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Diagnosis of Autism Spectrum Disorder (ASD) using Principal Component Analysis (PCA)

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Abstract— **Diagnosis of autism spectrum disorder is still challenging disorder due to unsolved issues arising from many severity levels and range of signs and symptoms. The Structural Magnetic Resonance Imaging (sMRI) scan is used in this study were obtained from the Autism Brain Imaging Data Exchange (ABIDE) dataset. The preprocessing step is carried out using Statistical Parametric Mapping (SPM) where the realignment and normalization process are done to ignore all the voxels that lie outside the brain. After normalization, the extracted part of the brain is used as input for the principal component analysis (PCA) algorithms. It decreases the computation to the solution for a positive semi definite symmetric matrix of an eigenvalue-eigenvector problem. The PCA coefficients are used by Support Vector Machine to classify the autistic and normal brains. The predicted results of the implemented algorithm are assessed using 10 fold method for cross validations. PCA for ASD is suitable to analyze its performance in the diagnosis of ASD. The experimental results show that the correct rate of classification for autistic and control sMRI scans is 70.90%.**

Keywords— Autism Spectrum Disorders, Principal Component Analysis, Structural Magnetic Resonance Imaging, SVM, PCA.

I. INTRODUCTION

Autism was first defined by, Leo Kanner, a psychiatrist at Johns Hopkins University, in 1943. Autism spectrum disorders (ASDs) impact one out of every 100 children new born today. Autism is an extremely variable neurodevelopment disorder that first develops during infancy or childhood, with strong genetic underpinnings and generally follows a constant course without exemption [1]. The field of medical image analysis has developed gradually due to the collective contributions from many areas of medicine, computer science, biomedical, computer vision, virtual reality, robotics , mathematics, electrical engineering, physics, and data science. Standard user-interface, researchers at remote sites, computer assisted intelligent medical image analysis methods can provide effective analysis tools to help the quantitative and qualitative clarification of medical images for differential diagnosis, intervention, monitoring and treatment of medical disorders. Neuroimaging is the use of various techniques to either directly or indirectly image the structure, function/pharmacology of the nervous system. There are various categories of neuroimages such as structural magnetic resonance imaging (sMRI), functional connectivity MRI (fcMRI), resting state functional MRI (rs-fMRI), magnetic resonance spectroscopy (MRS) and diffusion tensor imaging (DTI), positron emission tomography (PET) and single photon emission tomography (SPECT). The rest of this paper is organized as follows: Section II describes the recent work carried out in the area of diagnosis of autism. Section III describes the experimental results obtained using PCA for diagnosis of autism. Section IV gives the conclusion.

II. RELATED WORKS

Ecker et al [4] suggested that gray matter volume was highly correlated with ASD using Partial least-squares (PLS) analysis. This pattern also identified an additional set of network components such, as the cerebellum; and dorsolateral, orbital, and ventral medial prefrontal cortex, and limbic regions, such as the cingulated cortex and amygdale are associated with autism. They also found that ASD is compatible with the concept of autism as a brain disconnectivity/underconnectivity syndrome and associated with distributed abnormalities of both gray matter and white matter volume in cortical and subcortical systems.

Mcalonan et al [13] found that the anatomy of brain systems within, core prefrontal–striato-parietal grey matter abnormalities in autism may be replicable in age-matched and intellectually able groups, using automated voxel-based whole brain analysis methods. They also considered correlation analysis revealed significantly more numerous and more positive grey matter volumetric correlations in controls compared with children with autism.

Rojas et al [7] observed that there is gray matter enlargement in areas that have been functionally identified such as the medial frontal gyri, sensorimotor cortex and middle temporal gyrus. Voxel-wise analyses of regional gray matter volume were conducted using voxel-based morphometry (VBM) for the whole brain. An ANCOVA model was employed with two covariates, to examine differences in regional GM volume between groups, total GM volume and age.

Itahashi et al [8] suggested the possibility that such morphological alterations might arise in specific brain networks connected with cognitive and affective functions and employed the multimodal study that highlighted people with ASD showed co-occurred alterations in different aspects of brain morphology.

