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Artificial Intelligence Techniques to improve cognitive traits of Down Syndrome Individuals: An Analysis

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ABSTRACT

Improving the learning process requires to improve the cognitive traits of individuals with low mental skills. The artificial intelligence (AI) has been used to support the different individuals with impairments. People with Down syndrome fall in intellectual impairment. Different AI techniques of convolution neural network, artificial neural network and decision tree are widely applied to address the different cognitive traits. We have summarized the artificial intelligence review utilized for such individuals. The aim of this research article is investigate the usability of computational intelligence for addressing the deficits of cognitive skills and other traits. The individuals with cognitive impairment survive with limited mental challenge, therefore, they hardly perform daily life assignments. The individuals with down syndrome face mild to severe cognitive challenges that affects to their daily life activities, education and performing employment. So, they can have reduced the social and economic burden of their family and to make their live productive. Achieving these goals requires improvement in their cognitive challenge. A survey of (N = 50) of the individuals of Down syndrome has been carried out with the support of team of psychologists and teachers of homogeneous education system.

KEYWORDS

Artificial Intelligence (AI), Down Syndrome Individuals (DSI), Cognitive Analysis and Traits

1. INTRODUCTION

1.1 About Down Syndrome

Down Syndrome Individuals are the part of every society born with multiple challenges and on other hand they are challenge for the family where they born. They are supposed to be social and economic burden on family and society. Down syndrome is caused by trisomy on

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chromosome-21 with a prevalence level of approximately 1 in every 800 births (Jamshidnezhad et al., 2021). Down syndrome is occurred due to an extra copy of 21st chromosome also called trisomy-21. Individuals with DS may have substantial intelligent impairments and normally possess a level of Intelligent Quotient (IQ) ranging from 30 to 70. In addition to cognitive skills that are mostly decreased in these individuals include expressive language, memory, and fine motor skills. In cognitive ability, these individuals also have significant limitations in adaptive behaviour (AB).

The adaptive abilities are linked with general cognitive skills measured with IQ (Hamburg et al., 2019). While the quality of life in both education and social domains are progressing for DS individuals, the attention is required to potentially treat the IQ and cognitive difficulties (Baburamani et al., 2019). Their learning consequences are either slower or satisfactory depend on the educational approaches (Leghari and Ali, 2021). Learning process associated with cultural, and environmental factors is important for DS individuals due to their social requirements and independency (Barbosa et al., 2018; Luna-Garcia et al., 2018 and Kamoun, 2001). Hence, due to their common difficulties in cognitive and fine-motor skills, the potential of individual with Down syndrome as learners might be perceived as limited (Marques et al., 2015; Jan Blacher, 2002 and Smith & Smith 2021). They face several different problems in daily life activities while walking, talking, chewing, and learning (Jan Blacher, 2002). Down Syndrome people have different cognitive level of strengths known as memory impairment in childhood and adulthood. A very rare research work has been done on facing problems in accessing technology support to Down Syndrome people.

1.2 Down's Mental Impairment

The challenges that affect any Down syndrome are the lack of low mental capability. The mental challenge is further divided into four severities defined as mild, moderate, severe and profound. This categorization depends on range of intelligent quotient score and symptoms found in Down syndrome ((Hamburg et al., 2019). Around 85% population is owned by mild category. They can play games, use computers, and count numbers. Individuals those with lower cognitive efficiency are able to carry out their work and perform self-care tasks with the support of parents and teachers. The individuals with severe cognitive traits generally have very low ratio of intelligent quotient. Even they can learn self-care ability and linguistic performance.

1.3 Motivation

A down syndrome individual's social life, education and employment can be affected by the limited mental impairment, wherein lack of thinking ability and decision-making power can affect the improvement in learning and in performing routine life activities, which adversely effect on their social development and interactions. Furthermore, lack of technological involvement and in education can demolish their competency. Vast research has been done in the field of Global Health and medical issues related to any individual and their families. Artificial Intelligent techniques are being used (Smith & Smith, 2021 and Kaelin et al., 2021) in the field of differently abled individuals (Special Needs people) from past few years. The motivation behind this research is to analyze and improve the limited mental capability with interactive software approach using Artificial Intelligent techniques for the productive development in the social and learning lifestyle of Down syndrome individuals.

1.4 Scope of the Research

A detailed analysis of the artificial intelligence applications is carried out to evaluate the cognitive traits of the individuals. The technological part is applied on dataset in using artificial intelligence, machine learning and artificial neural network and CNN. A software approach with ANN model utilized to evaluate actual mental strengths with the help of the software.

