EDITORIAL

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# An Enhanced Prediction Model For Autism Spectrum Disorder

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## Abstract

Autism spectrum disorder (ASD) is a behavioural condition that affects the child's social interaction, communication, and behaviour. The early identification of ASD is critical for the effective and timely therapies. This study presents an enhanced prediction model for Autism Spectrum Disorder (ASD). It is based on facial features extracted from the face image. Mallat's multi-resolution algorithm is employed in this work for extracting facial features. Two distance based classifiers such as Euclidean Distance Classifier (EDC) and Absolute Distance Classifier (ADC) are employed for the ASD prediction. The proposed ASD prediction system is evaluated on face images of autistic and non-autistic children. The database is obtained from the Kaggle data repository. A total of 2940 facial images (1470 autistic and 1470 non-autistic) are employed for performance analysis. Experimental results show that the proposed ASD prediction system provides promising results with an accuracy of 97.01% by EDC and 96.87% by ADC classifiers.

## Keywords

Autism spectrum disorder, Computer aided diagnosis, Machine learning, Image based diagnosis, Prediction system.

## Imprint

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## 1. Introduction

Autism is a behavioural condition that may be characterised by problems in three important domains: social interaction, communication, and behaviour. The current diagnostic criteria for autism are based on the above three core behaviours and are recognized as Wing's Triad of deficits. Before a diagnosis can be established, all three behavioural deficits need to occur together and need to be evident by the age of 36 months. It is very unusual for a solid diagnosis of autism in children younger than the ages of 3 or 4. A screening instrument called the CHecklist for Autism in Toddlers (CHAT) and has had some success in pinpointing children as young as 18 months old who have autism [1]. This screening instrument was developed based on the theories of the behavioural and cognitive characteristics of autism.

Children with autism often do not respond to other people and treating them as objects. They often avoid making eye contact or make incorrect use of eye contact, and frequently do not answer when they are addressed by their name. Their behaviour is inconsistent with the expectations of the culture, and they seem to be unaware to the emotions of other people. However, while some children with autism shy away from social interaction, not all of them live in an universe of their own. Some individuals do impulsively approach other people, but it is often primarily for the purpose of carrying out some repeated or peculiar fixation, such as caressing another person's clothing or hair. They may ask a restricted number of questions, most of which are unsuitable to the context, and very few of which are about the emotions or ideas of the persons being questioned. Autism is thought to include a spectrum of illnesses due to the observed variety in social deficits.

Typically developing youngsters engage in a wide variety of communication behaviours. These include indicating something to another person by pointing at it, presenting it to them, or giving it to them in order to convey their interest in the item. Autism-stricken children seldom demonstrate pointing or expressing behaviour like this. Children who are developing normally also utilize gestures to complement their words and to communicate their emotions, and they enhance these expressions with the right eye contact and facial expression. Youngsters with autism typically have facial expressions that do not correspond with their accent, and many of these children do not acquire any kind of functional speech at all. Children with autism spectrum disorder commonly substitute the word "you" for the word "I," or they could refer to themselves by their first name.

## 2. Related Works

The primary objective of this study is to investigate a variety of machine learning algorithms, including SVM (support Vector Machine), Random forest Scan, decision trees, and logistic regression, which have been utilised by a variety of researchers, and to compare the results based on how accurate and efficient they are[2].

This paper presents the findings of a comprehensive survey on the diagnosis of autism spectrum disorder in children using machine learning and deep learning algorithms, information and communication technology (ICT) tools, humanoid robots, and virtual reality (VR) environments. Their performance metrics have also been discussed [3].

Within the scope of this research, we explore the extent to which children participate in conversations with their parents. It is investigated how auditory, linguistic, and conversation act aspects, which are obtained from both participants, interact with one another. Additionally, the impact of visual signals is being looked at as well [4].

This study analyses and makes predictions about likely instances of autism spectrum disorder (ASD) in adults, children, and adolescents using data from ASD screening. An examination of the datasets pertaining to each of the age groups allows for the derivation of conclusions. For the purposes of prediction and comparison, machine learning methods such as Artificial Neural Networks (ANN), Random Forest, Logistic Regression, Decision Tree, and Support Vector Machines (SVM) are used [5].

