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Machine Learning for Detection and Classification of Fetal Brain Abnormalities: A Review

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Abstract: Machine learning is an powerful tool that allow the computers to learn automatically without human assistance. It can be applied for medical images to help physicians in rendering medical diagnoses. Since human brain is one of the most complex and sophisticated organ in human body, study of it's structure, function and disease is important. The development of the brain begins at the first few weeks after conception. Brain development is adversely affected by preterm birth. As approximately 3 in 1000 women are pregnant with a fetal of abnormal brain, detecting and classifying fetal brain abnormalities is important. Machine learning is a very good approach and can be used for early detection of fetal brain abnormalities, thus we can improve the quality of diagnosis and treatment planning. I present an detailed review of machine learning techniques applied for the detection and classification of fetal brain abnormalities.

Keywords: Fetal brain, Machine learning, Random forest classifier, SVM

I. INTRODUCTION

Machine learning is a well-known field in engineering and computer science. To perform a particular task without using direct instructions, machine learning relying on patterns. It is a class of artificial intelligence. In order to make predictions and decisions, Machine learning algorithms build a mathematical model based on training data. Machine learning is closely related to computational statistics, which focuses on making predictions using computers. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

In order to look for patterns in data and make better decisions in the future based on the examples that we provide, process of learning begins with observations or data, such as examples, direct experience, or instruction. The main aim is to allow the computers learn automatically without human intervention and adjust actions accordingly. It is a great tool used in pattern recognition and image processing. It can be applied for medical images to help physicians in rendering medical diagnoses. Also, it prevents human based diagnostic error and the effort during an examination. It is can be used as well for fetal brain MRI images for early detection of abnormalities, diagnosis and classification of certain diseases. Scanning fetal brain is essential, because approximately 3 in 1000 pregnancies have fetuses with different types of abnormal brain. Early detection of the fetal brain abnormalities will indicate how the pregnancy will be managed, possible treatments that can be taken, help parents understand and be prepared for dealing with the abnormality. Moreover, early discovery of these abnormalities can improve the quality of diagnosis and follow up planning.

Most of the work that used fetal brain images focused on segmenting fetal brain images to detect abnormalities or separating the fetal brain from the rest of the body. Some of the studies considered the use of machine learning methods to identify abnormalities existing in the fetal brains. This paper presents review on various machine learning techniques used for detection and classification of fetal brain abnormalities.

II. METHODOLOGY

Detection and classification of fetal brain abnormalities is very important because many of the fetuses are born with abnormal brain, which will lead to major brain diseases. Few published works have addressed detection of fetal brain abnormalities in different ways and used different image modalities like magnetic resonance imaging, ultrasonic etc. magnetic resonance imaging (MRI) has recently emerged as an essential tool in the study of the developing human brain. However, automatic brain extraction and orientation is not yet solved, but remains challenging in wide field of view raw fetal MRI volumes. This has limited research to small scale studies. [1] presented an automatic fetal brain extraction and orientation framework to remove this limitation. A two-phase random forest classifier, and an approximate high-order Markov random field solution is used to results in a brain mask for an MRI stack. To represses the influence of maternal tissues and provides likely positions of tissue centroids inside the brain, a two-phase Random forest classifier is processed. An approximation of a high-order MRF finds the optimal selection of landmarks and these landmarks along with a confidence weighted probability map provide an estimate of the center of and ROI around the brain.

Ultrasound imaging is a one of the modality to study fetal growth. Ultrasound (US) imaging is low cost, radiation free and real-time. Identification of fetal brain structures is an essential part of basic prenatal screening for abnormalities [2]. It is necessary to estimate fetal head circumference, which is used in dating pregnancies beyond 14 weeks. Hence to locate four local fetal brain structures in 3D ultrasound images, a technique is proposed in [3]. The technique is based on a discriminative model (Random Forests), a general machine learning framework gaining popularity in biomedical image, because of its power to embbed simple constraints on image interpretation. A classifier is constructed to classify voxels to five classes; background, Choroid Plexus (CP), Posterior Ventricle Cavity (PVC), Cavum Septum Pellucidum (CSP) and Cerebellum (CER).

Autism spectrum disorder (ASD) is a disabilitiy that cause life-long cognitive impairment and social, communication and behavioral challenges. For improving the life quality of autistic patients, early diagnosis and medical intervention are important. Yan jin et al. [4] demonstrated the feasibility of using machine learning techniques for identifying high-risk ASD infants at an early stage. Observation like ASD-induced abnormalities in white matter tracts and whole brain connectivity have already started to appear within 24 months after birth is used for the identification of high risk ASD infants. In particular, by using the connectivity features gathered from WM connectivity networks, which are generated via multiple diffusion statistics such as mean diffusivity, fractional anisotropy and average fiber length and multiscale regions of interest, they suggested a novel multikernel support vector machine classification framework.

