	0.92	0.92	0.92	
Lesion-Area	is contrasted	0.74	0.75	**0.79**	0.76	0.83
Lesion-Area	Density	0.9	0.9	**0.92**	0.9	
Lesion-Area	Density Type	0.75	0.76	**0.8**	0.76	
Lesion-Area	Is Peripherical Localized	**0.8**	0.76	0.72	0.74	
Lesion-Area	Is Central Localized	**0.8**	0.76	0.72	0.74	
Lesion-Area	Others	0.91	0.91	0.91	0.91	
Lesion Component	All	0.93	0.93	0.93	0.93	0.93

Group	UsE Annotations	Selected Classifier	Selected CoG Features
Liver	All	Any	All
Vessel	All	Any	All
Lesion-Lesion	Contrast Uptake	LDA	*BounderyLiverGrayDiff*, *LesionGrayStd*, *Entropy*, *SurfaceArea*
Lesion-Lesion	Contrast Pattern	KNN	*LesionGrayMean*, *LesionBounderyGrayMean*, *BounderyLiverGrayDiff*, *LesionBounderyGrayStd*,
Lesion-Lesion	Other	Any	All
Lesion-Area	Is Contrasted	LDA	*LesionLiverGrayDiff*, *Solidity*, *Entropy*, *Kurtosis*,
Lesion-Area	Density	LDA	*lesionBoundryGrayMean*
Lesion-Area	Density Type	LDA	*LesionBounderyGrayMean*, *Solidity*, *LesionGrayStd*
Lesion-Area	Is Peripherical Localized	KNN	*LiverGrayStd*, *LesionGrayStd*, *lesionBounderyGrayStd*
Lesion-Area	Is Central Localized	KNN	*LiverGrayStd*, *LesionGrayStd*, *LesionBounderyGrayStd*
Lesion-Area	Other	Any	All
Lesion-Component	All	Any	All

3. Model Selection

- Lesion Lobe
- Lesion Segment



Results

Results

Group name	Affiliation	Num of runs
BMET	School of Information Technologies, University of Sydney, Australia	8
CASMIP	The Hebrew University of Jerusalem, Israel	1
piLabVAVlab	Boğaziçi University, Turkey	1

#	Group	Completeness	Accuracy	Total Score
1	BMET	0.98	0.91	0.94
2	CASMIP	0.95	0.91	0.93
3	piLabVAVlab	0.51	0.39	0.45

Test Results

Group name	Run	Completeness	Accuracy	Total Score	method used	feature used
BMET	run1	0.98	0.89	0.935	SVM-linear	CoG
BMET	run2	0.98	0.90	0.939	SVM-linear	CoG+
BMET	run3	0.98	0.89	0.933	SVM-RBF	CoG
BMET	run4	0.98	0.90	0.939	SVM-RBF	CoG+
BMET	run5	0.98	0.91	0.947	IR-noFS	CoG
BMET	run6	0.98	0.87	0.927	IR-noFS	CoG+
BMET	run7	0.98	0.91	0.947	IR-FS	CoG
BMET	run8	0.98	0.87	0.926	IR-FS	CoG+
CASMIP	run1	0.95	0.91	0.93	LDA+KNN	CoG+
piLabVAVlab	run1	0.51	0.39	0.45	MF-KL	CoG
piLabVAVlab	run2	0.51	0.89	0.677	MF-EUC	CoG
piLabVAVlab	run3	0.51	0.88	0.676	MF-KL	CoG

4. Results

GroupName	Liver		Vessel		LesionArea		LesionLesion		LesionComponent	
name	complete.	acc.	complete.	acc.	complete.	acc.	complete.	acc.	complete.	acc.
BMET-run1	1.00	0.91	1.00	1.00	0.92	0.78	1.00	0.72	1.00	0.93
BMET-run2	1.00	0.93	1.00	1.00	0.92	0.77	1.00	0.77	1.00	0.94
BMET-run3	1.00	0.93	1.00	1.00	0.92	0.76	1.00	0.72	1.00	0.93
BMET-run4	1.00	0.93	1.00	1.00	0.92	0.77	1.00	0.77	1.00	0.94
BMET-run5	1.00	0.93	1.00	1.00	0.92	0.79	1.00	0.83	1.00	0.94
BMET-run6	1.00	0.80	1.00	1.00	0.92	0.72	1.00	0.79	1.00	0.93
BMET-run7	1.00	0.93	1.00	1.00	0.92	0.79	1.00	0.83	1.00	0.94
BMET-run8	1.00	0.93	1.00	1.00	0.92	0.68	1.00	0.73	1.00	0.92
CASMIP	1.00	0.93	1.00	1.00	0.85	0.81	0.90	0.82	1.00	0.94
piLabVAVlab-run1	0.62	0.77	1.00	0.42	0.46	0.20	0.20	0.00	0.12	0.15
piLabVAVlab-run2	0.62	0.88	1.00	1.00	0.46	0.77	0.20	1.00	0.12	0.15
piLabVAVlab-run3	0.62	0.88	1.00	0.99	0.46	0.77	0.20	1.00	0.12	0.15


Questions ?