Impact of MRI technology on Alzheimer's disease detection

Presented By

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Supervisors

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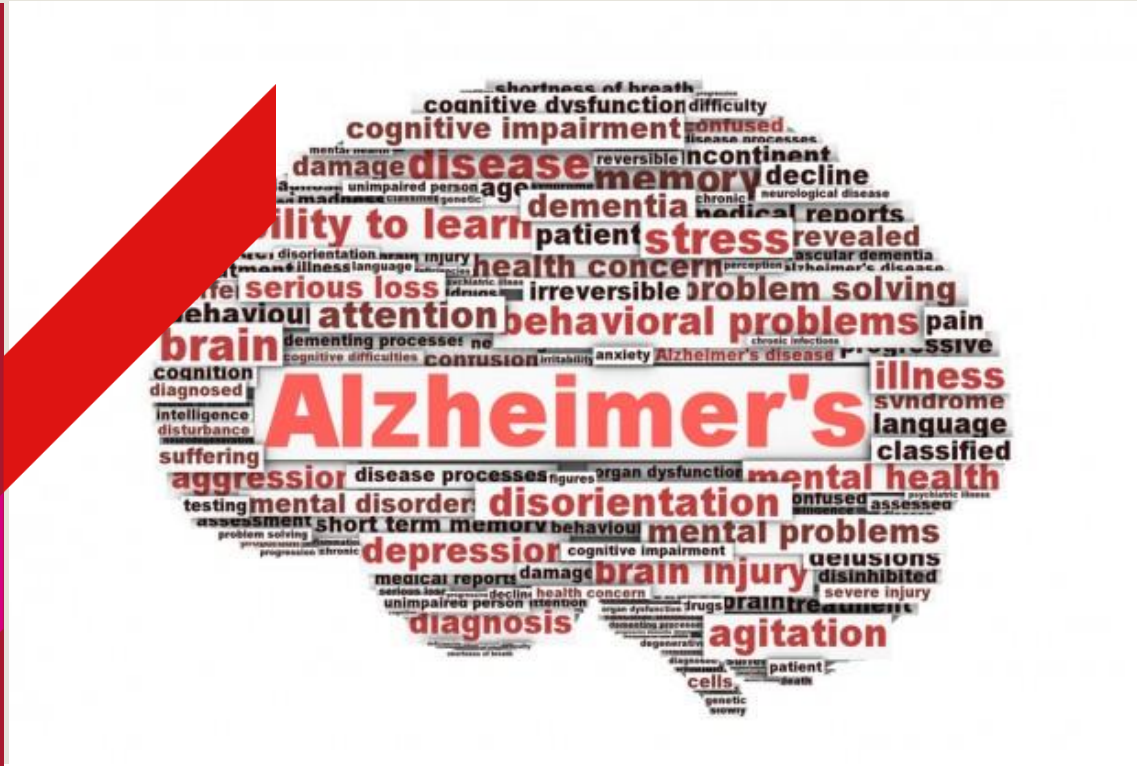

Outlines

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1. Alzheimer's disease
2. A biomarker- MRI
3. Different imaging acquisition protocol
4. The proposed method
5. Performance analysis
6. Conclusion

Alzheimer’s disease

- Most common cause of dementia
- Progressive neurodegenerative disorder
- Dr. Alois Alzheimer first described the symptoms in 1901.

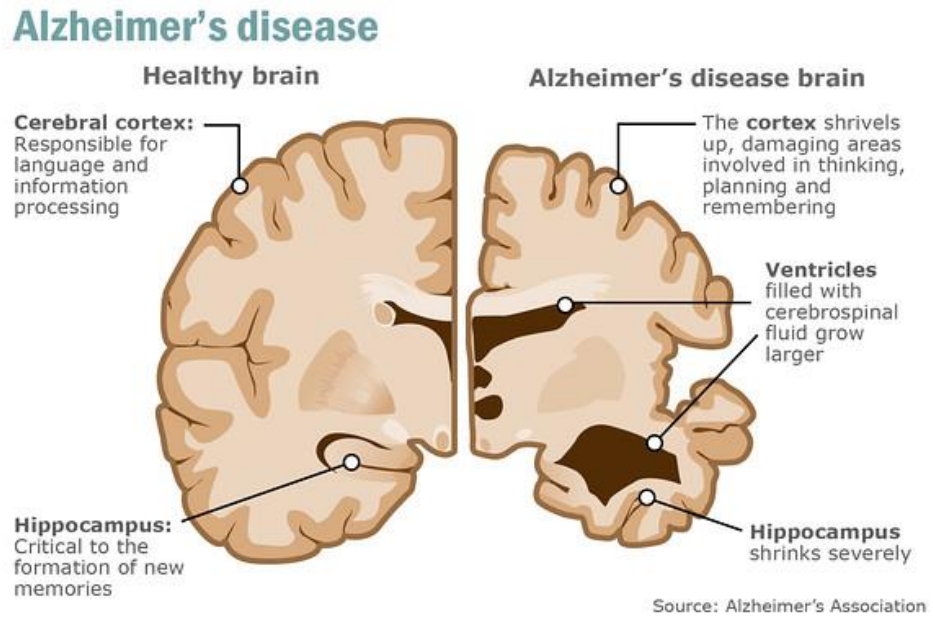


Fig. Healthy brain and Alzheimer’s brain

Alzheimer’s disease

- The major players-Tau Protein and Amyloid Plaques.
- The destructive accumulation starts at hippocampus.

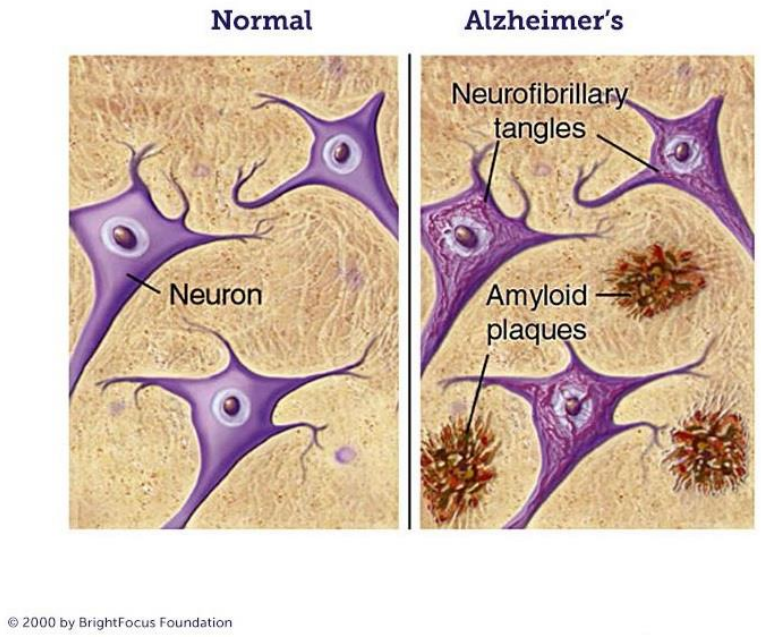


Fig. Healthy brain and Alzheimer’s brain

Alzheimer's disease

- Over 135 million people worldwide by 2050

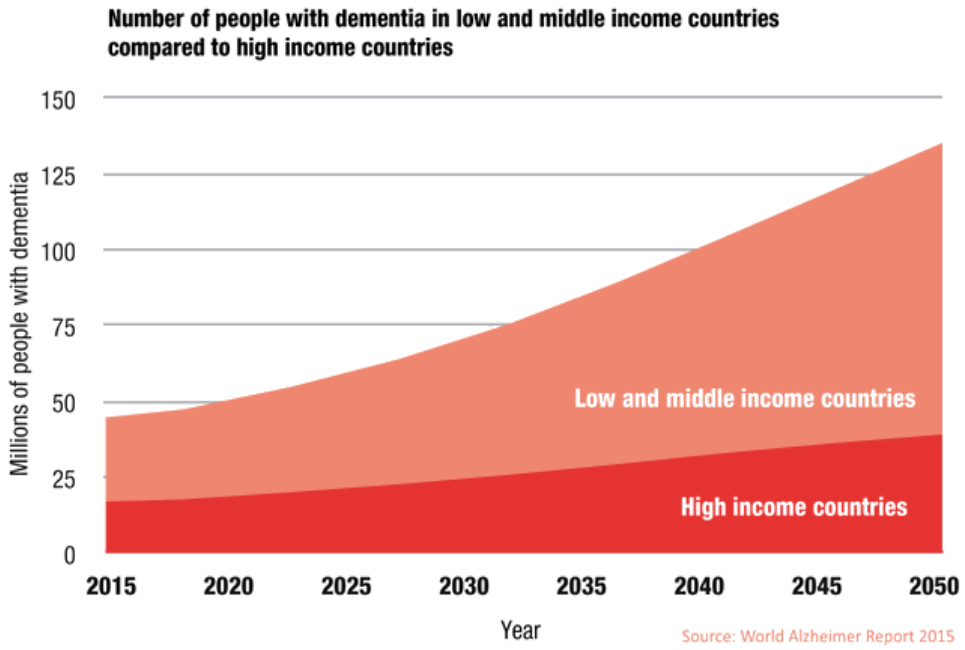
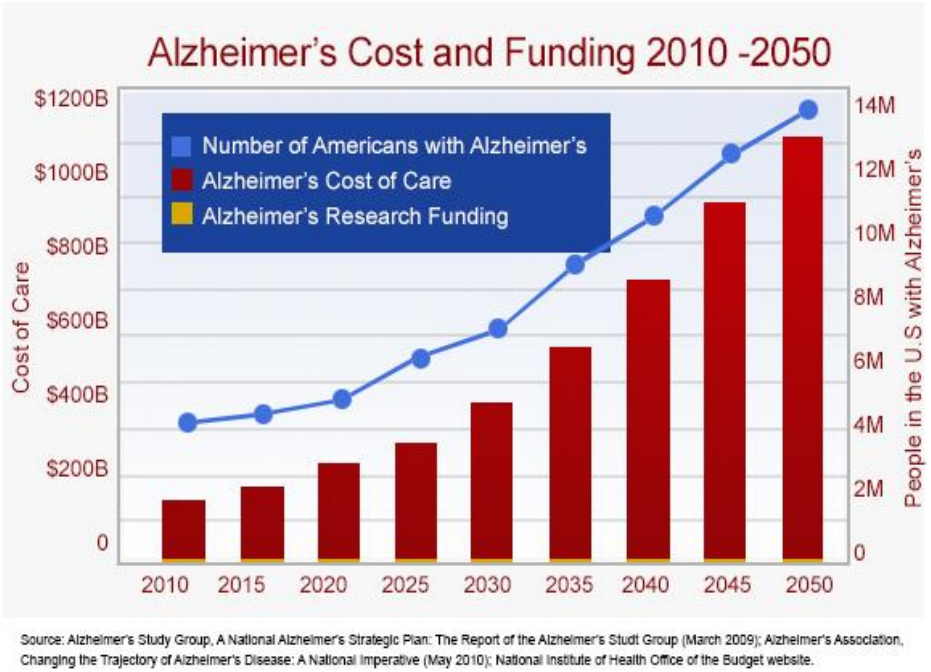


Fig. Dementia statistics

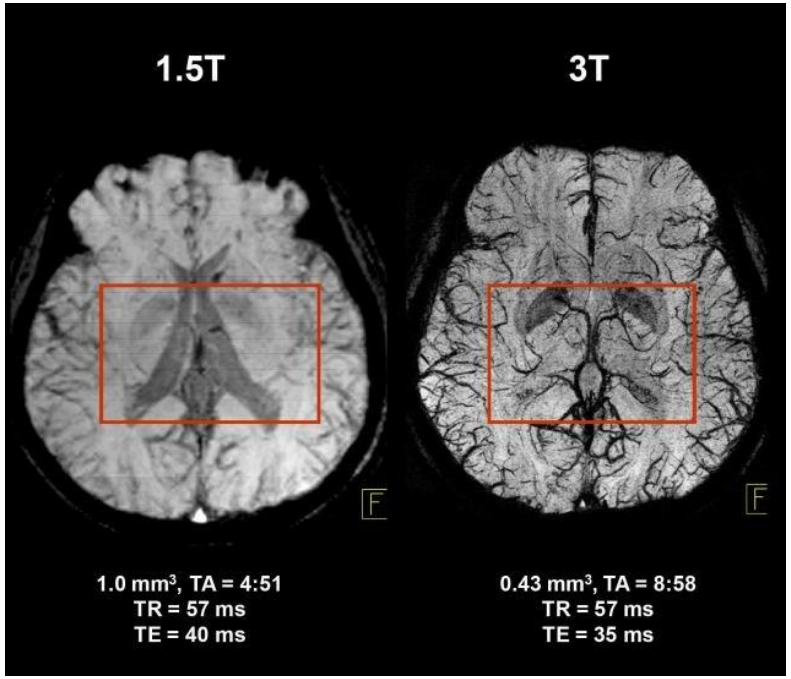


Source: usagainstalzheimers.org

Fig. Alzheimer's disease funding

Magnetic Resonance Imaging (MRI)

- MR images of AD patients- cortical atrophy, and enlarged ventricles.



