Discerning Alzheimer's Disease on Compact Dataset: A learning Perspective

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ABSTRACT

Computer aided design (CAD) is an attractive topic in Alzheimer's disease (AD) analysis. Several areas of algorithm are based on a comparatively massive coaching dataset. However, small hospitals area unit sometimes unable to gather decent coaching samples for strong classification. Though information sharing is increasing in scientific analysis, it's unclear whether or not a model supported one dataset is similar temperament for different information sources. Employing a little dataset from an area hospital and an oversized shared dataset from the Alzheimer's disease Neuro imaging Initiative (ADNI), we conducted an on-uniformity analysis and located that completely different functional resonance imaging (fMRI) information sources show different sample distributions in feature house. Additionally, we proposed a good data transfer technique to diminish the disparity among completely different datasets and improve the classification accuracy on datasets with scant coaching samples. The accuracy in flatted by just about two hundredth compared there with of a model primarily based solely on the first little dataset. The results demonstrated that the planned approach could be an overland effective method for CAD in hospitals with solely little coaching datasets. It solved the challenge of restricted sample size in detection of AD, which could be a common issue however lack of adequate attention. Furthermore, the paper sheds new light-weight on effective use of multisource information for nervous disorder design.

Keywords: Computer-aided diagnosis, Small dataset, Domain adaptation, Alzheimer's disease, rs-fMRI, Machine learning

1. INTRODUCTION

The issues related with the maturing populace are getting progressively genuine as individuals live more and richness rates decrease in many nations. Moreover, since a more no worthy extent of people are older, more individual's area thigh danger of creating dementia. At present, roughly 47 million individuals worldwide live with dementia, furthermore, this number is anticipated to increment to more than 131 million by 2050. Alzheimer's illness (AD) is the most basic type of dementia analysed in older individuals and altogether decreases their personal satisfaction. An exacta dearly determination is fundamental for auspicious treatment and hazard decrease. Over the previous decade, a few imaging modalities have been utilized in AD determination, including dissemination tensor imaging (DTI), basic attractive reverberation imaging (MRI) also,

positron out flow tomography (PET). Among these modalities, practical MRI (fMRI) plays a significant job in checking cerebrum movement and investigating the useful network among various cerebrum locales; hence, fMRI is a promising system for the examination and location of mind illness. Investigates about PC helped finding (CAD) frameworks which use AI calculations to analyse or anticipate sicknesses have jumped up as o flat, particularly for AD separation from fMRI filters. Be that as it may, certain issues stay in the advancement and use of CAD frameworks. Huge datasets are profoundly significant for AD inquire about studies and CAD. Information sharing is a potential technique for fathoming this issue. Some enormous research establishments and affiliations have started to share their information, similar to the Alzheimer's disease Neuroimaging Initiative (ADNI). Be that as it may, regardless of whether enormous organizations are happy to impart their information to littler associations, it is in distinct whether the mutual huge dataset can be utilized to improve arrangement execution on the neighbourhood little dataset. Numerous examinations researching AD segregation utilizing fMRI depended on a solitary information source with constrained AD tests, including the above referenced looks into. We found conflicting or even opposing ends in comparative considers performing cerebrum arrange investigations in AD. For instances ekaretal discovered that the world wide availability in patients with Promotion was higher than that in the ordinary controls (NCs), while Zhaoetal reached the contrary determination. What's more, Zhaoetal discovered that the normal standardized trademark way length in the patients with AD was more prominent than that in the NCs, while Sanz-Arigitaetal acquired the contrary outcome. We consider a few factors that may have added to this marvel.

Right now, first investigated the heterogeneity of AD datasets from various information sources and affirmed our theory that diverse fMRI information sources have unique test circulations in the component space. At that point, as straight forward and productive area adjustments strategy was utilized to lessen the dissimilarity in the example conveyance between the huge shared dataset and the little present dataset. At last, atypical AI model was worked for AD segregation based on the information after adjustment. Utilizing this technique, we accomplished a huge increment in the exactness of arrangement utilizing just the little datasets. All the more explicitly, the arrangement precision was over 20% more noteworthy than that utilizing classifiers prepared with guileless blends of tests from various information sources and around 30% more noteworthy than that utilizing classifiers prepared distinctly with the little objective dataset. Wachinger what's more, Reuter utilized generals straight model coordinated with occasion weighting in area adjustment of AD order and acquired improved execution. A similar technique has been applied right now examination. Be that as it may, we didn't discover improvement in the grouping precision contrasted and that of utilizing gullible blends of tests. It demonstrates that the exhibition of previously mentioned examinations will be debased pretty much in such a state of restricted preparing tests. The outcomes showed that the arrangement proposed right now paper is a successful strategy for beating the difficulties of Computer aided design utilizing little example sets and clears another path for singular emergency clinics and associations to construct explicit assistant conclusion applications.

