JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

Quantification of white matter hyperintensities based on diffusion tensor imaging and support vector machine

L. Zheng[1], R. Gao[2], W. Lu[1], L. Shi[1], W. Lu[1], J. Qiu[1]
1Shandong First Medical University & Shandong Academy of Medical Sciences, Tai'an, Shandong, China
2Shandong University Of Science And Technology, Qingdao, Shandong, China

INTRODUCTION

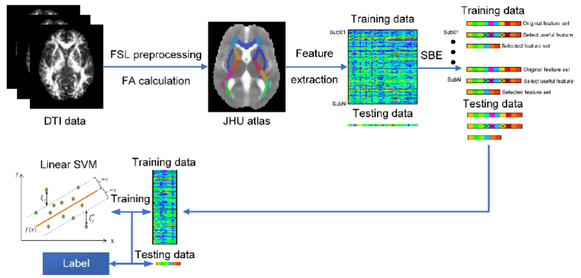
Clinical quantification of white matter hyperintensities (WMHs) is based on the Fazekas scale on T2-weighted MRI images[1]. Fractional anisotropy (FA) calculated from diffusion tensor imaging (DTI) was widely used to assess white matter lesions[2,3].

AIM

It is hypothesized that FA associated with machine learning algorithm such as support vector machine (SVM) could be used for WMHs quantification.

METHOD

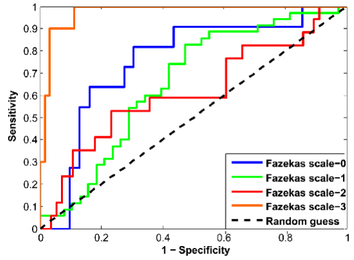
Subjects with WMHs were collected which included 11 Fazekas scale-0 subjects, 35 Fazekas scale-1 subjects, 17 Fazekas scale-2 subjects and 10 Fazekas scale-3 subjects. DTI images were acquired from the enrolled subjects and processed by FSL[4]. FA maps were calculated from DTI image for each subject, and segmented by Johns Hopkins University (JHU) white matter atlas[5]. Mean FA value of each white matter region was extracted and taken as feature for machine learning. The FA features were normalized to a range from 0 to 1. A quaternary label for subjects with different Fazekas scales was defined. Sequential backward elimination was used for feature selection. A linear support vector machine was configured to quantify WMHs and leave-one-out-cross-validation was applied for performance evaluation. Accuracy, sensitivity, specificity and receiver operating characteristics curve were used as evaluating metrics.



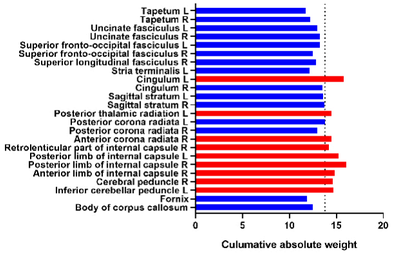
The framework of this study.

RESULTS

24 FA features were selected by sequential feature selection approach. The linear SVM achieved a total accuracy of 84.2105% via the selected features. Quantification accuracies for Fazekas scale 0-3 subjects were 84.2105%, 65.7895%, 77.6316% and 93.4211%, respectively. The white matter regions contributed most to the quantification were the left inferior cerebellar peduncle, right cerebral peduncle, right anterior limb of internal capsule, bilateral posterior limb of internal capsule, right retrolenticular part of internal capsule, right anterior corona radiata, left posterior thalamic radiation and left cingulum.



Receiver operating characteristic curves of the proposed linear SVM classifier.



Twenty-four white matter regions after feature selection and white matter regions contributed most to the prediction (marked in red). L and R represent left and right.

Subject type	Accuracy	Sensitivity	Specificity	AUC	*p*
Fazekas scale-0	84.2105%	0.8182	0.6935	0.7537	0.003
Fazekas scale-1	65.7895%	0.8286	0.5263	0.6549	0.009
Fazekas scale-2	77.6316%	0.5294	0.7679	0.6124	0.075
Fazekas scale-3	93.4211%	1	0.8889	0.9746	<0.001

Quantification result for WMHs subjects with different Fazekas scales.

CONCLUSIONS

Clinical quantification of white matter hyperintensities (WMHs) was based on Fazekas scale calculated from T2 FLAIR images[1]. The quantification process is time-consuming and is depended on doctor's experience. Fractional anisotropy (FA) has been widely used to assess white matter damages. So, the innovation of this study was to develop an automatic quantification approach using FA and machine learning. The results demonstrated that DTI images and machine learning could be used to accurately quantify WMHs levels. Several white matter regions could be used as biomarkers for clinical quantification of WMHs.

REFERENCES

1 **Wahlund L-O**, **Barkhof F**, **Fazekas F**, **et al**. A New Rating Scale for Age-Related White Matter Changes Applicable to MRI and CT. *Stroke 2001; 32: 1318-1322*.
2 **Thomas B**, **Eyssen M**, **Peeters R**, **et al**. Quantitative diffusion tensor imaging in cerebral palsy due to periventricular white matter injury. *Brain 2005; 128: 2562-2577*.
3 **Shon Y-M**, **Kim Y-I**, **Koo B-B**, **et al**. Group-specific regional white matter abnormality revealed in diffusion tensor imaging of medial temporal lobe epilepsy without hippocampal sclerosis. *Epilepsia 2010; 51: 529-535*.
4 **Smith S-M**, **Jenkinson M**, **Woolrich M-W**, **et al**. Advances in functional and structural MR image analysis and implementation as FSL. *NeuroImage 2004; 23: 208-219*.
5 **Oishi K**, **Zilles K**, **Amunts K**, **et al**. Human brain white matter atlas: identification and assignment of common anatomical structures in superficial white matter. *NeuroImage 2008; 43: 447-457*.
6 **Chang C-C**, **Lin C-J**. LIBSVM: a library for support vector machines. *ACM T Intel Syst Tec 2011; 2: 27*.

ACKNOWLEDGEMENTS

This work was supported by the Key Research and Development Program of Shandong Province (2017GGX201010), Academic Promotion Programme of Shandong First Medical University (2019QL009), Traditional Chinese Medicine Science and Technology Development Plan of Shandong Province (2019-0359), and Taishan Scholars Program of Shandong Province (TS201712065).

CONTACT INFORMATION

Weizhao Lu

No. 619 Changcheng Road, Taian, Shandong Province, China, 271016

Phone: +8615621521980

E-Mail: mingming9053@163.com