Source: Gachon Medical School, Korea

Datasets/Projects

Table: Different phases of ADNI project

Projects	1.5TMRI	3T MRI	DTI	fMRI	Weighted Image
ADNI-1	Yes	Yes	No	No	T1/T2/PD
ADNI-GO	No	Yes	No	No	T1/T2/PD
ADNI-2	No	Yes	No	No	T1/T2/PD
ADNI-3	No	Yes	No	No	T1/T2/PD

MR Scanner manufacturers: GE Medical Systems, Philips Medical Systems, Siemens

Research Questions

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How does the performance result of AD/MCI detection/classification vary

- Across two MR imaging field strengths?
- Across different scanner manufacturers and its models?
- Across two supervised algorithms (RBF-SVM and ELM)?

Research Questions

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How do affected regions due to progression of AD/MCI vary

- Across two MR imaging field strengths?
- Across different scanner manufacturers and its models?

Background Studies

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Primarily 3 types of features from MRI

- Voxel-based features
- Vertex based features
- Pre-defined ROI-based features

Background Studies

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Voxel based features

- Voxels of the whole brain are partitioned into three different tissues (GM, WM, and CSF).

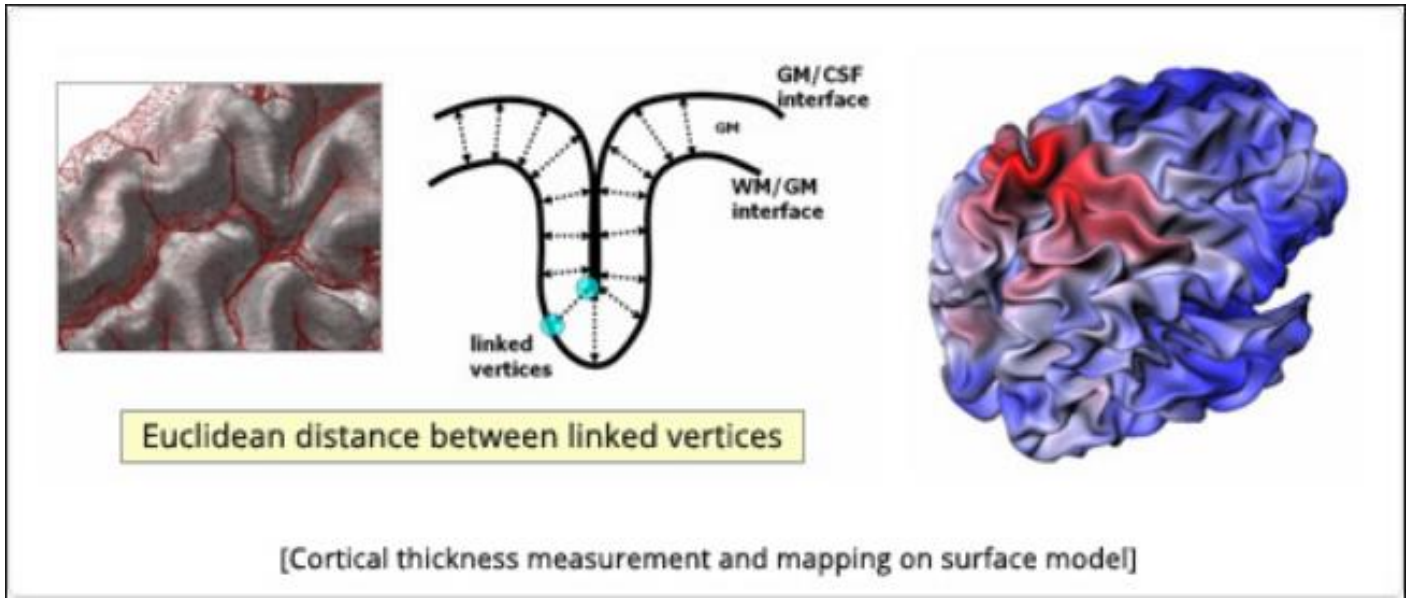
- ROI based methods to overcome dimensionality problem
  - VBM (Voxel-based morphometry): measures brain volume
  - DBM (Deformation based morphometry): measures the deformation field
  - TBM (Tensor based morphometry): measures jacobian of deformation

- Multi-atlas based method to overcome bias, outperforms single atlas based method.

Background Studies

Vertex based features

- Cortical thickness
- Cortical Surface area



Pre-determined ROI-based features

- Medial temporal lobe, successively affects the entorhinal cortex, hippocampus, limbic system, and neocortical areas

Background Studies

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Table: A summary of classification accuracy of different classifiers using different feature type

Study	Type of Features	Dataset	Category of features	Classifier	Classification accuracy			
					AD/CN	AD/MCI	CN/MCI	sMCI/pMCI
(Liu et al. [70])	M-ROI	AD-97 pMCI-117 sMCI-117 CN-128	Tissue density map based	SVM	92.51	-	-	78.88
(Misra et al. [92])	S-ROI	AD-56 pMCI-27 sMCI-76 CN-66	Tissue density map based	SVM	-	-	-	81.50
(Salvatoreet al. [93])	SUFR	AD-137 pMCI-76 sMCI-134 CN-162	Tissue density map based	SVM	76.00	-	72.00	66.00
(Li et al. [74])	All vertices	MCI-24 CN-26	Cortical Surface based	SVM	-	-	80	-
(Wee et al., [36])	Atlas	AD-198 pMCI-89 sMCI-111 CN-200	Cortical Surface based	Multi-kernel SVM	92.35	79.24	83.75	75.05
Lama et al. [94]	Cortical thickness and surface area	AD-70 MCI-74 CN-70	Cortical Surface-based	Regularized ELM	76.61	-	-	-

Background Studies

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Table: A summary of classification accuracy of different classifiers using different feature type

Study	Type of Features	Dataset	Category of features	Classifier	Classification accuracy			
					AD/CN	AD/MCI	CN/MCI	sMCI/pMCI
(Sorensen et al. [95])	Hippocampus	AD-101 MCI-233 pMCI-93 sMCI-140 CN-169	Pre-defined ROI based	SVM	91.20	-	76.40	74.20
(Chincarini et al. [96])	Biologically selected regions	AD-144 pMCI-136 sMCI-166 CN-189	Pre-defined ROI based	SVM	97.00		92.00	74.00
Zu et al. [97]	Feature concatenation	AD-51 pMCI-43 sMCI-56 CN-52	Multimodal (MRI and FDG-PET)	Multi-kernel SVM	95.95	80.26	-	69.78
Alam et al. [98]	MRI bases texture	AD-86 CN-86	Texture	Twin SVM	92.65	-	-	-

Background Studies

- Some robust methods are proposed – increasing reliability across field strengths.
- The MRI data integration- suitable regression based correction.
- Impact of different protocols- minor if proper pre-processing steps followed.