2. METHODS

We presented a basic novel space adjustment technique intended to decrease the difference in the example conveyances among datasets from various sources. The system of our technique is port rayed. To begin with, we extricated weighted associations between various utilitarian districts as unique includes through cerebrum arrange displaying. Second, an element choice advance was executed before the area adjustments in cite elements of the first highlights were excessively enormous. The chose highlights from the two distinct information sources were circulated in two separate component spaces. At that point, we performed an adjusted subspace arrangement to adjust the example focuses from the two separate component spaces into a similar subspace. At last, the adjusted examples in a single subspace were as a coordinated dataset for the classifier preparing and testing.

A. Modified Subspace Alignment Method

The domain adaptation approach proposed in this paper was tailored from Fernandes they proposed a sub space alignment method for visual reputation that yielded good outcomes in an object reputation task, and this

algorithm is efficient because of its in-transit simplicity. Here, we modified this method to make it suitable for a small dataset and fMRI records. Given two datasets from different domains, i.e., source domain DS containing m samples and target domain DT containing n samples, $[x1,...,x_m]=XS \in DS$ and $[x1,...,x_n]=XT \in DT$. The subspace alignment mapped the statistics into subspaces and discovered switch matrix M, which aligned one subspace with the alternative. Assuming that the function size of the samples is dm, first, we can acquire Eigen vectors for each domain by using composing their subspace.

$$F(M) = \| V_S M - V_T \|^2 \quad \text{------------------ (1)} \tag{1}$$

$$M^* = \arg \text{Nin}_M(F(M)) \quad \text{------------------ (2)}$$

$$F(M) = \| V^u V_S M - V^u V_T \|^2 = \| M - V^u V_T \|^2 \text{--- (3)} \tag{3}{(2)}$$

In this equation, we can gain the optimal Once the characteristic vectors are mapped, all the facts area aligned into an unmarried subspace. Finally, all projected function vectors belonging to a certain subspace may be used for the schooling and prediction.

Using the subspace alignment method, the performance is associated to the so le hyper parameter. Parameter corresponds to the measurement of the subspaces that as the trouble of being smaller than the variety of samples or the feature size dm. According to consistency the Oregon similarity feature of source information and target records, we can use theoretical end result to determine the higher bound of d. Given a fixed deviation, with the in equation can be obtained.

That means as long as we select a subspace sized satisfying the condition the answer mapping procedure is solid and now not over-fitting. In this study, because the variety of dis now not wide, we have tried all the feasible price of and were given the most excellent one. Compared with the approach in, we changed the principal issue analysis (PCA) with SVD, which has several advantages. First, the fee of the functions used in this situation ranged from zero to one, and many features with in the function vectors had a price near to 0. Under this circumstance, calculating the covariance matrix in a PC A may additionally lose numbers which can be very near to zero, while the use of SVD can gain more stable results. Second, the dimension of the subspace can't be large than the wide variety of samples with in the smaller dataset or feature measurement dm if using a PCA.

Samples are very restricted and far smaller than dm in our situation, but SVD is free of constrain to fi n adequate samples, and we used rights angular vectors as Eigen vectors. Finally, performing a PCA requires centred and standardized facts, which is not vital in SVD.

B. Discriminant Analysis Classifier

A discriminant evaluation classifier is anon parametric probabilistic model used to categorise a brand-new statement based totally on the following 3 quantities: posterior probability, prior probability, and value. This version assumes that the statistics in each class have a multi variate normal distribution. The model uses the identical covariance matrix for the lining discriminant analysis and manor woman covariance each magnificent for the quadratic analysis. This technique has been effectively applied for the detection of AD. Assuming there are K instructions and given statement x, the expected type is the minimization of the expected classification price as follows:

$$\hat{y} = \arg \min \sum^K \hat{P}(k|x)C(y|k) \quad \text{------------------ (4)}$$

Where the expected category is the posterior chance of class K for commentary is the value v of classifying a remark as y when its authentic magnificence is k. Generally, the cost is zero if the category is accurate and 1 otherwise. A thorough presentation of discriminant evaluation can be located. We have tried both type of discriminant in the study, and higher performance completed with linear discriminant.