Advanced statistical, computational and pattern recognition technologies that evaluate multiple variables/measurements simultaneously are Multivariate analysis (MVA) techniques (i.e. multivariate analysis of variance, multivariate regression, , machine learning etc.). To provide a theoretical improvement over traditional univariate techniques which examine each acquired measurement individually, MVA technologies is used. MVA techniques [5] can be employed to discover what physiological/anatomical measurements and what brain regions best help characterize different types of neurodevelopmental disorders. Furthermore, extremely important challenges in clinical pediatric neuroimaging, an area in which MVA technologies are capable of assisting are reliably predicting disease onset, detecting and diagnosing disease and monitoring treatment response. To identify clinical factors and imaging parameters that are associated with important issues such as patient outcomes, disease progression and more, MVA techniques can also be used. For predicting gestational age (GA) and neurodevelopmental maturation of a fetus, Ana I.L. Namburete et al. [6] proposed an automated framework based on 3D ultrasound brain images. This method used age related sonographic image patterns in concurrence with clinical measurements to develop a predictive age model for the first time, which improves on the GA-prediction potential of US images.

An emerging effective and non-invasive tool in pregnancy follow-up and prenatal diagnosis is fetal MRI. However, there is a significant variability in the orientation position of the fetus in the MR images. This makes these images more difficult to interpret and analyze compared to standard adult MR imaging, which standardized anatomical imaging aligned planes. To address this issue [7] proposed automatic localization of the fetal anatomy, in particular, the brain which is a structure of interest for many fetal MRI studies. In this method, first extract superpixels and then compute histogram of features for each superpixel based on dense scale invariant feature transform (DSIFT) descriptors using bag of words. Then construct a graph of superpixels and train a random forest classifier to distinguish between brain and non-brain superpixels.

Magnetic resonance image analysis has revealed a complex fusion of structural alterations across all tissue compartments and are associated with wide-ranging neurodevelopment disorders and persistent into adolescence and adulthood. G.Ball et al.[8] applied machine-learning methods to compare whole-brain functional connectivity in preterm infants at term-equivalent age and healthy term-born neonates in order to test the hypothesis that preterm birth results in some changes in the functional connectivity by term-equivalent age. Functional connectivity networks were estimated in 105 preterm infants and 26 term controls using group independent component analysis and a graphical lasso model. To identify discriminative edges within each network, a random forest based feature selection method was used and to classify subjects based on functional connectivity alone, a nonlinear support vector machine was used.

Diagnosis of fetal presentation (head or buttock in the maternal pelvis) and confirmation of pregnancy viability are the first essential components of ultrasound assessment in obstetrics. The former is essential for labour management and the latter is useful in assessing the presence of an on-going pregnancy. [9] proposed an automated framework for detection of fetal presentation and heartbeat from a predefined free-hand ultrasound sweep of the maternal abdomen. They proposed a method that exploits the presence of key anatomical sonographic image patterns for the first time, and automated framework allowing sonographers to detect heartbeat from an ultrasound sweep and fetal breech presentation. For a frame by frame categorization of each 2D slice of the video, the framework includes a classification regime. Conditional random field model is used to regularize classification scores by taking into account the temporal relationship between the video frames. Subsequently, a kernelized linear dynamical model is used to identify whether a heartbeat can be detected in the sequence, if consecutive frames of the fetal heart are detected.

Omneya Attallah et al. [10] proposed a pipeline process for fetal brain classification (FBC) which uses machine learning techniques. The main contribution of this process is the classification of fetal brain abnormalities in early stage, before the fetal is born. The proposed algorithm will detect and classify a variety of abnormalities from MRI images with a wide range of fetal gestational age using a simple and flexible method with low computational cost. The proposed method includes four phases; segmentation, enhancement, feature extraction and classification. For the classification, they used 4 classifiers such that support vector machine, K-nearest neighbor (KNN), Linear discriminate analysis (LDA) and Ensemble subspace discriminates.

Many brain MRI-based processing methods and brain extraction are initial preprocessing steps and which is important basis for accurate fetal MRI analysis. However, due to the large variation in fetal brains across different gestational weeks and complex

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maternal tissues surrounding the fetal brains, it is very difficult to automatically extract fetal brains from fetal MRI. [11] proposed a novel two-step framework using the deep learning method for solving the challenging problem of automatic fetal brain extraction in 2D in utero fetal MRI slices. The proposed frame- work consisted of two fully convolutional network (FCN) models, i.e., a shallow FCN and an extra deep multi-scale FCN (M- FCN). The first to locate the fetal brain and to extract the region of interest (ROI) containing the brain, a shallow FCN is used. Then, M-FCN further refined within the brain ROI, the segmentation and produced the final brain mask by leveraging the multi-scale information and residual learning blocks. Dilated convolutional layers were employed in both FCNs to control the size of feature maps and increase the field of view.