Proposed Methods

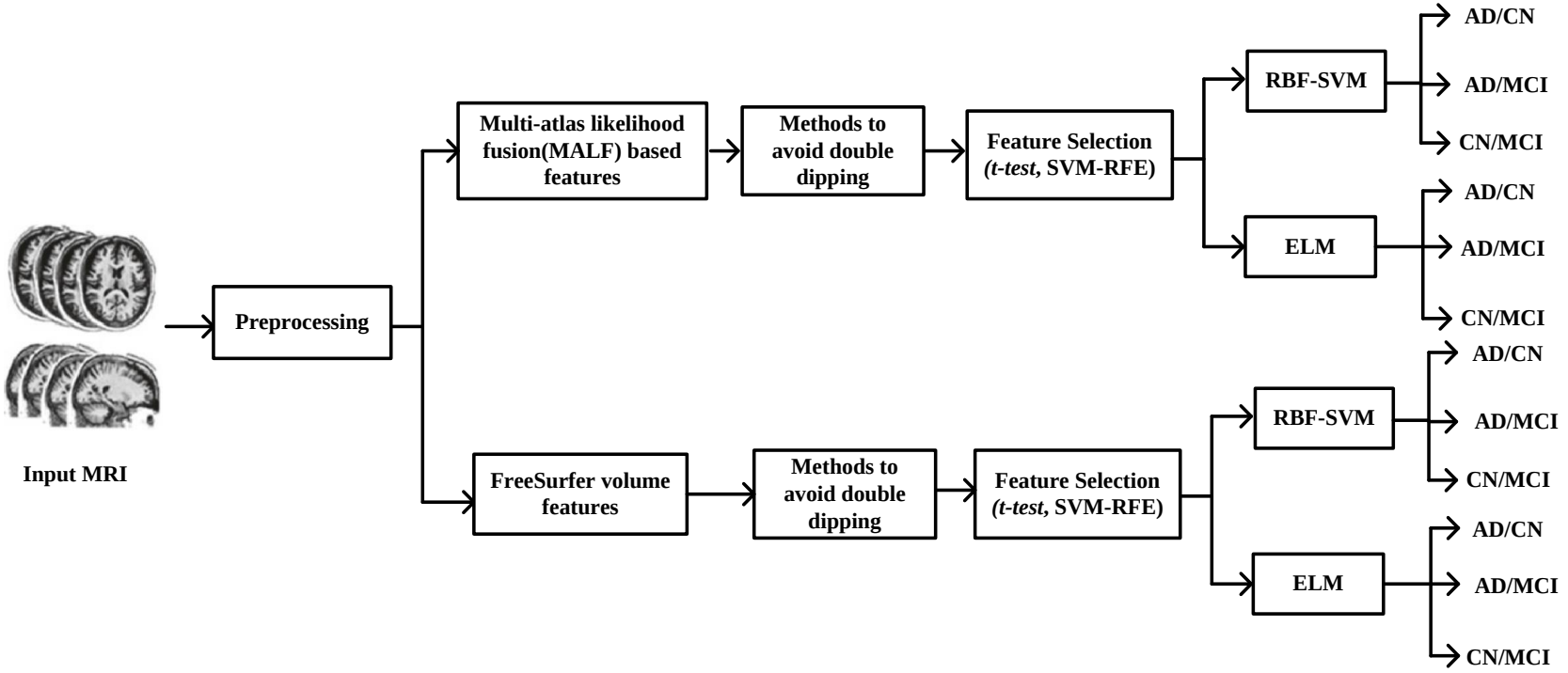

Figure: Schematic diagram of the proposed approach

Proposed method

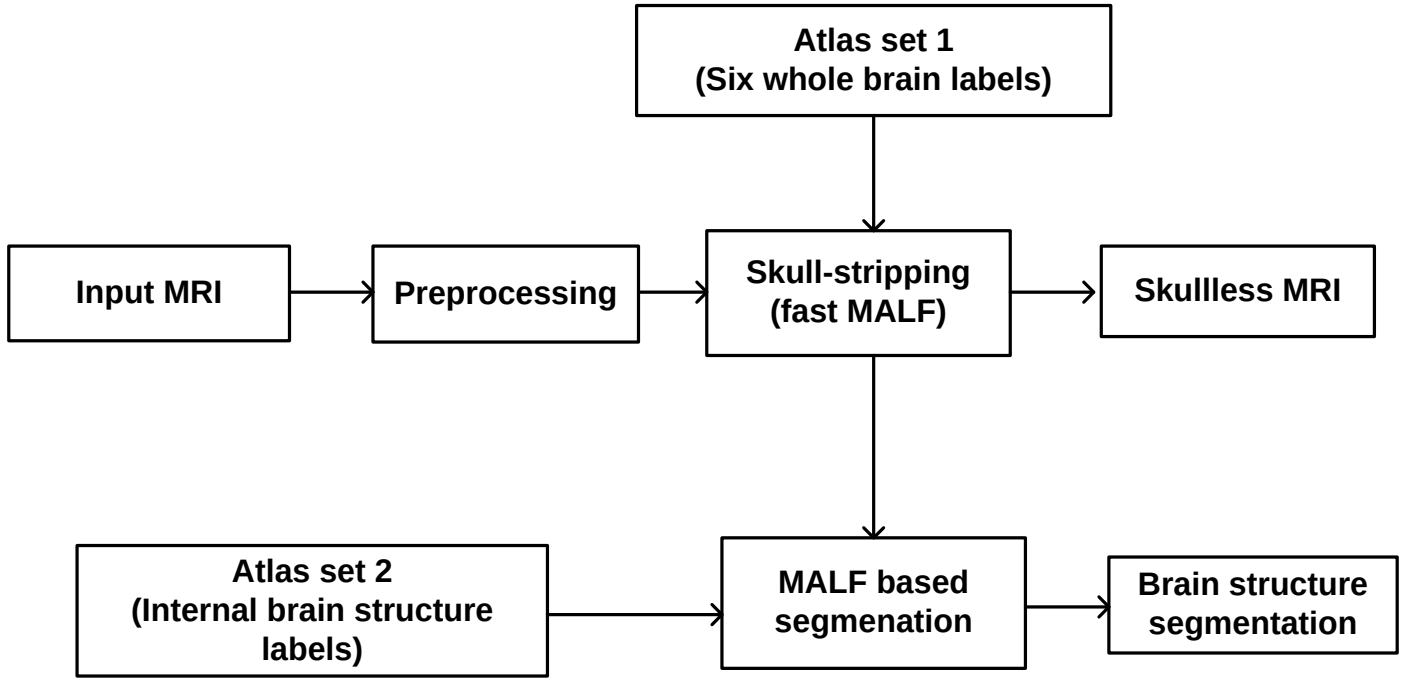

Fig: Schematic diagram of MALF based segmentation

Proposed method

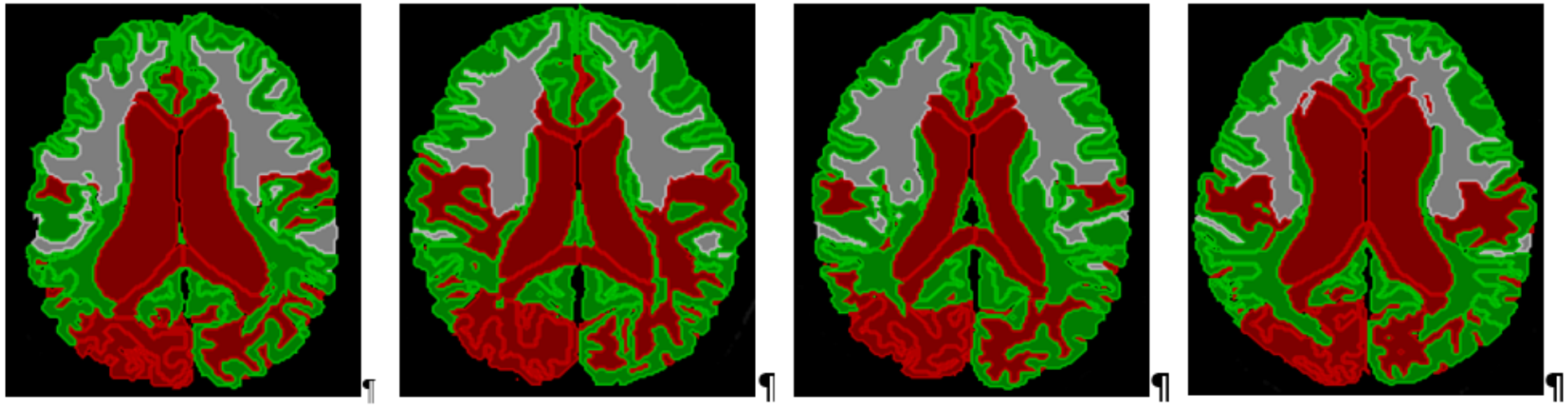

Figure: MALF based segmentation of four different subjects over four scanner models

Proposed method

- Regarding segmentation accuracy, MALF is superior or comparable to other fusion based methods.
- The number of brain structures is 8, 19, 54, 136, and 282 for each of the five granularity levels, respectively

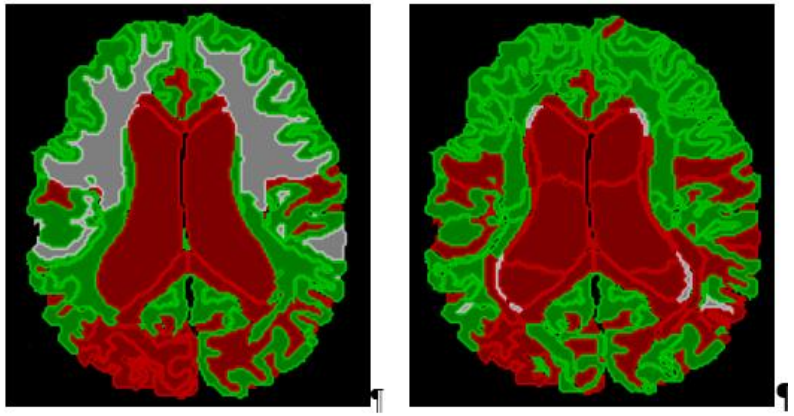

Figure: MALF based segmentation of a subject image at two granularity levels

Proposed method

- The brain volume is segmented into 40 labels

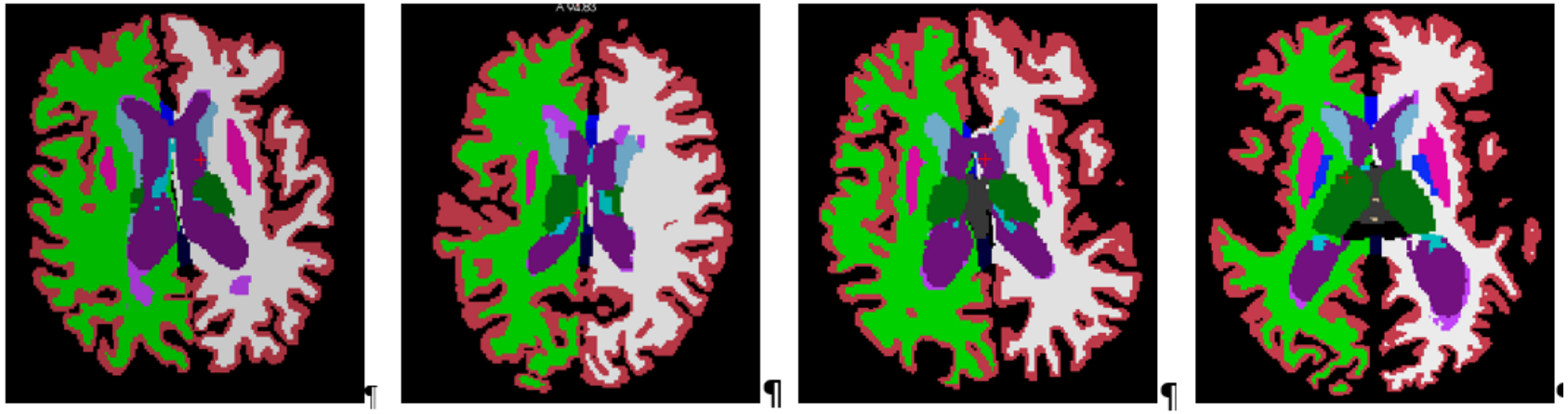

Figure: FreeSurfer based subcortical segmentation of four different subjects over four scanner models

Proposed method

Feature Selection approaches

- Filter based approach: two sample *t*-test
- Wrapper based approach: Support Vector Machine Recursive Feature Elimination

Supervised Algorithms

Support Vector Machine

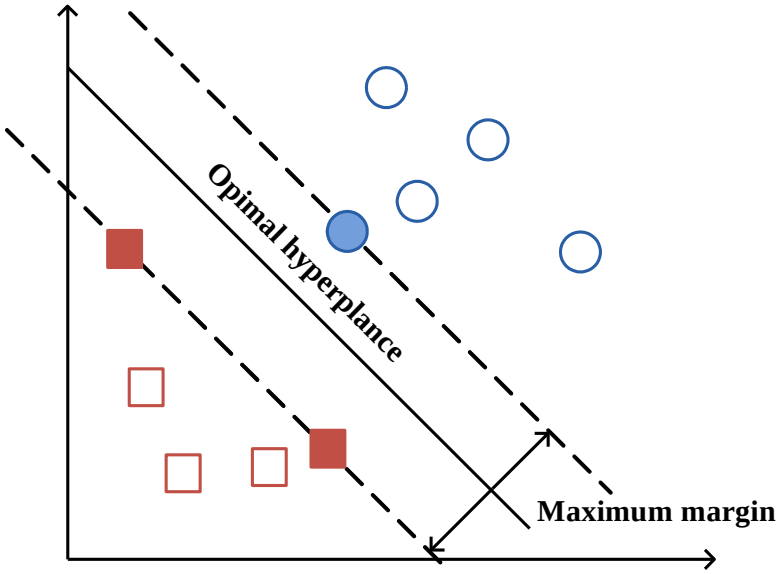

Figure: Linear Support Vector Machine

$$RBF\,Kernel, K(x, x') = \exp(-\gamma \| x - x' \|^2), \gamma > 0$$

Supervised Algorithms

Extreme Learning Machine

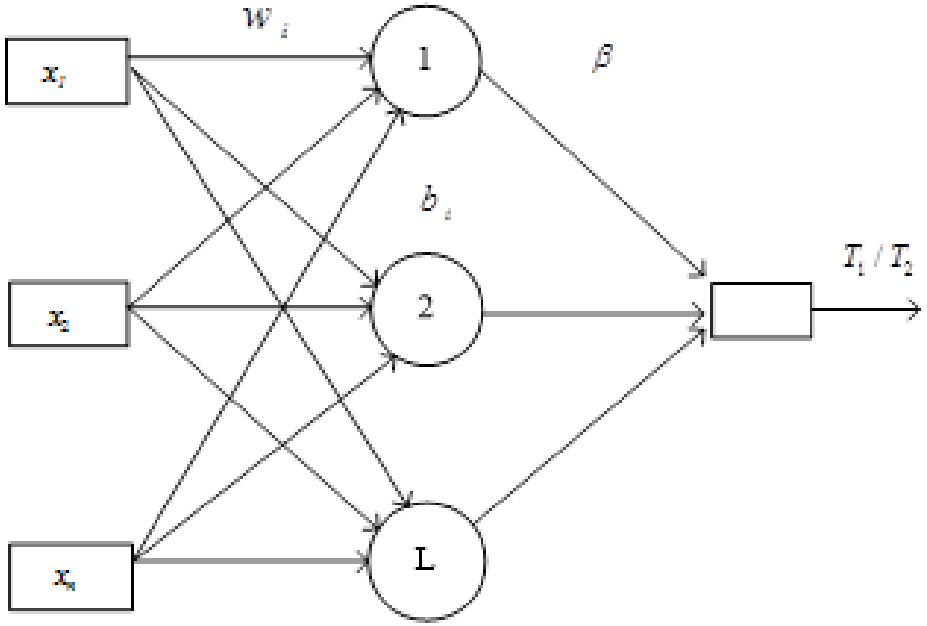

Figure: ELM SLFN approach

Data

Table: Selected data for MALF and FreeSurfer based approach

Classification sets	Model of the scanners	Dataset for MALF	Dataset for FreeSurfer
AD vs CN	GE Signa HDX	AD=40, CN=40	AD=41, CN=41
	GE Signa Excite	AD=74, CN=74	AD=60, CN=60
	Siemens Symphony	AD=35, CN=35	AD=19, CN=19
	Siemens TrioTim	AD=67, CN=67	AD=54, CN=54
AD vs MCI	GE Signa HDX	AD=51, MCI=51	AD=40, MCI=40
	GE Signa Excite	AD=72, MCI=72	AD=60, MCI=60
	Siemens Symphony	AD=35, MCI=35	AD=34, MCI=34
	Siemens TrioTim	AD=67, MCI=67	AD=54, MCI=54
CN vs MCI	GE Signa HDX	CN=40, MCI=40	CN=40, MCI=40
	GE Signa Excite	CN=72, MCI=72	CN=62, MCI=62
	Siemens Symphony	CN=42, MCI=42	CN=19, MCI=19
	Siemens TrioTim	CN=75, MCI=75	CN=70, MCI=70

Preprocessing

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- **Gradwarp**: Corrects the image geometry which is distorted by the scanner. This gradient non-linearity distorts the image geometry. Gradwarp corrects this distortion.
- **B1 non-uniformity**: Uses calibration of time-varying radio frequency field (B1) parameters to correct the artifacts of an image. This artifact, the non-uniformity in image intensity occurs when the degree of uniformity at head coil and receiver coil varies during Radio Frequency(RF) transmission.
- **N3**: This method normalizes the non-uniform intensities, sharpening the histogram of an image.
- A method applied to avoid double dipping

Performance Evaluation

1. $\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$

2. $\text{Sensitivity} = \frac{TP}{TP+FN}$ (Recall/TPR)

3. $\text{Specificity} = \frac{TN}{TN+FP}$ (TNR)