In this paper, all of the experiments and outcomes were based totally on line and is criminate

3. EXPERIMENTAL SETUP

A. Data series and pre-processing

There have been two datasets used in this have a look at. Data source I, the neighbourhood small dataset (target dataset), was accumulated in Hospital at Wuhan. It contained 26 subjects in total, including 12 sufferers recognized with AD according to the NINCDS-ADRDA criteria and 14 whole some controls. Each difficulty had one fMRI scan simplest. These 26 subjects are all to be had samples in Hospital. Data supply II, the big shared dataset (source dataset), and contained 86 topics. Data source II used in the coaching of this text had been acquired from the Alzheimer's disease Neuroimaging Initiative database (adni.Loni.Usc.Edu). The ADNI was released in 2003 as a public-private partnership, led by Principal Investigator Michael W. Weiner, MD. The primary purpose of ADNI has been to test whether serial MRI, PET, different biological markers, and clinical and neuropsychological assessment can be mixed to measure the development to f slight cognitive impairment (MCI) and early AD. For up-to-date records, see www.Adni-info.Org. Most topics from statistics source II had passed through fMRI test extra than once; there had been 117 scans of 34 AD sufferers and 175 scans of 52 healthy controls (excluding scans with strange head movement and specific facts acquisition setups) in total. Each experiment becomes seemed as a person pattern to make the shared dataset as massive as feasible. To be noted, the scans which belong to one problem were appeared as an entire and either all dispensed to schooling set or trying outset. It won't occur where in a few cans from a topic were in education data whilst few different scans from the identical situation had been in trying out set. Therefore, it's a feasible way to amplify the education set.

The observe protocol changed into approved via the ethics committee eat Tongji scientific university of Huazhong University of Science and Technology, and written informed concurs were obtained from all subjects from records source I. Demo graphic information and different characteristics of the 2 datasets are proven in Table I. We accumulated the Tongji dataset on a GE signa HDxt3. Zero Tesla MRI scanner. The unique parameters are as follows: TR/TE=2000/30ms, turn angle=ninety°, imaging matrix=64×64, voxel length=3.0mm×3. 0mm×3.zeromm, wide variety of slices=33, and each collection has 240 volumes. FMRI information in the ADNI database become receive done 3T Philips MRI scanner with the following parameters:TR/TE=3000/30ms, turn angle=80°, imaging matrix=64×64, voxel, size=3.31mm×3.31mm× 3.31mm, quantity of slices=48, and every collection has140 volumes.

Post-processing of all fMRI images was completed the use of SPM8, REST and DPARSF. After disposing of the primary ten volumes of every series for signal equilibration, slice timing and realigning for head motion correction were carried out. Then the practical photos have been normalized into the Montreal Neurological Institute (MNI) area the usage of echo-planar imaging (EPI) template. Samples with head motion large than 2.5mm have been excluded. There suiting photos were spatially smoothed the usage of a Gaussian kernel with 6 mm×6mm×6mmFWHM, and REST turned into used to remove the linear trend so f time guides. Finally, temporal bandpass filtering with in the c programming language of 0.01–zero. 08Hz changed into applied to the time publications of every voxel, and nuisanceco variates, including six head movement parameters, global mean sign, white matter signal, and cerebra spinal fluid sign were regressed out. Time collection of ninety areas of interests (ROIs) for each pattern have been extracted by warping the automatic an atomically labelling (AAL) at las for processed brain pictures for further evaluation.

B. Future Extraction

We calculated the pairwise Pearson correlation coefficients between any time-collection of 90 ROI sin each experiment, resulting in a 4005-dimensional characteristic vector for one experiment describing the correlation coefficient matrix. Then the Kendall's tau correlation coefficients had been used for feature choice system. The Kendall's tau coefficient has been proved to be effective for feature choice in neuro imaging studies about CAD. Since the wide variety of samples is restrained (292 from the ADNI dataset and 26 from the Tongji dataset), we performed the experiments with 10 to 200 selected features at an c program language period of 10 to assess the generalizability of the approach. In the experiments of version, we first performed the function choice procedure in massive ADNI dataset. Then, the consequential selection was applied to the small Tongji dataset. That way we acquired a subset of feature sin ADNI dataset after characteristic choice technique and the same sub set of features turned into selected for Tongji dataset.