III. COMPARISON

TABLE I Comparison of Different Methods

Paper	Classifier Used	Accuracy
Mark Ison et al. [1]	Random forest classifier	81%
M. Yaqub et al. [3]	Random decision forest	91%
Yan Jin et al. [4]	Multikernal SVM	76%
A. Alansary et al. [7]	Random forest classifier	94.55%
G. Ball et al. [8]	Non linear SVM	80%
M.A. Maraci et al. [9]	SVM	93.1%
Omneya Attallah et al. [10]	LDA Linear SVM KNN Ensemble Subspace Discriminates	79% 79% 73% 80%
Jinpeng Li et al. [11]	FCN	100%

IV. CONCLUSION

Machine learning have made a large impact in a broad range of application domains. Today, they are the first choice to solve many problems in computer vision, speech recognition and natural language processing. Recently, machine learning is widely using in medical field for medical diagnosis to reduce human diagnostic error. The development of the brain begins at the first few weeks after conception. Brain development is adversely affected by preterm birth. There are various machine learning techniques for detection and classification of fetal brain abnormalities. This paper presents review on detection and classification of fetal brain abnormalities using machine learning techniques. Depending on techniques used, the prediction accuracy is different for all the cases. However, machine learning has played a great role for the detection and classification of fetal brain abnormalities. Recently, deep learning, a class of machine learning is also used for the detection of abnormalities in the fetal brain and which provide more accurate result compared to other methods.

REFERENCES

[1]. Mark Ison, Eva Dittrich, Rene Donner, Gregor Kasprian, Daniela Prayer and Georg Langs, " Fully Automated Brain Extraction and Orientation in Raw Fetal MRI," *MICCAI Workshop on Perinatal and Paediatric Imaging*, 2012, pp. 17-24.
[2]. L. J. Salomon, Z. Alfirevic, V. Berghella *et al.*, " Practice guidelines for Performance of the routine mid-trimester fetal ultrasound scan," *Ultrasound in Obstetrics & Gynecology*, 2011, vol. 37, no. 1, pp. 116-126.
[3]. M. Yaqub, R. Napolitano, C. Ioannou, A. T. Papageorghiou and J. A. Noble, " Automatic Detection of Fetal Brain Structures in Ultrasound Images," *IEEE International Conference on Symposium on Biomedical Imaging*, 2012, pp. 1555-1558.
[4]. Yan Jin, Chong-Yaw Wee, Feng Shi, Kim-Han Thung, Dong Ni, Pew-Thian Yap and Dinggang Shen, "Identification of Infants at High-Risk for Autism Spectrum Disorder Using Multiparameter Multiscale White Matter Connectivity Networks," *Human Brain Mapping*, 2015.
[5]. Jacob Levman and Takahashi, " Multivariate Analyses Applied to Fetal, Neonatal and Pediatric MRI of Neurodevelopmental Disorders,"*Elsevier Journal on Neuroimage*, 2015, pp. 532-544.
[6]. Ana I.L. Namburete, Richard V. Stebbing, Bryn Kemp, Mohammad Yaqub, Aris T. Papageorghiou and J. Alison Noble, " Learning- Base Prediction of Gestational Age from Ultrasound Images of the Fetal Brain," *Elsevier Journal on Medical Image Analyses*, 2015, pp. 72-86.
[7]. A. Alansary *et al.*, "Automatic Brain Localization in Fetal MRI Using Superpixel Graphs," *IEEE International Conference on Machine Learning Meets Medical Imaging*, 2016, pp. 13-22.
[8]. G. Ball, P. Aljabar, T. Arichi, N. Tusor *et al*., " Machine Learning to Characterise Neonatal Functional Connectivity in the Preterm Brain," *Elsevier Journal on Neuroimage*, 2016, vol. 124, pp. 267-275.
[9]. M.A. Maraci, C.P. Bridge *et al*., " A Framework for Analysis of Linear Ultrasound Videos to Detect Fetal Presentation and Heartbeat," *Elsevier Journal on Medical Image Analysis*, 2017, pp. 22-36.
[10]. Heba Gadelkarim, Omneya Attallah and Maha A. Sharkas, "Detecting and Classifying Fetal Brain Abnormalities Using Machine Learning Techniques," *IEEE International Conference on Machine Learning and Applications*, 2018, pp. 1371-1376.
[11]. Jinpeng Li *et al*., "Automatic Fetal Brain Extraction from 2D in Utero Fetal MRI Slices Using Deep Neural Network," *Elsevier Journal on Neurocomputing*, 2019.