4. $\text{Precision} = \frac{TP}{TP+FP}$ (PPV)

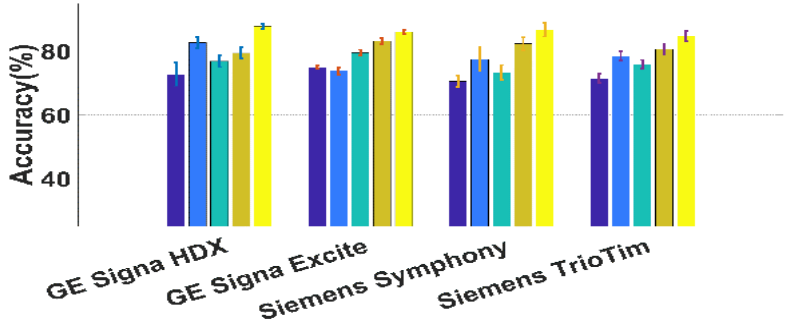
5. $F_1\ score = 2 * \frac{precision * sensitivity}{precision + sensitivity}$

6. $Gmean = \sqrt{sensitivity * specificity}$

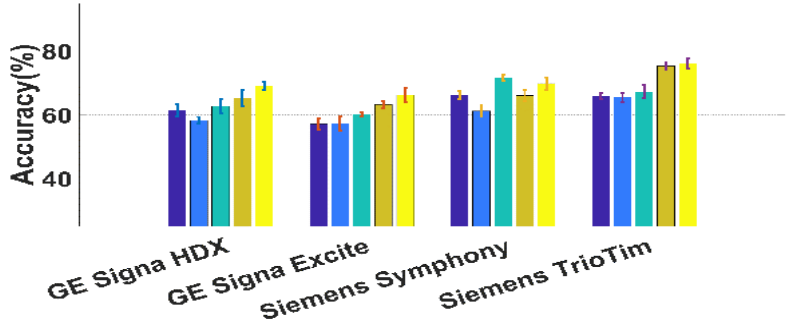
Indicator	Explanation
TP	True Positive, anticipating an AD to AD
FP	False Positive, anticipating HC to AD
TN	True Negative, anticipating an HC to HC
FN	False Negative, anticipating an AD to HC

Validation: 5-cross-validation with running the program 30 times

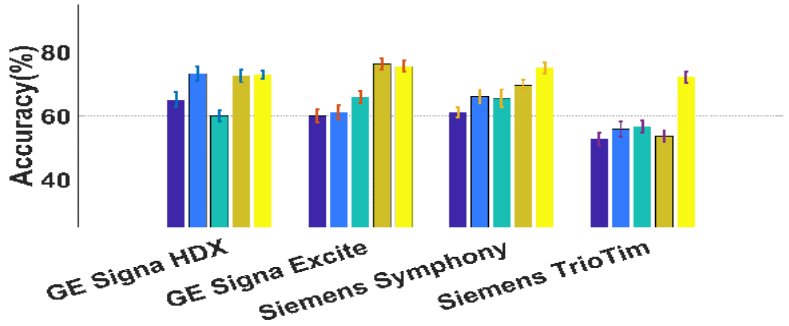
Result and Discussion



(a) AD vs CN



(b) AD vs MCI



(c) CN vs MCI

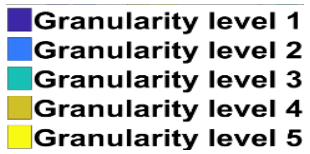


Figure: Performance accuracy of MALF based method using RBF-SVM over four different protocols

Result and Discussion

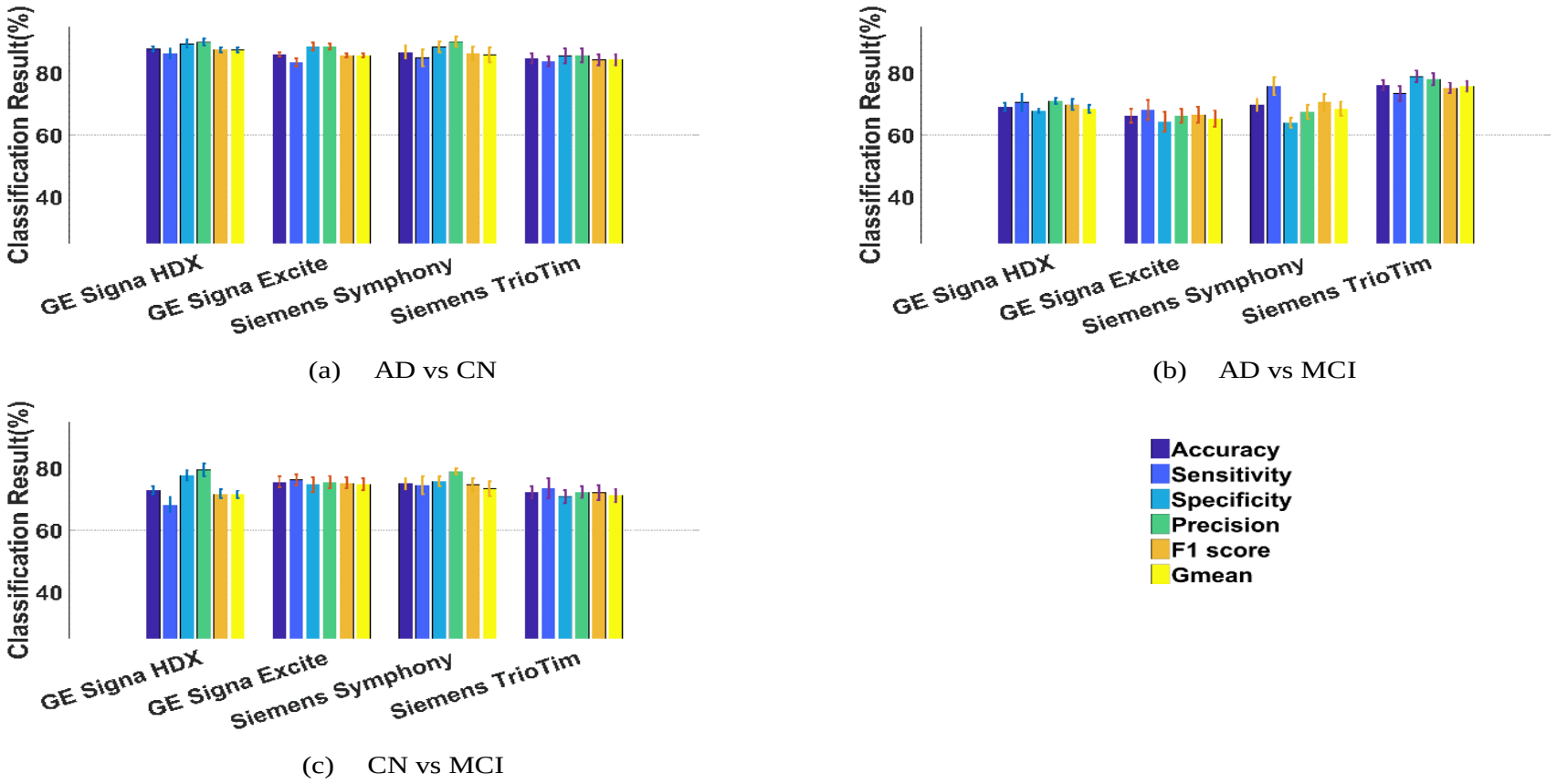
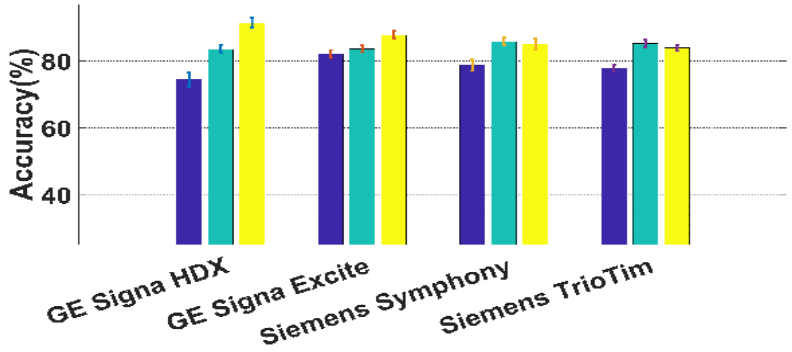
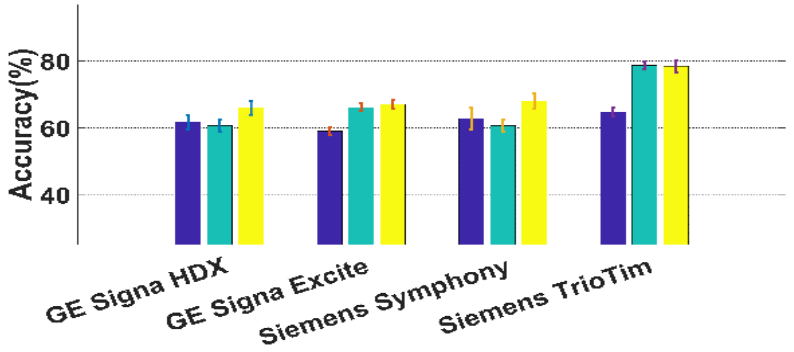


Figure: Performance result of MALF based features at granularity level 5 using RBF-SVM over four different protocols

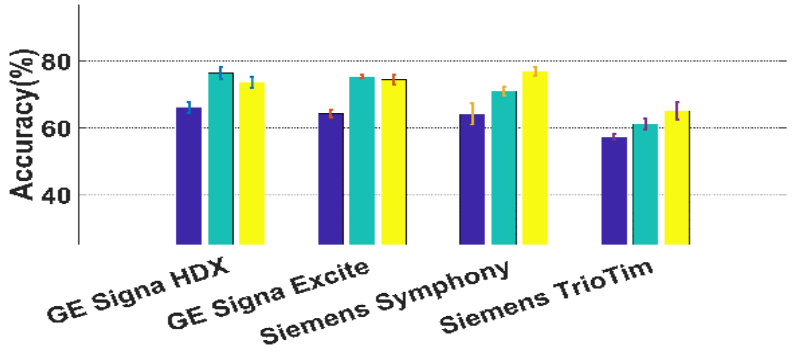
Result and Discussion



(a) AD vs CN



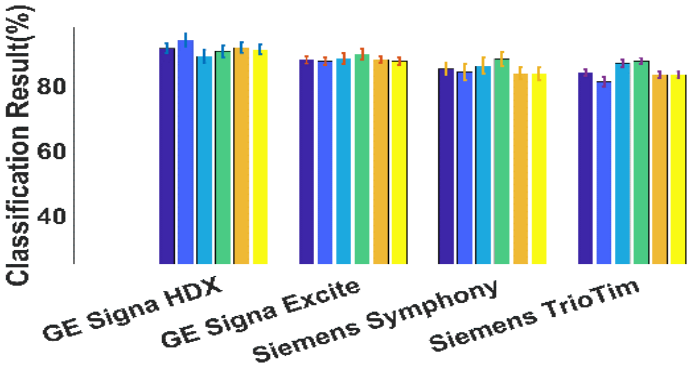
(b) AD vs MCI



(c) CN vs MCI

Figure: Performance accuracy of MALF based method using ELM over four different protocols

Result and Discussion



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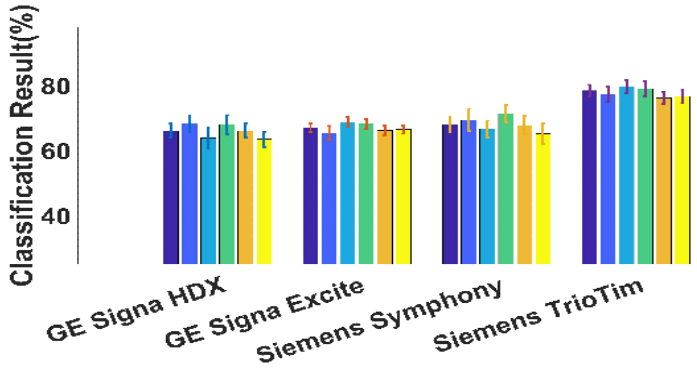
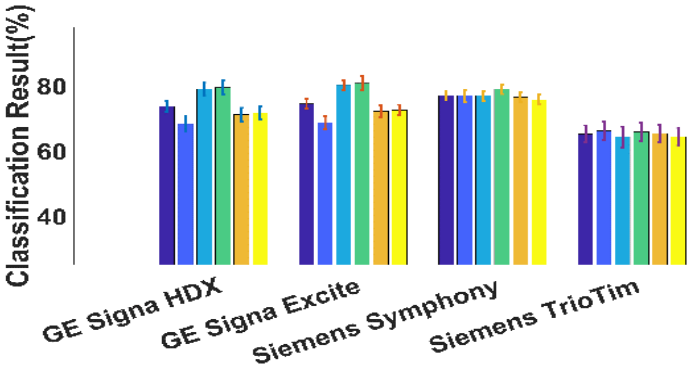