Cheng et al [6] applied a 2D version of voxel-based morphometry (VBM) in differentiating the white matter concentration of the corpus callosum for the group of 16 high functioning autistic and 12 normal subjects. It is revealed that in the corpus callosum region in autism there is less white matter concentration that is mainly due to hypoplasia rather than atrophy.

Waiter et al [23] found that local white matter deficits in corpus callosum which are mainly in the anterior splenium and isthmus, and right hemisphere. The whole brain analysis, were ca
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C. Feature extraction based on PCA

The main purpose of principal component analysis (PCA) is to decrease the dimensionality of a data set consisting of a large number of consistent variables, while retaining the variation present in the data set [2]. In this work, PCA algorithm is implemented to the preprocessed images which can help to extract the features. An orthonormal basis vector that maximizes the scatter of all the projected samples is generated by PCA. The remaining voxels for each subject are rearranged into a vector form, after the preprocessing steps. It

TABLE I. REVIEW OF RESEARCH CARRIED OUT ON ASD USING sMRI

Study	Datasets	Preprocessing tool	Statistical Analysis tool or method	Features extracted	Findings
Eilam stock et al 2016 [11]	ABIDE datasets of 1000 participants	VBM, SPM8	SVM-multi variate classification	Whole brain	Increased GM volume in frontal brain regions, including the medial prefrontal cortex, superior and inferior frontal gyri, and middle temporal gyrus in individuals with ASD
Edoardo Pappaianni et al 2016 [12]	From ABIDE datasets 43 male with ASD and 46 male with healthy control are selected	SBM, SPM12	ICA	Cerebellam region	Abnormalities in temporal, frontal, and parietal networks of several cerebellar regions and the Fusiform Gyrus.
Vigneshwaran Subbaraju et al 2015 [5]	ABIDE datasets	VBM	SVM- Extended Metacognitive Radial Basis Function Neural Classifier (EMcRBFN)	Whole brain	Premotor cortex, supplementary motor cortex area omatosensory and cortex subregion affected for females. The precentralgyrus, motorcortex, medial frontal gyrus the paracentrallobule, the superior frontal gyrus and the frontal areas are affected for adolescent males
Rajesh K.Kana et al 2015 [19]	1055 participant, 506 ASD, 549 typically developing individual	VBM	ALE- meta analysis	GM, WM, CSF & cortical matter	Abnormalities in GM & WM
Julia Richter et al 2015 [15]	18 right handed children	FreeSurfer	ANCOVA	Frontal, Temporal and Parital gyrus,	Reduced cortical thickness
Alessandra Retico et al 2014 [9]	52 male ASD subject and 15 matched control	VBM, SPM, FSL	Machine Learning based on SVM	Whole Brain	Identification of a peculiar pattern of brain alternation
Lauren. E Libero et al 2014 [16]	60 individuals with ASD and 61 healthy individuals	Freesurfer	SBM	Cortical structural region	Increase in difference in (SA), volume (CV) and gyrification
C. Ecker et al 2014 [21]	Totally 168 men, among them 84 with ASD and 84 are healthy control	Freesurfer	SurfStat toolbox	Cortical structural features CV, CT, SA	Signifance different in CV
Lena Lim et al 2013 [17]	29 age-matched healthy and 19 boys with ASD	VBM	SVM- Gaussian process classification (GPC)	GM, WM and CSF	The pattern recognition analysis is based on distributed GM patterns
Hazlett et al 2012 [10]	134 infants, 98 of high risk and 36 of low risk	AutoSeg, HeadCirc	ANOVA	Whole brain volume	Decreased Cerebrum, cerebellam and lateral ventricles
C.Ecker et al 2009 [21]	22 control adults & 22 with ASD	SPM5	SVM, LibSVM, SVMRef	GM, WM and CSF	Abnormalities in GM, and WM
Sarah Brieber et al 2007 [22]	15 children of ASD and 15 healthy control	SPM, VBM	Analysis of covariance (ANCOVA)	GM, WM and CSF	Abnormalities in GM near the right temporo-parietal