Making use of a machine learning technique, the goal of our thesis paper is to predict and differentiate between children who have autism and children who do not have autism. To begin, we have attempted to be as thorough as possible in the collection of data from the surveillance side. We also set some specific questions and make an effort to obtain responses that are as accurate as possible to all of our queries. In addition, supervised learning algorithms are used in the diagnostic process to determine whether or not children exhibit the characteristics of ASD. KNN and Random Forest, out of all the algorithms that have been tried, provide the highest accuracy and the quickest time to diagnosis [6].

By using a machine learning method in our thesis work, we hope to be able to identify autistic children and separate them from children who do not have autism. To begin, we have attempted to collect as much information as we can from the surveillance side. In addition, we pose a number of specific questions and work to locate answers that are as accurate as possible to all of the queries. In addition, supervised learning algorithms are used to determine whether or not children have the signs of ASD. KNN and Random Forest demonstrate the greatest accuracy and speed to diagnosis of all the algorithms that have been employed [7].

In this research, we have utilised machine learning algorithms and validated their performance using a dataset consisting of patients diagnosed with autism spectrum disorder. As a consequence of our work, we were able to provide a comparison of the efficacy of several diagnostic methods for ASD [8].

The properties of fillers and laughter, which play key roles in communication as social signals and were seen to be employed differently by people with ASD and TD in earlier study, are the topic of this work. Fillers and laughter both play essential roles in communication. We looked at a number of these characteristics and conducted a statistical analysis to see how useful they are for distinguishing individuals with ASD from those with TD [9].

The ability to accurately forecast the disease at an early stage ought to assist in achieving a speedy recovery. In this study, the Random Forest classifier was used for the purpose of predicting autism spectrum disorder (ASD) based on several behavioural characteristics. With an overall accuracy of 0.96%, the findings have met our expectations, and we are happy with them. The dataset that was utilised for prediction included ten characteristics of behaviour and ten extra characteristics of individuals [10].

In this study, we employ a parallel strategy to examine language modalities and identify connections between objective measures of social communication and ASD symptoms. Specifically, we focus on how language varies across different contexts. We examine the interactions that 33 autistic children had with diagnosticians in a clinical setting and extract the language patterns that were present in those discussions. Long-Short Term Memory (LSTM) networks are used in our methodologies in order to learn Speech Activity Detection (SAD) patterns and speaker diarization patterns in order to provide vocal turn-taking metrics. The ADOS-2 Calibrated Severity Scores (CSS) of Social Affect may then be forecasted with the assistance of our innovatively conceived pipeline (SA). When compared to the top algorithms in the market, the suggested framework is able to deliver state-of-the-art predictive diagnostic estimations of ASD severity [11].

## 3. Methods and Materials

Facial images contain a huge amount of information. From the face image, one can easily realize the identity, gender, emotional status, ethnicity and age as well. This information plays an important role in the direct communication between people. In the real world people usually interact and respond very accurately based on the interpretation of faces and facial gestures of others. HCI is an emerging field in information technology that uses collected information from the facial images. The majority of information from the facial images has already been extensively investigated except for the prediction of ASD which is a new and unexplored problem. The success of every pattern recognition system is dependent on the optimal design of three modules: pre-processing, feature extraction, and classification. These modules are listed in the order that they are executed in the system. Figure 1 depicts the comprehensive block diagram of the proposed ASD prediction system.