2. AI APPLICATIONS AND COGNITIVE IMPAIRMENT

Individuals with low mental power require digital services that will assist them to provide auxiliary technology to strengthen their mental capabilities, and to enable in education and employment as possible. In most cases cognitive impairments are assessed from psychologists. Therefore, this is the reason that artificial intelligence techniques support them, and their parents and teachers mostly aim at training individuals rather than diagnosing their needs. This detailed review presents an overview of the highly illustrative research work of the past ten years, discussing the improvement in learning and cognitive strengths of Down syndrome individuals. Moreover, research paper matrix is employed to identify the research gape out of the background of past decade.

2.1 Applications for Diagnosis of Brain Disorder

The involvement of artificial intelligence in assessing the disease and detection of facial behaviours has been one of main domain of research. In research carried out (2013) to present knowledge of the neurocognitive, psychopathological, and neurobiological assessment and treatment of patients with Down Syndrome has suggested that rehabilitation is the sole effective method for improving cognitive and linguistic abilities (Vicari et al., 2013; Rosen et al., 2015 and Hategan et al., 2018). In the same year, researchers have proposed neuroimaging technique using machine learning (ML). Potential bio-supportive artificial intelligence models used to predict mental age are based on brain or neuro image data, which serve Neuroimaging data with ML techniques which provides excessive insights for developmental disabilities in the Down syndrome children. Different ML models discussed and proposed with imaging features. The interactive software enhances the mental level from severe to moderate (25-50%) and moderate to mild (50-75%).

In neuroimaging data retrieval, the proposed techniques are assessed including Magnetic resonance imaging (MRI), a bio-technology body and brain imaging scanning technology (Vicari et al., 2013). Magnetic imaging is the leading clinical techniques to evaluate level of mental impairment. Still this technique is used to analyse psychiatric abnormalities that are unable to detect using computed tomography (CT) (Rosen et al., 2015; Hategan et al., 2018; Raznahan et al., 2015 and Wintermark et al., 2018). AI multimodal learning applications and deep learning methods are developed for brain imaging (Webb S, 2017), that provide support in evaluating disorder (Raznahan et al., 2018 and Wintermark et al., 2018). Other applications are developed to support MRI (Böhle et al., 2019 and Carin & Pencina, 2018). Moreover, convolutional neural networks (Wolfers et al., 2015) and deep NN (Arbabshirani et al., 2017; Vieira et al., 2017 and Bengio, 2009) engaged in neuroimaging to explain the neural relationships of mental disorders (Arbabshirani et al., 2017; LeCun et al., 2015; Calhoun & Sui 2016; Plis SM et al., 2014; Payan & Montana 2015 and Hosseini et al., 2018).

Amanda Saksida et al., 2021 highlighted the problem of hearing impartment (HI) with majority of DS individuals (HI) since early childhood, which has not been yet searched whether it represents a potential of cognitive skills decline to their knowledge. The aim of the research study was to evaluate the effects of hearing impartment on receptive language and hearing skills in DS individuals in considering the possible unfavorable reasons for linguistic abilities in hearing impairment. The authors were trying to show that various factors of sleep quality, behavioural functioning, language skills and obstructive sleep apnea (OSA) are main factors of cognitive decline. They approached the method of Audiometry testing to perform in a soundproof booth to analyse the hearing impartment and judge relation between the HI and cognitive skills. For getting results, a survey was initiated consisting over 41 participants including children between age group ($3 > 10$) years and adolescents with DS out of 150 were engaged in survey. To obtain a more structured group the participants excluding having defects of serious disorder of language and visionary issues and severe cognitive ($IQ < 40$) were referred for audiological inspection process. The final dataset of 17 individuals including (9 girls, 8 boys of age 5.84 years) obtained. Cognitive skills were measured, and cardiac interventions collected. The audiometry assessment performed in a soundproof booth. Moreover, the authors proposed further research to seek to maintain the bridge between mental age and hearing impartment and to evaluate the influences of audiological rehabilitation on the improvements of motor and cognitive functioning and evaluate variations in cognitive decline in DS individuals. The recommendations of the author are what we are implementing here in this study.