C. Experimental Process

To examine the effectiveness of our technique, the following sets of AD discrimination experiments were accomplished.

(i) Only Tongji: Classification assignment most effective with neighbourhood Tongji dataset. During this venture, leave-one-outcross-validation (LOOCV) approach becomes carried out with 26 samples of Tongji dataset. More specifically, on every occasion 25 samples were used for function selection and training the discriminant evaluation classifier and the final one become used for testing.

(ii) Naïve Combination: ADNI dataset become brought to schooling set in Experiment

 More specifically, every time 25 samples from Tongji dataset plus all the ADNI samples have been used for feature selection and schooling the discriminant analysis classifier, and the closing one in Tongji dataset changed into used for trying out.

(iii) With Adaptation: As illustrated in Fig.3. At first, feature choice become carried out in ADNI data set and a subset of functions turned into acquired in this manner, then the identical subset of features turned into chosen for each sample for Tongji dataset. After that, Tongji facts (target domain) become projected to its subspace and mapped to the subspace of ADNI statistics (supply area). ADNI information turned into projected to its personal subspace. With this, ADNI statistics and Tongji information were aligned within the identical subspace. Finally, the ADNI and 25 out of 26 Tongji samples in ADNI subspace had been used for schooling the discriminant analysis classifier, and the final one for checking out. The final step is similar to Experiment (ii), where in the difference is that the data in (iii) was after model.

(iv) Instance Weighting: In addition, a popular linear version integrated with instance weighting for AD class turned into built for comparison that is the approach achieved Tongji dataset became cut up in to two parts, schooling element and trying out part. For every sample in schooling element, a weight changed into evaluated consistent with opportunity of those samples in ADNI area. Then these samples in conjunction with ADNI samples were fed into a fashionable linear version with log-likelihood function and elastic-net multi nominal regression. All the fed samples in log-likelihood characteristic were weighted. The weights of the schooling component from Tongji dataset have been as evaluated at beginning, and the ADNI samples were given a regular weight equal to 1. Finally, the skilled widespread linear model became used to classify the checking out a part of Tongji dataset. The splitting technique changed into repeated for 50 instances answer and only sampled the training set every time. Due to the limited quantity of samples in Tongji area, we delivered fifty percentages of the Tongji samples to the training set in place of ten to thirty percent. The accuracy, sensitivity, specificity and area below the curve (AUC) in each experiment have been calculated. All experiments had been achieved with MATLAB R2016a.

4. RESULTS

The aggregate of two data sets are heterogeneous illustrates the opportunity distributions of mini-mental state examination (MMSE) rankings and a while in both datasets. These distributions have been envisioned using kernel density estimation. In addition, a4005-dimension characteristic per scan changed into extracted, and the t-SNE method (developed from Stochastic Neighbour Embedding) become used to decrease the feature measurement and permit the visualization of high dimension al records. The result is shown in Fig.
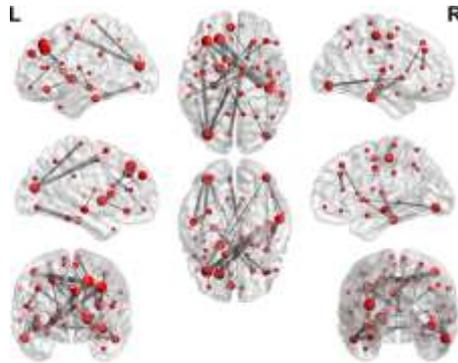

Figure1. visualisation of high dimension al records.

Obviously, the pattern factors from the Tongji dataset cluster mainly inside the upper margin of the ADNI sample points before version. It how is that the one-of-a-kind fMRI facts sources show one-of-a-kind pattern distributions with in the characteristic area. Consistency in function distribution of samples is of vital significance for achieving appropriate class overall performance in pattern popularity. Therefore, it is essential for CAD that uses fMRI facts from a couple of sources to cast off the in consistency in the sample distribution across specific facts assets. The sample distribution of the 2 datasets becomes also visualized in a 2-measurement characteristic area after adapting the Tongji data to the area of ADNI dataset. Pattern factors from the Tongji dataset no longer lay inside the margins of the ADNI facts factors but shifted to a distribution constant with that of ADNI dataset. The modified subspace alignment method bridged the gap of area variations to a positive extent.