Additional abbreviation: VBM , voxel based morphmetry; SPM, statistical parametric mapping; SVM , support vector machine; LibSVM, ; SVMRef, SVM recursive feature elimination; SBM , source based morphmetry; ANOCA, analysis of covariance; ANOVA, analysis of variances; ICA, independent component analysis; ALE, anatomical likelihood estimation; GM, grey matter; WM, white matter; CSF, cerebrospinal fluid; CV, cortical volume; SA, surface area; CT, cortical thickness;

TABLE I. REVIEW OF RESEARCH CARRIED OUT ON ASD USING SMRI

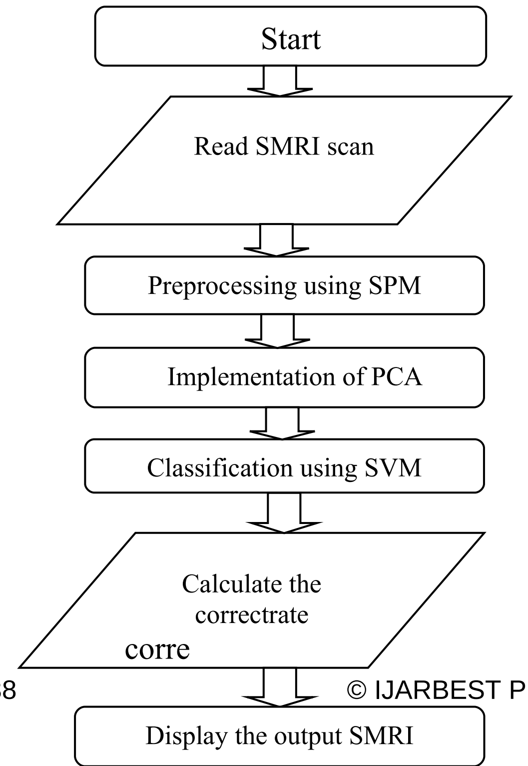

Fig 1 Steps in classifying autistic and healthy brain images using PCA

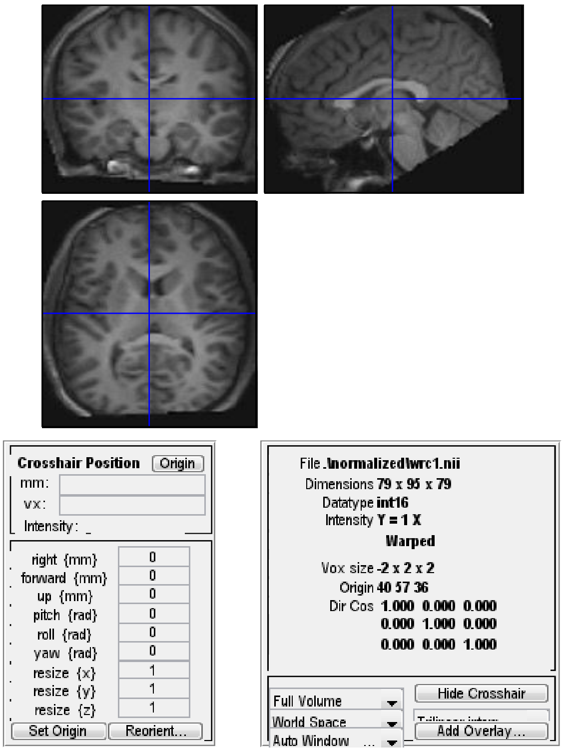

Fig 2(a) sMRI images of autistic brain

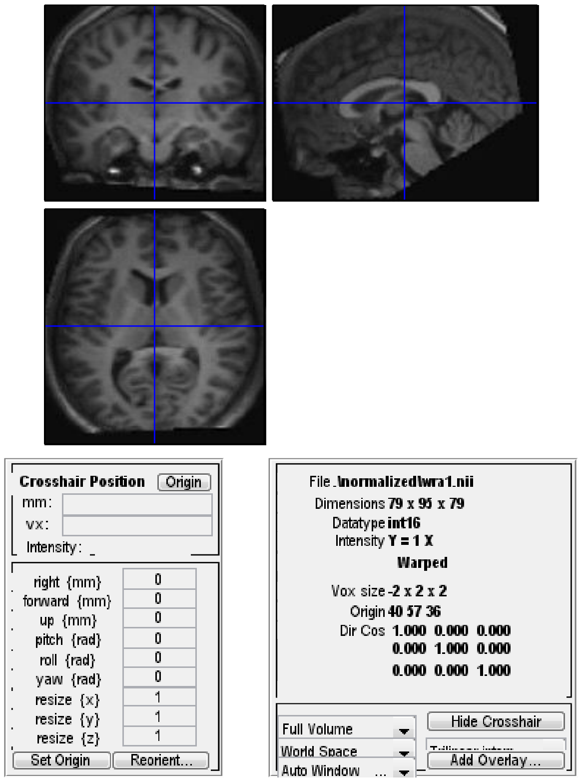

Fig 2(b) sMRI images of healthy brain

IV. CONCLUSIONS

This paper presented a review of recent work carried out for diagnosis of autism using sMRI. The examination of anatomical image using whole brain classification approach is done by employing SVM for ASD. PCA, which is implemented in this work is well suitable, to analyze its performance in the diagnosis of ASD.

REFERENCES

[1] Kanner L., 'Autistic disturbances of affective contact', Nervous Child, 1943, 2:217–250.