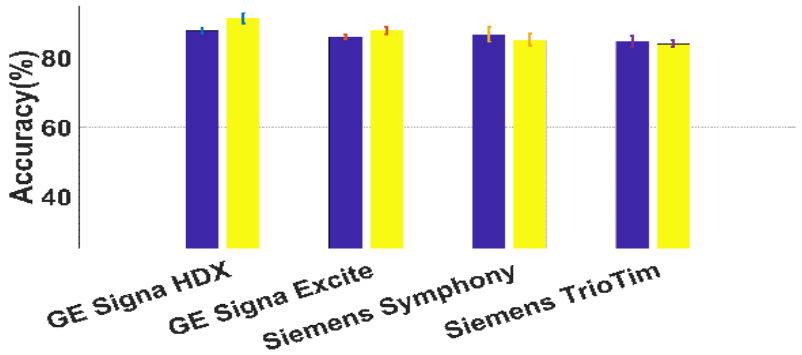
(b) AD vs MCI



(c) CN vs MCI

Figure: Performance result of MALF based features at granularity level 5 using ELM over four different protocols

Result and Discussion



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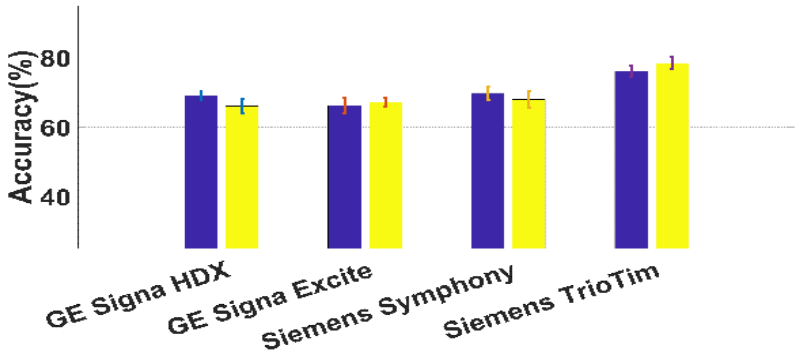
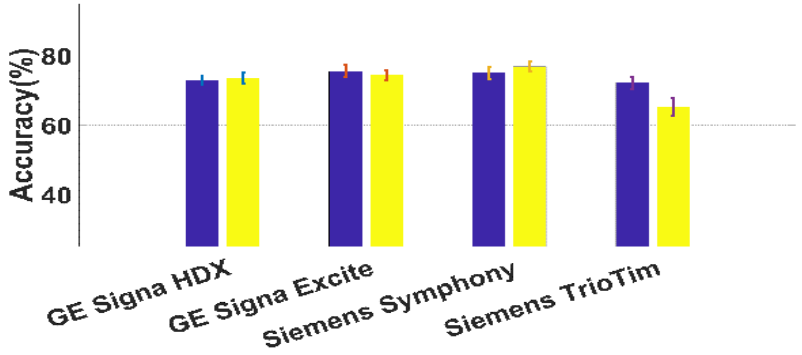


(b) AD vs MCI



(c) CN vs MCI

Figure: Comparison of ELM and SVM at granularity level 5 of MALF based method

Result and Discussion

Accuracy	Sensitivity	Specificity	Precision	Recall	F1 score	gmean								
GE Signa HDX								GE Signa Excite						
87.75	86.16666667	89.3333333	89.9127	86.16667	87.45805	87.4058		85.97619	83.47619	88.47619	88.52998	83.47619	85.59131	85.73762
0.830455	1.572025562	1.30207615	1.194383	1.572026	0.874182	0.832514		0.662755	1.282335	1.182403	0.999601	1.282335	0.68825	0.655996
Siemens Symphony								Siemens TrioTim						
86.61905	84.85714286	88.3809524	89.99365	84.85714	86.21411	85.80376		84.61538	83.74359	85.48718	85.67894	83.74359	84.22908	84.28702
2.10503	2.822449463	1.82766809	1.6088	2.822449	2.152925	2.335805		1.665816	1.548157	2.344824	2.138524	1.548157	1.674605	1.730086
83.31944	79.63888889	87	86.44	79.63889	82.42816	82.94702								
0.613967	0.748028486	0.83620196	0.918007	0.748028	0.659859	0.628629	stnd dev							
86.53846	84.39316239	88.6837607	88.34644	84.39316	86.18871	86.42833								
0.586061	1.171605801	0.5703112	0.501991	1.171606	0.68798	0.628548	stnd dev							

Figure: Performance result of MALF based features at granularity level 5 using RBF-SVM over four different protocols (AD/CN)

Result and Discussion

GE Signa HDX										GE Signa Excite					
91.375	93.91667	88.83333	90.45	93.91667	91.57487	90.9461			87.80952	87.42857	88.19048	89.51614	87.42857	87.87777	87.40879
1.443998	2.043	2.048268	1.790861	2.043	1.523403	1.507772		stnd dev	1.07648	1.087321	1.716474	1.678205	1.087321	1.046406	1.055725
Siemens Symphony										Siemens TrioTim					
85.05556	84.11111	86	88.08333	84.11111	83.66667	83.49931			83.91667	81.05556	86.77778	87.42063	81.05556	83.16542	83.25691
1.776999	2.42644	2.537081	2.100789	2.42644	1.846142	1.935311		stnd dev	0.957677	1.546429	1.152486	0.982435	1.546429	1.016827	0.986472
ımber															
82.84722	80.86111	84.83333	85.08356	80.86111	82.52412	82.56084									
0.579868	0.637409	0.858806	0.768599	0.637409	0.532884	0.574338		stnd dev							
87.51389	82.83333	92.19444	91.93779	82.83333	86.85638	87.22224									
0.769723	0.807057	1.014345	1.038117	0.807057	0.762405	0.757857		stnd dev							

Figure: Performance result of MALF based features at granularity level 5 using ELM over four different protocols (AD/CN)

Result and Discussion

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SVM														
GE Signa HDX									GE Signa Excite					
69.13333	70.46667	67.8	70.98692	70.46667	69.80688	68.43332			66.21429	68.09524	64.33333	66.19853	68.09524	66.44569	65.31488
1.279368	2.609444	0.610257	0.948286	2.609444	1.70151	1.33869		stnd dev	2.244314	3.212689	3.215973	2.213123	3.212689	2.497345	2.613297
Siemens Symphony									Siemens TrioTim					
69.80952	75.71429	63.90476	67.57025	75.71429	70.54619	68.43325			76.07692	73.33333	78.82051	78.03885	73.33333	75.11816	75.64453
1.939744	2.97775	1.588724	2.226372	2.97775	2.717196	2.361397		stnd dev	1.694356	2.36734	1.881333	1.919409	2.36734	1.749614	1.660865
70.92	68.45333	73.38667	74.03561	68.45333	70.49392	70.23124								
0.892266	1.182555	1.149433	0.964219	1.182555	0.95352	0.962	stnd dev							
70.38462	70.8547	69.91453	70.31145	70.8547	70.369	70.16158								
0.627171	0.540094	1.321812	0.81249	0.540094	0.508001	0.682437	stnd dev							

Figure: Performance result of MALF based features at granularity level 5 using RBF-SVM over four different protocols (AD/MCI)

Result and Discussion

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ELM																
GE Signa HDX									GE Signa Excite							
66	68.2	63.8	67.87143	68.2	65.9977	63.42197			67.04762	65.38095	68.71429	68.16548	65.38095	66.12667	66.41942	
2.117252611	2.123757	3.209898	3.232906	2.123757	2.110439	2.372136	stnd dev		1.322853	2.078113	1.607074	1.511997	2.078113	1.532076	1.319419	stnd dev
Siemens Symphony									Siemens TrioTim							
67.94444444	69.33333	66.55556	71.31111	69.33333	67.67857	65.09736			78.38889	77.22222	79.55556	78.91746	77.22222	76.11076	76.5596	
2.384630438	3.435224	2.549635	2.730814	3.435224	2.882962	3.098799	stnd dev		1.708292	2.28829	2.002553	2.400961	2.28829	1.928992	1.918087	stnd dev
Feeding same number																
35 each scann	69.27778	67.77778	70.77778	71.25922	67.77778	68.63073	68.40198									
but 125/125	0.578317	0.66858	0.816888	0.887103	0.66858	0.626356	0.644809	stnd dev								
Feeding All	72.47222	71.38889	73.55556	73.88047	71.38889	72.03998	71.91753									
195/195	0.901875	1.552611	1.450547	1.134213	1.552611	1.068764	0.949483	stnd dev								

Figure: Performance result of MALF based features at granularity level 5 using ELM over four different protocols (AD/MCI)

Result and Discussion

SVM													
GE Signa HDX									GE Signa Excite				
72.91667	68.16667	77.66667	79.45166	68.16667	71.69461	71.50645		75.47619	76.2381	74.71429	75.51718	76.2381	75.15281	74.82533
1.326672	2.361083	1.72873	2.01188	2.361083	1.501531	1.213801		1.742919	1.738877	2.377173	1.971516	1.738877	1.773204	1.86389
Siemens Symphony									Siemens TrioTim				
75.04167	74.41667	75.66667	78.86144	74.41667	74.62131	73.35273		72.2	73.55556	70.84444	72.27955	73.55556	72.06646	71.22899
1.72092	2.912764	1.59921	0.969244	2.912764	2.188854	2.318358		1.919051	3.26755	2.003318	1.806224	3.26755	2.281197	2.046349
75.83333	68.97222	82.69444	81.2041	68.97222	74.10172	75.23304								
0.734025	1.231828	1.087268	1.098211	1.231828	0.906782	0.818755	stnd dev							
70.93023	65.78295	76.07752	73.80797	65.78295	69.2435	70.45845								
0.682814	0.676595	0.843453	0.889429	0.676595	0.766667	0.736622								

Figure: Performance result of MALF based features at granularity level 5 using RBF-SVM over four different protocols (CN/MCI)

Result and Discussion

	GE Signa HDX									GE Signa Excite				
	73.58333	68.16667	79	79.39921	68.16667	71.0778	71.56063		74.40476	68.66667	80.14286	80.72387	68.66667	72.09416	72.46021
stnd dev	1.565156	2.361083	2.034191	2.188938	2.361083	2.036759	1.915062		1.454002	2.017982	1.562672	2.12455	2.017982	1.862604	1.629402
	Siemens Symphony									Siemens TrioTim				
	76.83333	76.83333	76.83333	78.82778	76.83333	76.42831	75.68516		65.14286	66.09524	64.19048	65.80214	66.09524	65.33555	64.26263
stnd dev	1.342818	1.8492	1.458231	1.422643	1.8492	1.44508	1.459613		2.622106	2.88004	3.225805	2.874324	2.88004	2.609312	2.591948
Feeding same number															
35 each scanner	72.90278	69.27778	76.52778	76.03864	69.27778	72.02172	72.4161								
but 120/120															
stnd dev	0.696214	0.996482	0.760726	0.710473	0.996482	0.803187	0.787517								
Feeding All	71.45833	68.02778	74.88889	73.86898	68.02778	70.07706	70.77554								
215/215	0.939693	1.459599	1.527734	1.336205	1.459599	1.06702	0.987505	stnd dev							

Figure: Performance result of MALF based features at granularity level 5 using ELM over four different protocols (CN/MCI)

Result and Discussion

		GE Signa HDX									GE Signa Excite														
		81.625	84.33333	78.91667	81.29278	84.33333	81.89088	80.86273		80.63889	79.88889	81.38889	81.58854	79.88889	80.05062	80.14456									
					STD																				
	stnd dev	1.710452	2.62E+00	1.934636	1.744692	2.62E+00	1.879328	1.873582		1.151447	1.308192	1.389846	1.427108	1.308192	1.228751	1.210099									
AD/CN																									
		Siemens Symphony									Siemens TrioTim														
		86.66667	86.66667	86.66667	88.44444	86.66667	86.46349	85.9483		86.16667	85.06667	87.26667	86.98834	85.06667	85.76895	85.99431									
						STDS																			
	stnd dev	1.77E+00	2.712254	3.26755	3.037127	2.712254	2.445867	2.3836		0.874281	1.720732	0.980265	0.865521	1.720732	1.04324	0.915388									
		GE Signa HDX									GE Signa Excite														
		70.83333	72.08333	69.58333	70.15185	72.08333	70.2595	69.98803		67.02778	63.94444	70.11111	69.39872	63.94444	65.62803	65.8947									
		1.285418	2.374735	2.463819	1.599141	2.374735	1.752523	1.517606		2.10686	3.2307	2.966393	2.304434	3.2307	2.606709	2.376838									
AD/MCI																									
		Siemens Symphony									Siemens TrioTim														
	stnd dev	78.33333	82.55556	74.11111	78.60238	82.55556	79.42706	77.13481		78.36667	75.73333	81	81.65257	75.73333	77.726	77.65882									
	stnd dev	1.578107	2.086874	1.433944	0.903857	2.086874	1.604557	1.876198		1.828573	2.19089	2.170862	1.812021	2.19089	1.842283	1.875283									