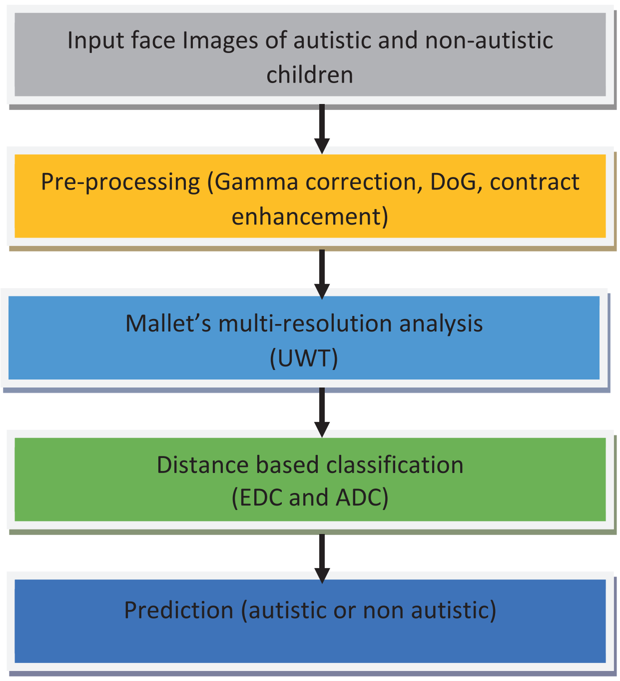


Figure 1 Proposed ASD prediction system

### 3.1 Pre-processing

As the face images were captured in natural lighting, there is a need for pre-processing them to remove the impacts of lighting fluctuations, such as shadows and highlights. Pre-processing steps are carried out prior to the feature extraction process. Gamma corrections, Difference of Gaussian filtering (DoG), and contrast equalisation are the three steps run before feature extraction. The overall brightness of an image may be adjusted via the use of gamma correction. Images that have not been properly adjusted might seem either excessively light or too dark depending on the circumstances. Understanding gamma is also necessary if you want to replicate colours as precisely as possible. The transformation that replaces gray-levels is given by

$$I = I^{\gamma} \qquad \gamma \in [0,1] \tag{1}$$

The Laplacian of Gaussian filter and the difference of box filter are two examples of filters that are comparable to the Difference of Gaussian (DOG) filter. High-pass filtering gets rid of both the valuable and the incidental information, which helps to simplify the recognition issue and, in many instances, improves the overall performance of the system. In a similar manner, DOG is a band-pass filter that eliminates all of the spatial frequencies that were present in the initial gray scale image.

In the last pre-processing step, the image intensities are rescaled such that a reliable estimate of total contrast or intensity variation can be standardised. Because the signal generally comprises extreme values caused by highlights, tiny dark areas such as nostrils, junk at the picture borders, etc., it is essential to utilize a robust estimator. The contrast equalization is defined in Eqns. (2) & (3)

$$I(x,y) = \frac{I(x,y)}{(mean(|I(x',y')|^{\alpha})^{1/\alpha}} \tag{2}$$

$$I(x,y) = \frac{I(x,y)}{(mean(\min(\tau,|I(x',y')|^{\alpha})^{1/\alpha}} \tag{3}$$

where the mean is over the whole (unmasked part of the) image and τ is a threshold used to truncate large values after the first phase of normalization.

### 3.2 Discriminant Features

Discriminant features are extracted using Mallat's multi-resolution algorithm. Undecimated Wavelet Transform (UWT) is an extension of convention wavelet transform. The key point in defining UWT is rather than not to down sample the filtering output, but to keep both even samples and odd samples and keep separately filtering even samples from the lower band. In other words, at each octave the decimation is replaced by splitting the sequences into even and odd sequences. They are the starting point for the next octave. This is visually shown via a two level filter banks in Figure 2, which not only strictly defines the UWT but also demonstrates the filter bank implementation of an algorithm in [12], for computing the UWT. The key point of the algorithm is to separately compute the inverse based on even samples or odd samples and then average the two outcomes. A filter bank implementation of the corresponding inversion algorithm has the similar structure to the forward transform.

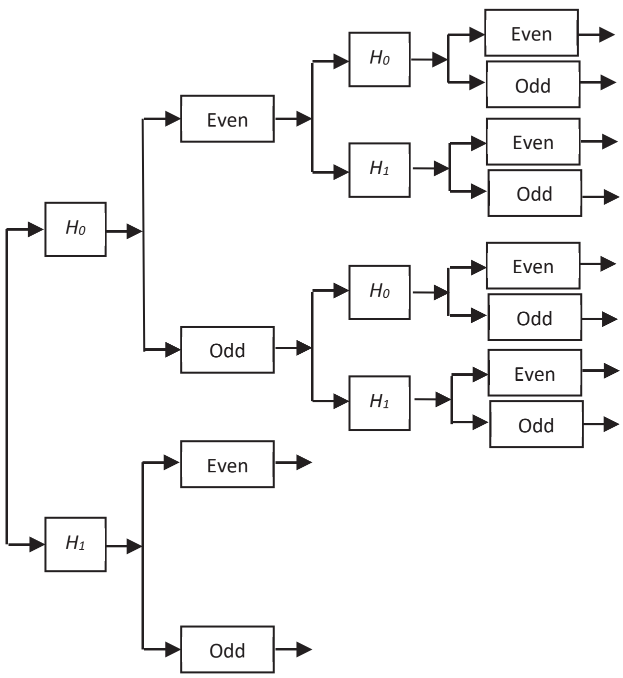

Figure 2 UWT filter bank implementation

### 3.3 ASD Prediction

Although a number of different pattern classifiers are available [13-14], the proposed ASD prediction system uses two straightforward classifiers. This is due to the fact that the primary focus is on the investigation of the relative efficacy of the extracted features in ASD prediction, rather than the performance of various classifiers. The standard minimal Euclidean Distance Classifier (EDC) is used for the first classification. The distance measure is defined by