[2] I. T. Jolliffe, "Principal Component Analysis, Second Edition."

[3] Mourão-Miranda J, Bokde AL, Born C, et al (2005). "Classifying brain states and determining the discriminating activation patterns: Support Vector Machine on functional MRI data". Neuroimage 28: 980-995.

[4] Magnetic. A. M. and Imaging. R, "Brain Anatomy and Its Relationship to Behavior in Adults With Autism Spectrum Disorder," vol. 69, no. 2, pp. 195–209, 2016.

[5] Subbaraju. V, Sundaram. S, Narasimhan.R, and Suresh. M. B, "Accurate detection of autism spectrum disorder from structural MRI using extended metacognitive radial basis function network," Expert Syst. Appl., vol. 42, no. 22, pp. 8775–8790, 2015.

[6] Chung. M. K., Dalton. K. M., Alexander. A. L., and Davidson. R. J., "Less white matter concentration in autism : 2D voxel-based morphometry," vol. i, pp. 242–251, 2004.

[7] Rojas D. C, Peterson.E., Winterrowd .E., Reite M. L, Rogers. S. J, and Tregellas.J. R, "Regional gray matter volumetric changes in autism associated with social and repetitive behavior symptoms," vol. 13, pp. 1–13, 2006.

[8] Itahashi. T, Yamada. T, Nakamura. M, Watanabe. H, Yamagata. B, and Jimbo. D, "NeuroImage : Clinical Linked alterations in gray and white