	Feeding same number							
19 each scanner								
but 70/70	81.0952381	80.33333	81.85714	82.78944	80.33333	81.12246	80.79404	
stnd dev	1.387758552	1.973909	1.252724	1.167142	1.973909	1.498489	1.461556	
Feeding All								
170/170	Feeding All							
	82.83333333	80.01961	85.64706	85.35603	80.01961	82.37482	82.62861	
stnd dev	0.303927021	0.681865	0.502944	0.395887	0.681865	0.349995	0.331246	
	Feeding same number							
19 each scanner								
but 70/70								
	69.30952381	69.47619	69.14286	69.21421	69.47619	68.22791	68.06904	
stnd dev	1.101520498	1.325511	1.822527	1.156254	1.325511	1.042485	1.294744	
Feeding All	Feeding All							
170/170								
	69.21568627	69.11765	69.31373	69.44827	69.11765	69.18036	69.11808	
stnd dev	0.614685905	0.593285	0.874998	0.63262	0.593285	0.562679	0.632833	

Figure: Performance result of FreeSurfer based features using RBF-SVM over four different protocols (AD/CN, AD/MCI)

Result and Discussion

		GE Signa HDX								GE Signa Excite					
		70.20833	70.91667	69.5	71.3678	70.91667	70.01309	69.2803	68.44444	60.94444	75.94444	71.98441	60.94444	65.69624	67.76647
CN/MCI	stnd dev	1.644064	2.410764	2.576418	2.140895	2.410764	2.049111	2.045288	1.088369	1.4306	1.362	1.387894	1.4306	1.245083	1.110016
		Siemens Symphony								Siemens TrioTim					
		63.88889	66.66667	61.11111	66.25556	66.66667	62.75556	60.19186	63.90476	48.71429	79.09524	72.21021	48.71429	57.43934	61.65707
	stnd dev	1.263497	2.89E-14	2.526993	4.619369	2.89E-14	1.020069	1.723495	1.260425	2.546771	2.423592	3.136974	2.546771	2.06002	1.514152

19 each scann	Feeding same number							
but 70/70								
	69.85714286	65.95238	73.7619	71.80434	65.95238	68.52318	69.51815	
stnd dev	1.953001623	2.601449	2.10503	2.235178	2.601449	2.23876	1.979709	
Feeding All	Feeding All							
175/175								
	67.82857143	56.32381	79.33333	73.36378	56.32381	63.45686	66.62342	
stnd dev	0.694200364	0.415961	1.153481	1.241001	0.415961	0.637967	0.637271	

Table: Performance result of FreeSurfer based features using RBF-SVM over four different protocols (CN/MCI)

Result and Discussion

MACQUARIE University

AD/CN	80.375	78.58333333	82.16666667	84.58333	78.58333	79.57381	79.01375947		77.66667	77.38889	77.94444	78.8984127	77.38889	76.78079	76.65052			Feeding same number						
																	19 each scanner	82.42857	79.28571	85.57143	86.65416	79.28571	81.85341	81.56275
stnd dev	1.544944	2.681621143	0.864364759	1.230791	2.681621	2.113194	1.842639089		1.227934	1.2444	1.736102	2.52883959	1.2444	1.416135	1.451154			but 70/70	0.786945	1.624496	0.575111	0.606416	1.624496	1.048193	0.923313
	Siemens Symphony								Siemens TrioTim															
																	Feeding All	Feeding All						
	83.66667	75	92.33333333	89.22452	75	78.59631	76.33333333		81.2	75.4	87	86.76825397	75.4	78.97941	79.92833		170/170							
																		82.90196	79.07843	86.72549	86.17831	79.07843	81.8819	82.43066
																		0.480706	0.719333	0.52802	0.532025	0.719333	0.580896	0.549909
stnd dev	4.13841	5.723514715	5.04006933	4.017281	5.723515	5.012429	9.071871393		1.15669	1.67332	1.640017	2.105382344	1.67332	1.41795	1.270969									
	GE Signa HDX								GE Signa Excite															
	70.58333	77.25	63.91666667	69.43651	77.25	71.44757	68.12950267		63.63889	60.88889	66.38889	66.50092593	60.88889	62.33041	62.44048									
AD/MCI																	19 each scanner							
									1.104747	1.217161	1.699861	1.34991517	1.217161	1.07292	1.212034		but 70/70							
stnd dev	1.124441	0.762821442	2.043000385	1.651234	0.762821	1.00597	1.660986112											Feeding same number						
																		70.14286	73.7619	66.52381	70.12043	73.7619	71.16424	69.10361
	Siemens Symphony								Siemens TrioTim									1.131719	1.325511	1.93793	1.53782	1.325511	1.129892	1.349785
	76.94444	77.22222222	76.66666667	82.53889	77.22222	77.44603	73.03162228		72.9	71.06667	74.73333	73.71428571	71.06667	71.171	71.80698									
																	Feeding All	Feeding All						
																	170/170							
stnd dev	1.755306	2.159064175	3.156213843	2.365413	2.159064	1.851185	3.562240567		1.470398	2.211776	1.855715	1.604591114	2.211776	1.845969	1.693319			69.13725	71.03922	67.23529	69.87388	71.03922	69.91973	68.42105
																		0.677477	1.183381	0.693433	0.579561	1.183381	0.784808	0.671082

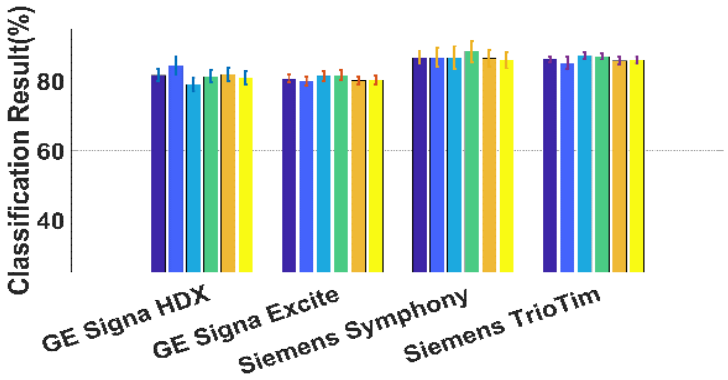
Figure: Performance result of FreeSurfer based features using ELM over four different protocols (AD/CN, AD/MCI)

Result and Discussion

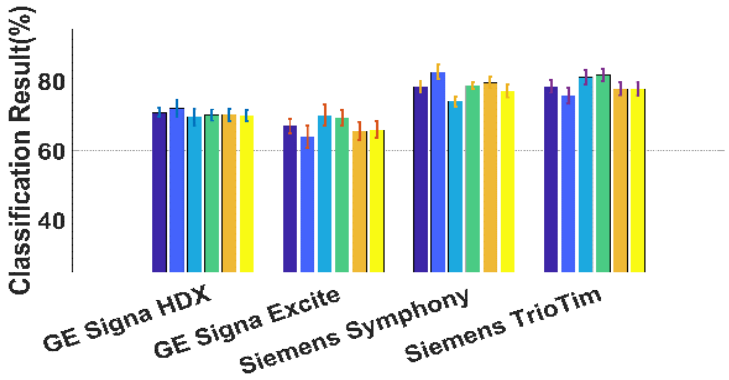
	GE Signa HDX								GE Signa Excite														
	71.95833	71.08333333	72.83333333	73.72222	71.08333	70.22328	70.02977055		69.58333	69.83333	69.33333	72.56865079	69.83333	69.51872	68.0192		19 each scanner but 70/70							
CN/MCI																		Feeding same number						
stnd dev	1.214289	1.565155789	1.940197881	1.948736	1.565156	1.181678	1.27372993		1.193653	1.769798	1.206623	1.212363632	1.769798	1.325011	1.44155			68.83333	63.09524	74.57143	73.32407	63.09524	66.16651	67.22722
																		1.236942	1.504548	1.652414	1.996569	1.504548	1.478166	1.346882
																	Feeding All 175/175	Feeding All						
																		66.04902	62.33333	69.76471	68.8187	62.33333	64.47124	65.08096
	Siemens Symphony								Siemens TrioTim															
																		0.862465	1.150664	1.162185	1.085162	1.150664	0.875399	0.830465
	62.83333	61	64.66666667	62.23514	61	63.45713	62.66666667		60	51.71429	68.28571	59.53835979	51.71429	53.36898	56.47212									
stnd dev	4.086001	4.806604652	6.288102248	5.374199	4.806605	6.24129	8.193072487		1.591674	2.034191	1.963782	2.623832796	2.034191	1.903172	1.781467									

Figure: Performance result of FreeSurfer based features using ELM over four different protocols (CN/MCI)

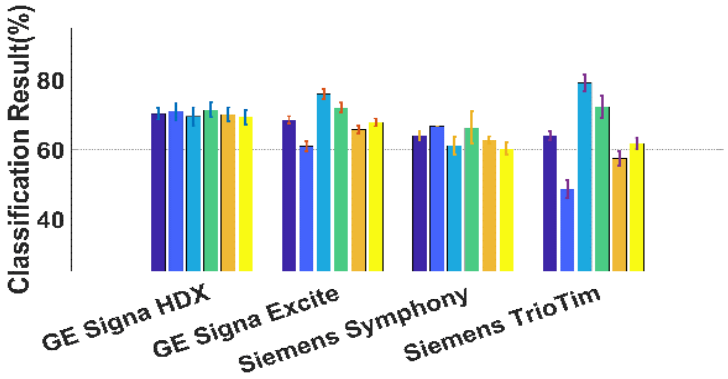
Result and Discussion



(a) AD vs CN



(b) AD vs MCI



(c) CN vs MCI

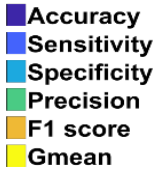
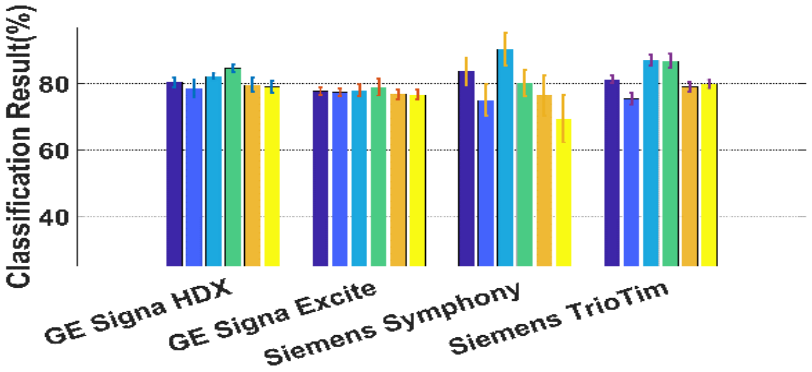
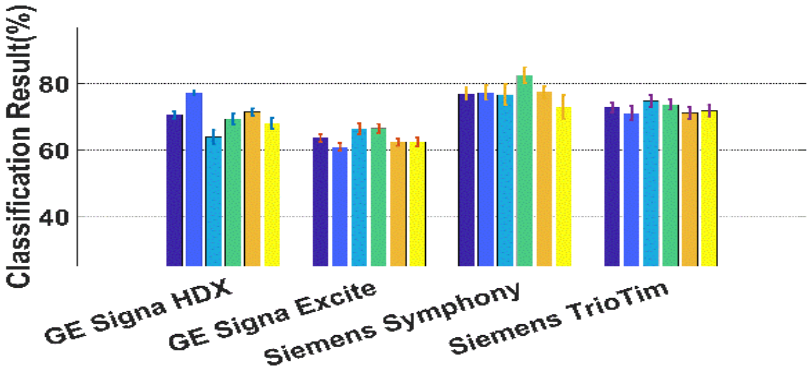


Figure: Performance result of FreeSurfer based method using RBF-SVM over four difference protocols