$$d(k) = [Feat - Feat_k]^T \bullet [Feat - Feat_k] \quad (2)$$

The prediction of *Feat* is obtained via the distance measure ($d$) if

$$d(i) = \min_{1 \le k \le N} [d(k)] \quad (3)$$

where $N$ is the total number training samples. The second classifier used in this work is the absolute distance classifier (ADC) and the distance measure is defined as

$$d(k) = \sum_{k=1}^{N} |Feat - Feat_k| \quad (4)$$

## 4. Results and Discussions

The proposed approach for predicting ASD is tested using facial images of autistic and typically developing youngsters. The information for the database was taken from the Kaggle data source [15]. The performance analysis makes use of a total of 2940 facial photographs, including 1470 non-autistic and 1470 autistic individuals' faces. Figure 3 and Figure 4 shows the sample images of autistic children and normal children respectively. The proposed system is evaluated using 10-fold cross validation approach.

The performance of the proposed ASD prediction system is evaluated in terms of prediction accuracy by changing the UWT levels of resolution and Table 1 shows the performance on Kaggle database images of autistic and non-autistic children.

Table 1

performance of the proposed ASD prediction system

| Level | Accuracy (%) | | Miss rate (%) | |
|---|---|---|---|---|
| | EDC | ADC | EDC | ADC |
| 1 | 72.18 | 71.36 | 27.82 | 28.64 |
| 2 | 83.33 | 82.82 | 16.67 | 17.18 |
| 3 | 97.01 | 96.87 | 2.99 | 3.13 |
| 4 | 89.97 | 88.84 | 10.03 | 11.16 |
| 5 | 75.58 | 74.76 | 24.42 | 25.24 |

It can be seen that the performance of ASD prediction system using EDC classifies Kaggle database image with an accuracy of 97.01% whereas ADC provides 96.87%. It is also noted that for all combinations, EDC provides promising results than ADC classifier. Figure 5 visualizes the performance of the proposed ASD system.

Figure 3. Sample images of autistic children

Figure 4. Sample images of non-autistic or normal children

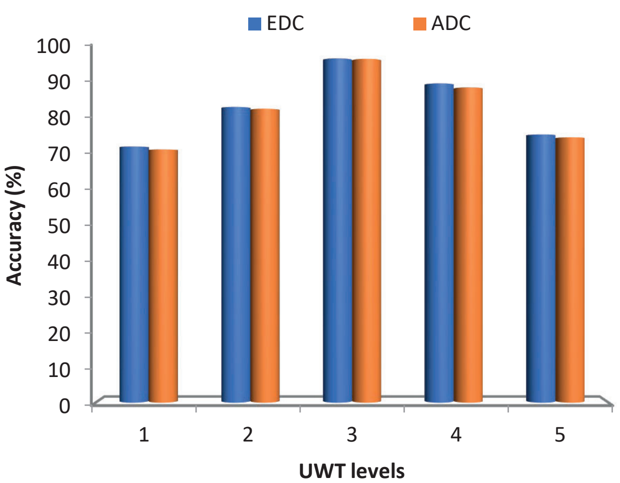


Figure 5 Accuracy obtained by the proposed ASD system using UWT and distance based classifiers.

## 5. Conclusions

In this study, an efficient approach for building a computerized system for the prediction of ASD is presented and discussed. The multi-resolution analysis with translation invariant, UWT is investigated and analyzed for feature extraction. The dstance based classifiers such as EDC and ADC are used for classification purpose. It is shown that the proposed method is very effective for ASD prediction. The evaluation of the system is carried out on Kaggle database facial images and the proposed system achieves very promising results. The prediction system is capable of identifying Autistic children using face images. Results indicate that the ASD prediction system can correctly classify the autism children from the input features of UWT and also achieve high recognition accuracy of 97.01% at 3rd resolution level by EDC and 96.87% by ADC.

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