matter morphology in adults with high-functioning autism spectrum disorder : A multimodal brain imaging study," YNICL, vol. 7, pp. 155–169, 2015.
[9] Retico, Michela Tosetti, Filippo Muratori, Sara Calderoni, "Neuroimaging-based methods for autism identification: a possible translational application?" Functional Neurology 2014; 29(4): 231-239
[10] Heather Cody Hazlet, Hongbin Gu, Robert C. McKinstry, Dennis W.W. Shaw, Kelly N. Botteron, Stephen Dager, Martin Styner, Clement Vachet, Guido Gerig, Sarah Paterson, Robert T. Schultz, Annette M. Estes, Alan C. Evans, Joseph Piven, "Brain Volume Findings in Six 608.doi:10.1176/appi.ajp.2012.11091425.
[11] Fan. J, Eilam-stock. T, Wu .T, Spagna.A, and L. J. Egan. L. J, "Neuroanatomical Alterations in High- Functioning Adults with Autism Spectrum Disorder Neuroanatomical Alterations in High-Functioning Adults with Autism Spectrum Disorder," no. July, 2016.
[12] Pappaianni. E, Siugzdaite R., and Grecucci. A, "An Abnormal Cerebellar Network in Children with Autistic Spectrum Disorder : A Morphometric Study," vol. 6, no. 3, 2016.
[13] Mcalonan G. M, Daly. Kumari. E, V, Critchley. H. D, Van Amelsvoort. T, Suckling.J, Simmons. A, Sigmundsson. T, Greenwood. K, Russell.A, Schmitz. N, Happe. F, Howlin. P, and Murphy. D. G. M, "Brain anatomy and sensorimotor gating in Asperger ' s syndrome," pp. 1594–1606, 2002.
[14] Retico A, Giuliano .A, Tancredi R, Cosenza. A, Apicella. F, Narzisi. A, Biagi. L, Tosetti. M, Muratori. F, and Calderoni. S, "The effect of gender on the neuroanatomy of children with autism spectrum disorders : a support vector machine case-control study," Mol. Autism, pp. 1–20, 2016.
[15] Richter. J, Henze. R, Vomstein. K, Stieltjes. B, Parzer. P, Haffner. J, Brndeis. D, and Poustka. L, "Psychiatry Research : Neuroimaging Reduced cortical thickness and its association with social reactivity in children with autism spectrum disorder," Psychiatry Res. Neuroimaging, vol. 234, no. 1, pp. 15–24, 2015.
[16] Libero. L. E , Deramus. T. P, Deshpande. H. D, and Kana. R. K, "Neuropsychologia Surface-based morphometry of the cortical architecture of autism spectrum disorders : volume , thickness , area , and gyri fi cation," Neuropsychologia, vol. 62, pp. 1–10, 2014.
[17] Lim. L, Marquand. A, Cubillo. A. A, Smith. A. B, Chantiluke. K, Simmons. A, Mehta. M, and Rubia K, "Disorder-Specific Predictive Classification of Adolescents with Attention Deficit Hyperactivity Disorder (ADHD) Relative to Autism Using Structural Magnetic Resonance Imaging," vol. 8, no. 5, pp. 1–10, 2013.
[18] Shen. M. D, Nordahl. C. W, Young. G. S., Wootton-gorges. S. L, Lee. A., Liston. S. E, Harrington. K. R, Ozonoff. S, and. Amaral. D. G, "fluid in infants who develop autism spectrum disorder," 2013.
[19] Deramus T. P. and Kana. R. K, "NeuroImage : Clinical Anatomical likelihood estimation meta-analysis of grey and white matter anomalies in autism spectrum disorders," YNICL, vol. 7, pp. 525–536, 2015.
[20] Ashburner. J, "Computational anatomy with the SPM software," Magn. Reson. Imaging, vol. 27, no. 8, pp. 1163–1174, 2009.
[21] Ecker. C, Daly. E, Brammer.X , and Murphy. C. M, "Investigating the predictive value of whole- brain structural MR scans in autism : A pattern classification approach," no. September 2009, 2016.
[22] Neufang. S, Brieber. S, Neufang. S, Bruning. N, Kamp-becker. I, Remschmidt. H, Herpertz-dahlmann. B, and Fink. G. R., "Structural brain abnormalities in adolescents with autism spectrum disorder and patients with attention deficit / hyperactivity disorder Structural brain abnormalities in adolescents with autism spectrum disorder and patients with attention deficit / hyperactivity disorder," no. January, 2008.
23] Gordon D. Waiter, Justin H.G. Williams, Alison D. Murray, Anne Gilchrist, David I. Perrett, Andrew Whiten, "Structural white matter deficits in high-functioning individuals with autistic spectrum disorder: a voxel-based investigation" NeuroImage, Volume 24, Issue 2, 15 January 2005, Pages 455-461
[24] Hazlett.H. C, Poe. M, Gerig. G., and Smith. R.G, "Magnetic Resonance Imaging and Head Circumference Study of Brain Size in Autism," vol. 62, 2016.

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