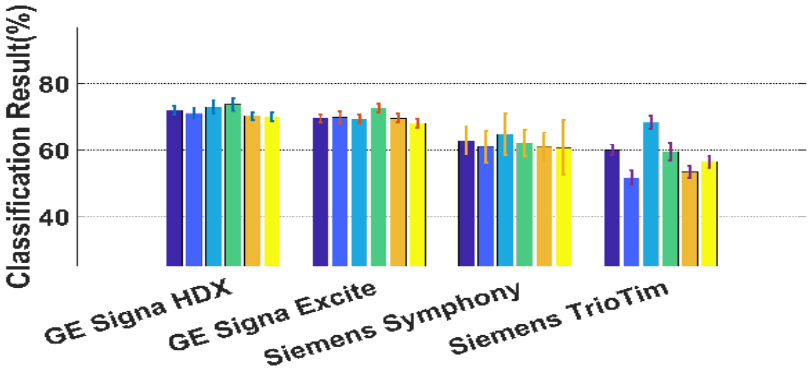
Result and Discussion



(a) AD vs CN



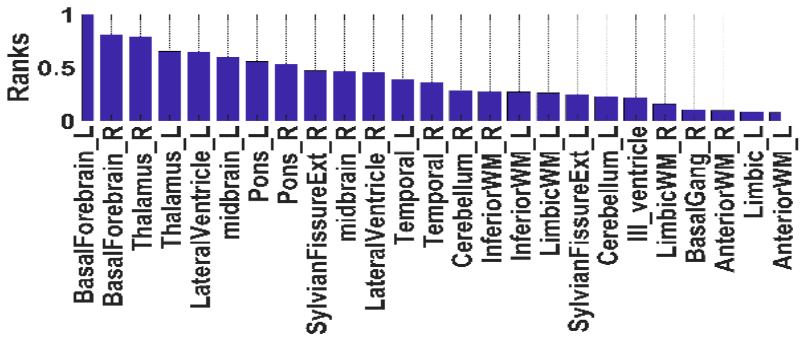
(b) AD vs MCI



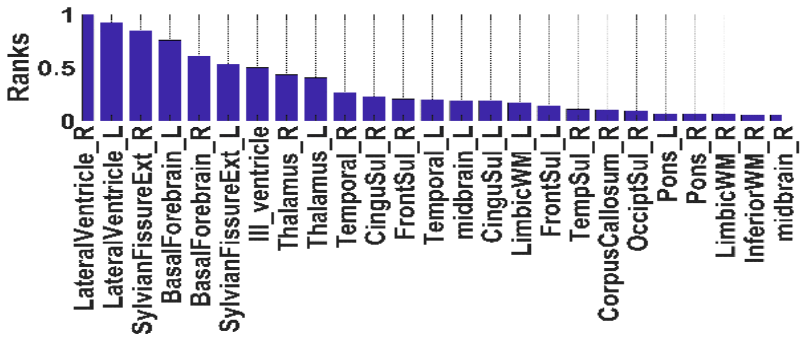
(c) CN vs MCI

Figure: Performance result of FreeSurfer based method using ELM over four difference protocols

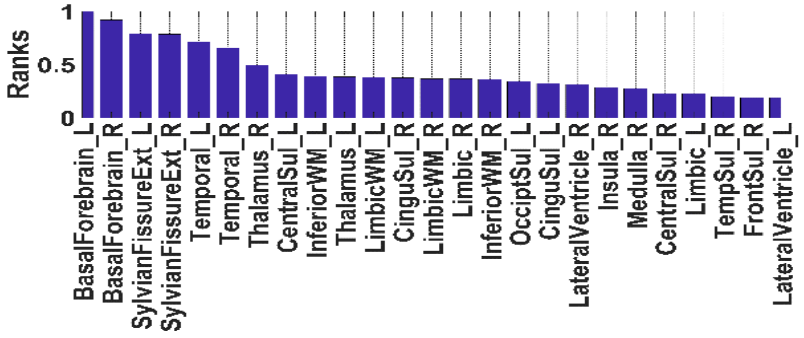
Result and Discussion



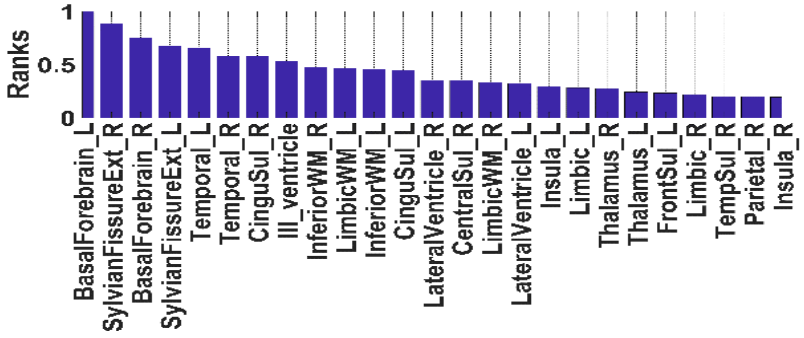
(a) Signa HDX



(b) Signa Excite



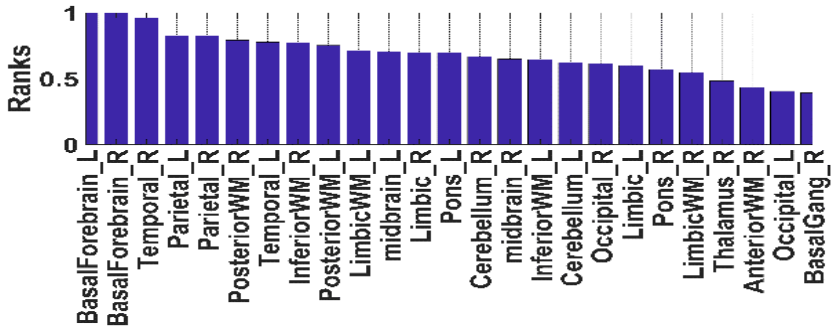
(c) Siemens Symphony



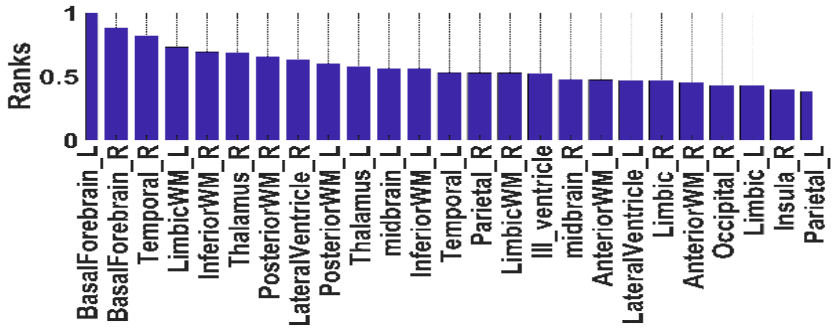
(d) Siemens TrioTim

Figure: Ranking of MALF based features at granularity level 3 while classifying AD/CN

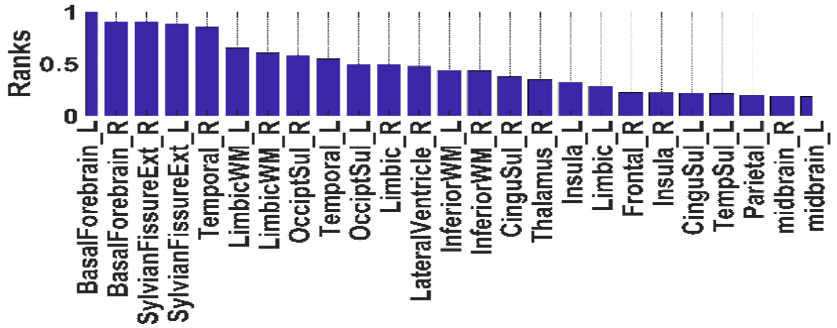
Result and Discussion



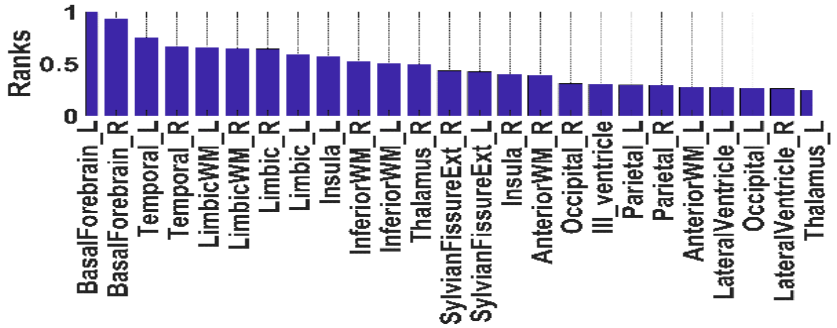
(a) Signa HDX



(b) Signa Excite



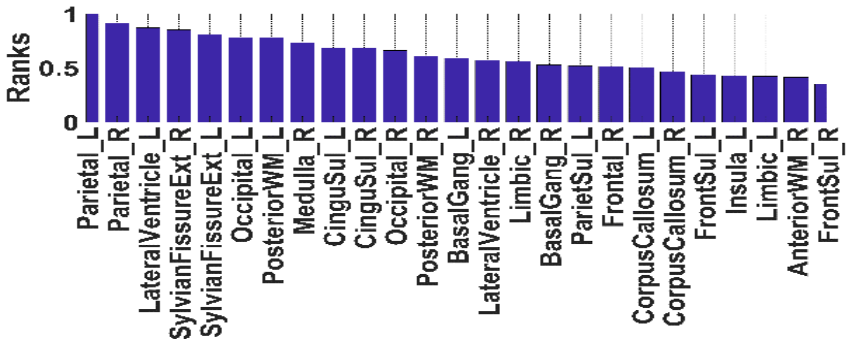
(c) Siemens Symphony



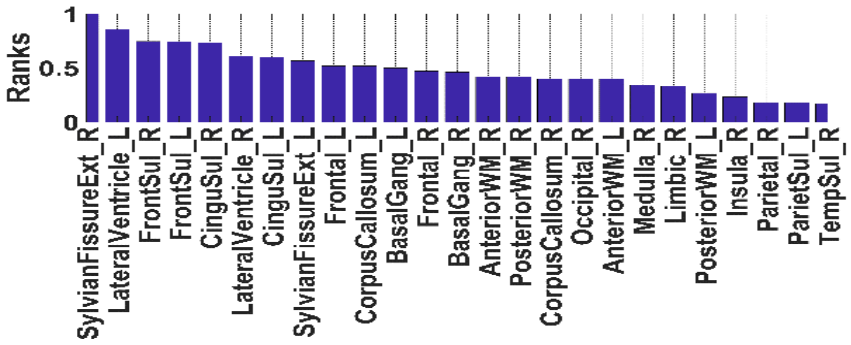
(d) Siemens TrioTim

Figure: Ranking of MALF based features at granularity level 3 while classifying AD/MCI