The class venture only with the nearby small data set from Tongji data supply did now not perform nicely, as proven in Fig.4. Its accuracy changed into slightly greater than 50%, which is sort of like random guesses. It's tough to assemble a strong version for auxiliary diagnosis of AD in a pattern set as small as Tongji dataset. When we used the huge shared data set from ADNI and mixed with Tongji dataset, the performance of the classifier significantly increased, reaching an accuracy of 60%. Thus, enlarging the size of schooling set in deed progressed the performance of a classifier. However, this development changed into in sufficient as compared with the class effects acquired in the edition experiment, where in the accuracy became greater than 80%. The unsatisfactory accuracy earlier than version shows that it isn't always feasible to obtain dependable class effects via sincerely adding exceptional records sources to acquire a larger schooling set.

The specific performance indicators are summarized in Table II. The accuracy after the variation improved through nearly thirty percentages compared with that in the type experiment using best Tongji dataset. However, the result of the overall linear model integrated with example weighting is no longer promising, for its performance became not advanced as compared with that of naïve combining the 2 datasets to teach the classifier. Thus, ordinary domain adaptation techniques might al so no longer is nicely accept able for the situation where in the goal samples are very in adequate. More considerations should be taken on fixing this project. The number of decided on features impacts the overall performance of the AD classification. As shown in Fig.4, while we selected a few functions for the type, the classifier done poorly. The accuracy of the classification improved as the quantity of decided on capabilities extended. However, the classifier overall performance stopped improving once a certain wide variety of capabilities (depending on the

sample size) became reached. Too few features are in adequate for class, while too many function scans be redundant. This locating is constant with previous research. We decide don the capabilities via ranking the Kendall's tau correlation coefficients. Table III lists the functions with a rating ranking in the pinnacle ten in Experiment (iii)The pinnacle 50 functions selected from the ADNI dataset are labelled in Fig.5, which turned in to generate with Brain-Net Viewer. Subspace dimension d play san vital role in the area adaptation. The accuracy accelerated as subspace sized improved as proven. We have compared the SVD subspace alignment with unique technique in all values of d with ninety selected features. The overall performance of SVD technique is as precise as that of authentic one in maximum cases, and now and again it's even higher. The top-rated is 25 in our experiment. Due to the limitation of sample length, we've tried all of the feasible values. In other applications, the parameter d can be tuned consistent with consistency theorem defined in modified subspace alignment method.

5. DISCUSSION

CAD systems used for AD classification based totally on fMRI facts have come to be a most important studies topic in recent years. However, it is tough for small hospitals and studies groups to collect enough samples for accurate category. Many small hospitals and studies corporations regularly encounter this difficulty. Data sharing is a likely choice for fixing this problem. In this look at, due to the fact the fMRI dataset from Tongji Hospital become too small, the classifier educated with confined samples accomplished poorly. The ADNI data set changed into added to increase the education data set and improve the type accuracy. Most studies investigating AD identity performed their experiments the use of a singled at a set thus, their models normally done properly for samples decided on from the same particular information supply. However, it's far unclear whether or not a model constructed on a specific dataset is well acceptable for different data resources. The version trained with the ADNI data set did now not perform properly on the Tongji dataset. Al though an alive augmentation with ADNI information progressed the class accuracy, the type performance remained terrible for in addition sensible application. We suppose the trouble laid in the difference among the two statistics as sets in which the samples have been received. By per forming heterogeneity analysis of the extra ordinary data sources, we found that the feature distribution of the samples from Tongji Medical College differed from that of the ADNI information, which showed our assumption. This discrepancy might also relate to many factors. Obviously, the chance distribution of age and MMSE rating in Tongji dataset is one-of-a-kind from that during ADNI dataset. Furthermore, the system and acquisition parameters are exception al among the 2 datasets. These factors bring about heterogeneity in facts from exclusive sources and the failure of naïve combination of multi-site records. Regarding multi-source statistics utilization, transfer getting to know is a potential way in scientific sign analysis. His mannitol applied example weighting to the picture fusion of transoesophageal echography (TEE) and X-ray fluoroscopy for ultrasound transducer localization. Schlegletal Used facts from more than one website via a semi-supervised mastering method to improve lung tissue type VanOpbroe ketal confirmed that transfer mastering out performed common supervised getting to know processes in MRI brain-segmentation tasks the use of multi-site information. Domain version is a promising method in transfer mastering. In this have a look at, we used a simple area version method to decrease the disparity in the feature distribution among the huge and small datasets for AD detection. Our experiments proven that adapting the Tongji dataset to the ADNI domain the use of this technique yielded a dramatic improvement inside the type. The accuracy become nearly 20% greater than that the use of the naïve mixture of samples and approximately 30% greater than that the use of the small dataset. Our area edition technique diminishes the disparity in the characteristic space between samples from different statistics assets and successfully improves the type accuracy when pattern size is extremity restricted. This have a look at offers an oval method for small hospital sand research corporations to expand CAD structures for neurological diseases.