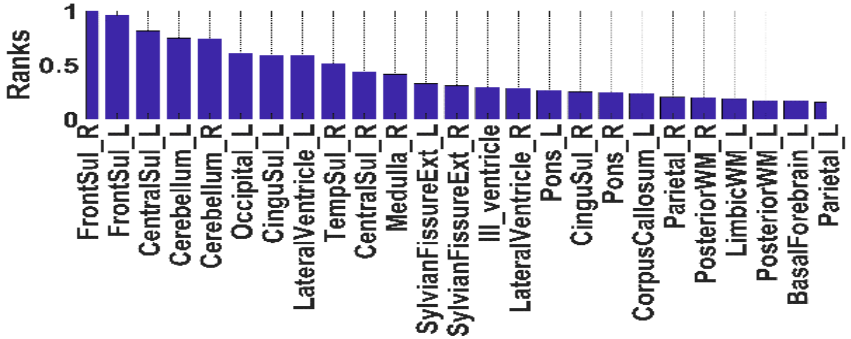
Result and Discussion



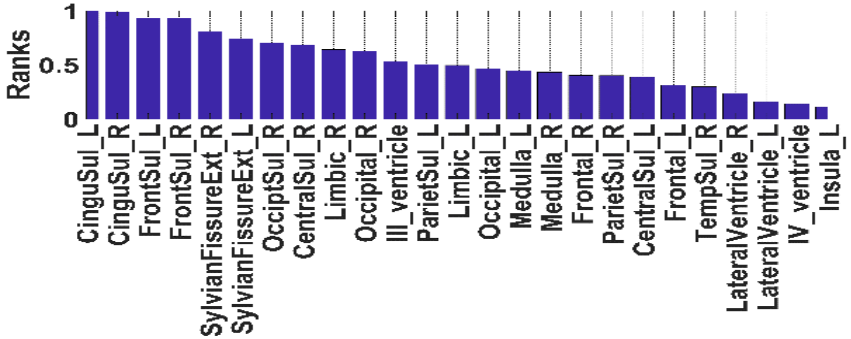
(a) Signa HDX



(b) Signa Excite



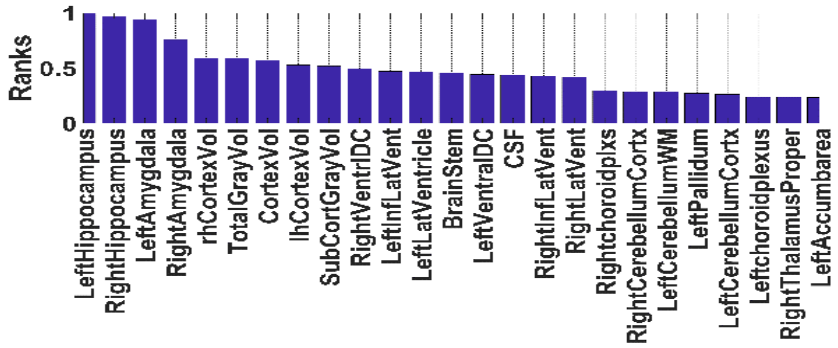
(c) Siemens Symphony



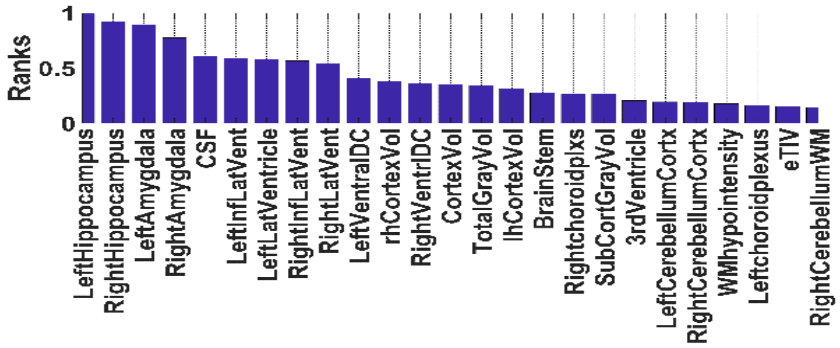
(d) Siemens TrioTim

Figure: Ranking of MALF based features at granularity level 3 while classifying CN/MCI

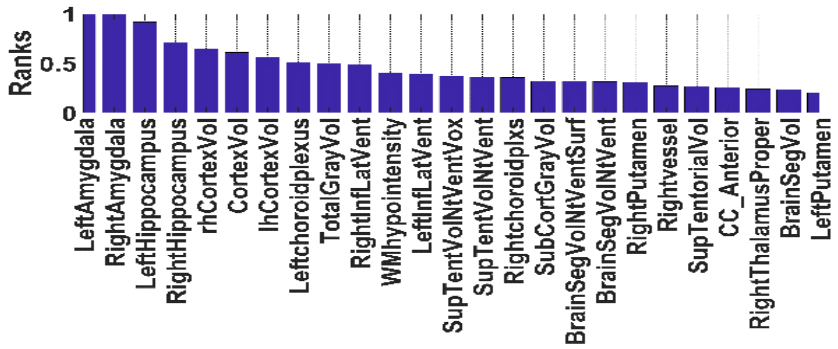
Result and Discussion



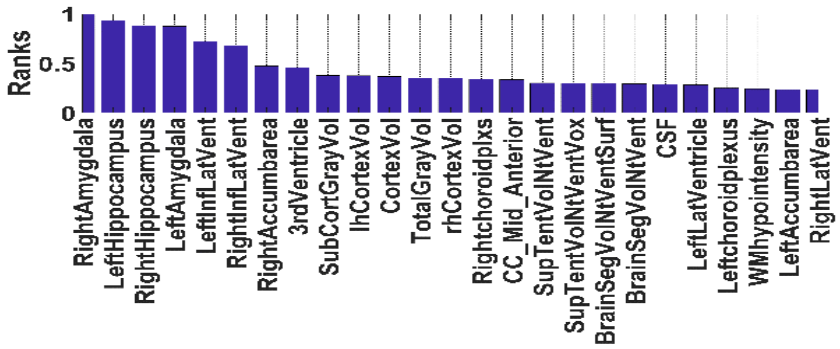
(a) Signa HDX



(b) Signa Excite



(c) Siemens Symphony



(d) Siemens TrioTim

Figure: Ranking of FreeSurfer based features while classifying AD/CN

Result and Discussion

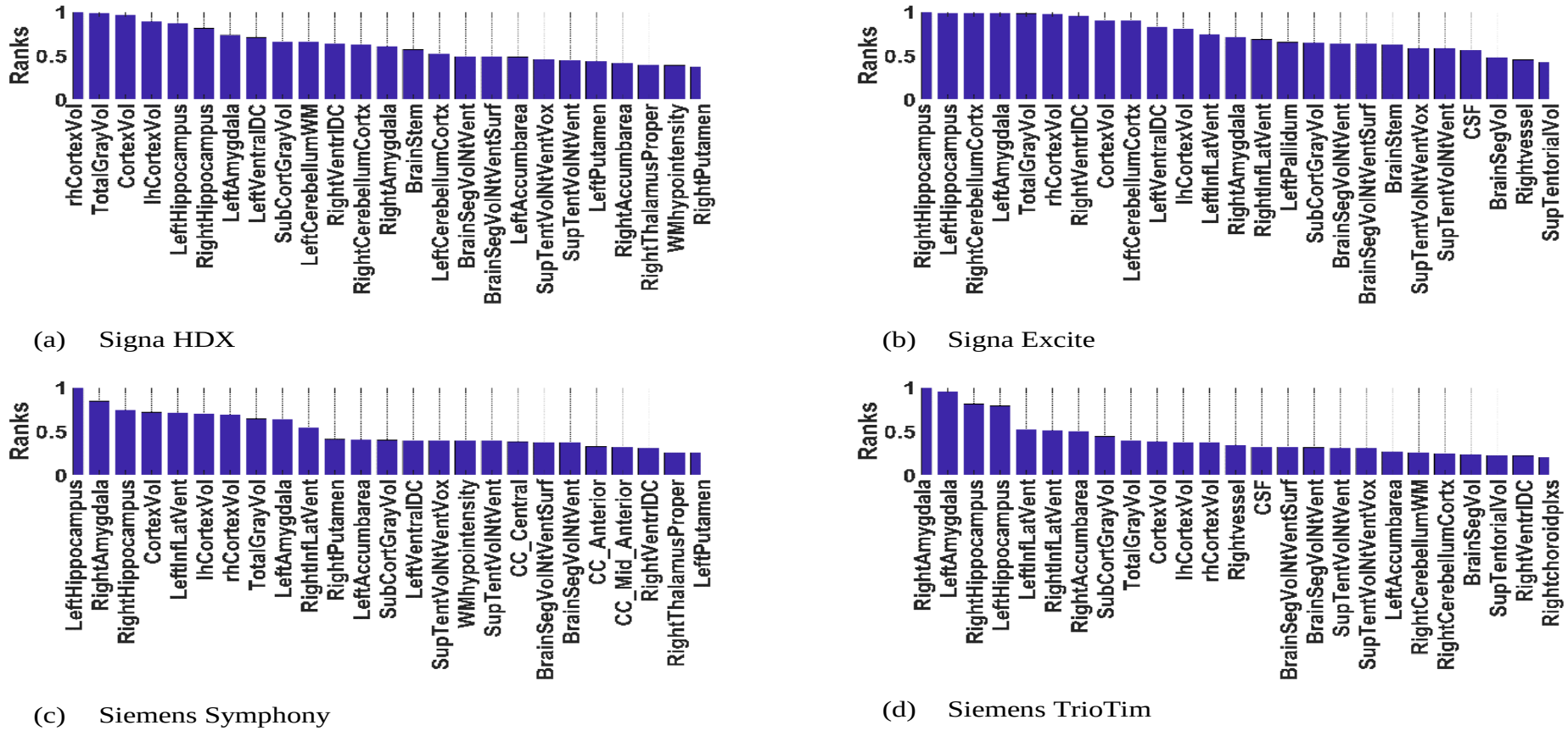
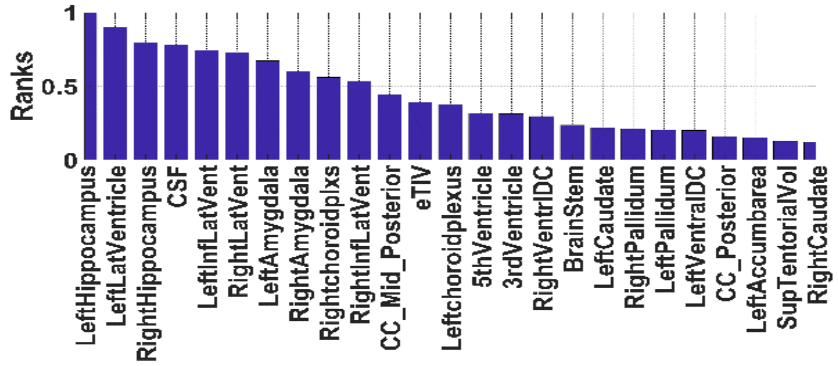
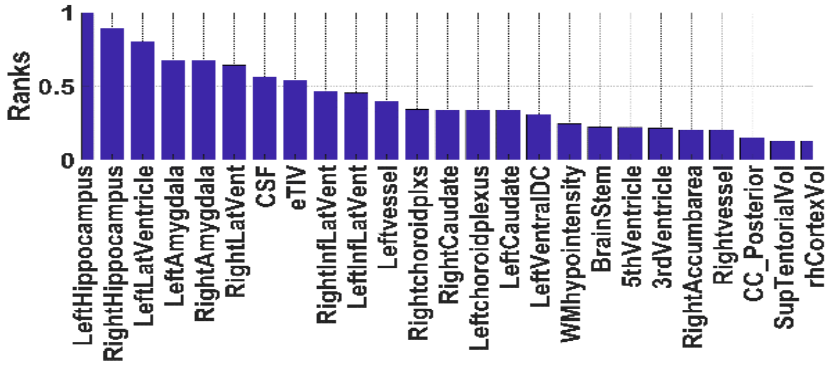


Figure: Ranking of FreeSurfer based features while classifying AD/MCI

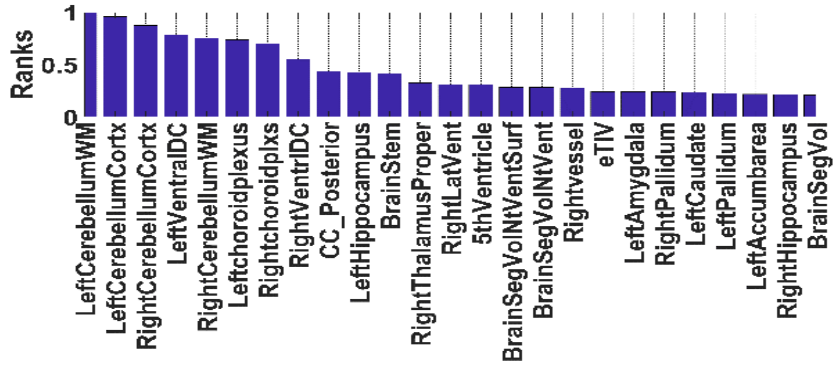
Result and Discussion



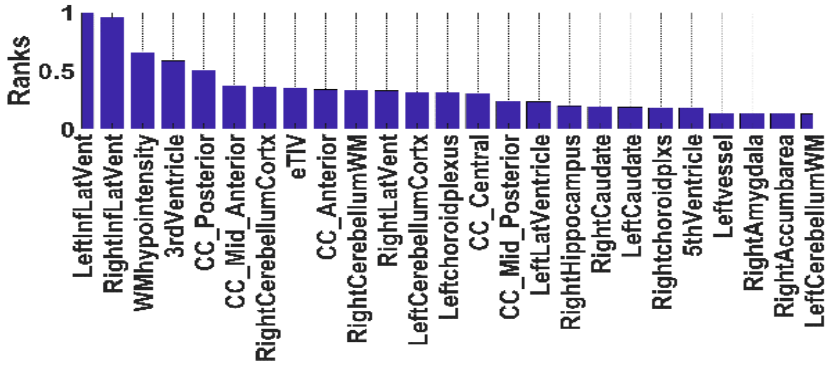
(a) Signa HDX



(b) Signa Excite



(c) Siemens Symphony



(d) Siemens TrioTim

Figure: Ranking of FreeSurfer based features while classifying CN/MCI

Conclusion

- Higher granularity level provides better classification performance across the protocols
- TrioTim performs better for AD/MCI
- No superiority of one classifier over the other.
- Classification performance varies across four different protocols
- Ranking order of different brain structures/regions varies across different protocols

MACQUARIE University

Thank You!

Question & Answer