The changed subspace alignment approach introduced in this paper is are natively clean algorithm as compared with different domain adaptation methods, such as characteristic augmentation primarily based approaches, function transformation based totally strategies, dictionary based totally approaches, and different techniques. This technique may be conveniently tailored for a couple of domains so long as we map the opposite of main

names to a single source area. Information loss is a difficulty of the subspace alignment technique because this approach employs SVD to produce the base vectors of the subspaces. Only hyper parameter slightly influenced the experiment al results. Hyper parameter denotes what number of dimensions there are in a subspace, and dis directly involved with data loss. Hence, the chart of d is in accordance with our expectations. The subspace alignment method has been efficaciously carried out in other scientific image recognition applications, demonstrating its simple shape and tremendous application. The general liner model integrated with instance weighting yielded d is appointing outcomes. Its overall performance becomes not higher than that of the naïve mixture method.

We suppose the in sufficient sample sin goal dataset is the fundamental reason. The instance weighing estimates the probability distribution sin side the source dataset and target data set after which evaluates the chance of the target samples underneath the source distribution. The limited range of samples in the goal dataset complicates the correct estimation of the target distribution; therefore, it brought massive error while comparing the weights. However, the changed subspace alignment method makes use of all records in the target dataset irrespective of whether or not their labels are to be had and adapts the goal samples to the subspace of the supply area, thereby lowering the disparity among the two data sets.

Our technique is properly acceptable for category project on a completely small dataset. In this take a look at, the feature choice method is based totally on Kendall's tau correlation coefficients. The pinnacle ten decided on functions and the areas concerned are indexed in Table IV. Among those areas, the hippo campus is ranked first and has been established to be highly associated with AD. The connectivity among front all regions and different areas, which turned in to selected as a class characteristic, has been related with AD in other studies. Additionally, most other indexed areas are consistent with several previous research. The consistency of our outcomes with those acquired in different research suggests that the features selected with Kendall's tau correlation coefficients are reliable for classification. We only considered purposeful connectivity capabilities due to the fact these features are broadly utilized in studies investigating AD identification based on fMRI. Other types of biomarkers or functions can be covered in this method to achieve better class overall performance. There are a few obstacles to our look at. We only demonstrated that unique fMRI statistics assets show special distributions inside the function space. However, how factors, such as devices, the setup of the technical parameters, etc., influence the pattern distribution within the function are a stay sun clear. On the opposite hand, AD studies progress slowly in local hospitals, and it's far hard for us to obtain additional samples for evaluation and comparison. Meanwhile, physicians in these developing regions do no longer have as many wealthy reviews as the one's doctors in huge scientific centres, there by growing the need of CAD assistance. For CAD system son AD type, more studies on early AD detection are now trending. MCI is an important early level of Alzheimer's disease, and distinguishing MCI from normal growing old is greater giant and thought a detecting AD. There are many super papers about MCI class, and we have got load sin aspiration from these studies. To identity MCI population is one of the critical assignments in our future works. As expand of deep studying, using deep neural network in auxiliary prongs is to computerized extract features and conduct transfer mastering is promising. We are searching a head to constructing robust deep studying architecture within the future.

6. CONCLUSION

In this paper, we confirmed that the AD type mission the usage of a small dataset can be higher to solve the usage of the changed subspace alignment approach. This approach can efficiently improve the accuracy of the category in small pattern units. Researchers can use this technique to alleviate the project of extremely restricted pattern size, especially whilst collecting neuro imaging facts is difficult and computer-aided diagnoses with limited samples are required. Our work may additionally assist researchers to make higher use of shared records and promote the alternate of gathered facts.

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