In the same year (Falin H.E et al., 2021) worked on a machine learning model to predict Down syndrome in trimester antenatal screening. The authors used Machine learning random forest model to predict Down's syndrome. In a long survey, around 58,972 pregnant women undergone screening. In second phase of survey, same method was applied to 27,170 pregnant women to analyse predictive efficiency. In results, the ML random forest model revealed prediction ratio of 66.7% DS, with a 5% false positive rate in data set. The model achieved DS detection rate of 85.2%, with a 5% false positive rate. The study showed that the ML model expands the DS prediction rate with the similar false positive ratio in contrast to the laboratory risk model. The authors emphasized for further exploration in machine learning based detection system, therefore the domain is required to be work more. Similarly, this recommendation is relating to research study.

Moreover, (Jojoa-Acosta et al., 2021) analyzed to determine how the neuropsychological assessment of intellectual functioning in DS individuals during aging. The purpose of the research was to predict repressive control capacity using novel data-driven method. A sample of $n = 188$; 49.47% men; 33.6 ± 8.8 DS adult individuals having mild-moderate levels of mental retardation was taken into process. The authors used ML Random Forest model to support vector machine and logistic regression algorithms for prediction of inhibition capacity. Neuropsychological method was applied for data of assessment of memory skills, language skills, attention executive functions, and praxis were submitted for execution in algorithm. The research outcomes reveal that the finest interpreters for inhibition capacity were verbal memory, constructive praxis, planning, immediate memory, and written verbal comprehension. The authors recommend the least set of neuropsychological assessments and potential intervention for Down syndrome and Intellectual disabled individuals, to enhance capacity for independent surviving. The recommendations resemble to our research study.

James et al., 2017 employed a machine learning (ML) approach. The purpose of this approach was to predict mental age using structural neuroimaging dataset in DS individuals ($N = 46$) and typically developing ($N = 30$). The chronological age was subtracted from predicted age (mental age) to get

difference score of brain-predicted age. Further, to obtain the dataset the participants experience a Positron Emission Tomography (PET) scans to evaluate the degrees of beta amyloid deposition, and cognitive assessment. The research model analysed the brain-predicted age calculation in three levels. In first level, similarity index of Gaussian Processes (GP) regression model using Magnetic resonance imaging (MRI) dataset was collected. The model accuracy assessed in second level for differentiating brain-predicted age. In third and fourth levels, testing and brain-age was predicted, and model coefficients applied to the data from participants. For summarizing the variation in brain-predicted age a matric was defined after the above procedures. For further research the authors emphasized for examined trajectories of change in DS individuals to get further information about the likelihood of future neurologic decline and negative brain aging.

Similarly, Aida et al., 2018 proposed an Artificial Intelligence technology-based method to identify affected fetuses early in pregnancy through amniocentesis with accurate genetic testing to provide the woman with the preference for selective continuation of the pregnancy or termination. The aim of the study was to replace traditional process of chromosome photographs with artificial intelligence-based image processing recognition techniques and rule-based classification algorithms for karyotyping. To mimic physical structure, the authors proposed an automatic system to classify chromosomal classes using outcomes from screening tests in the trimester of pregnancy, and ultrasonographic findings. To get the dataset sample of 2500 pregnant women was collected to determine the figures of maternal levels. All women underwent ultrasound examination. After the ultrasound examination and maternal blood sample, the blood samples were analysed using the Prisca software. The Expert System based on Artificial Neural Network parameters indicates that the tested subject has one of the prenatal syndromes or is healthy.

Moreover, in a research (James H. Cole et al., 2017) highlighted the problem increasing brain diseases due to the burden of age-associated functional decline. Therefore, to better understand individual's differences in the brain ageing process techniques are required to propose for individual prediction of brain aging. The authors proposed a Machine learning supervised model for brain age prediction. Neuroimaging data obtained from MRI scans to process into machine learning regression model. Cross validation included 90% participants and predicted age of let out of 10%. The model is trained using the training process. The predicted mental age compared with the chronological age of test-set participants. The brain-predicted age difference between brain age and chronological age with older appearing brained assumed to reflect advance aging and younger brains. The predicted brain age used as a metric to statistically relate to other measured characteristics of the participants. The authors have emphasized that the technical aspects of analyzing brain age are further improved. Neuroimaging brain age measures could be used to evaluate neuroprotective impediments.

(Houssem Turki et al., 2014) proposed a Dynamic Bayesian Network (DBN) for knowledge extraction from historical data on temporal data to develop structure learning algorithm for predicting mental retardation in Down syndrome individuals. The experiment was taken place at Medical Genetics and Child Psychiatry at a hospital of Tunisia. Authors obtained heterogeneous dataset in collaboration with team of experts. The purpose of the research is the extraction of knowledge from great number of data which evolve in a dynamic way. The summarized study of the AI techniques is given in Table 1.

2.2 Proposed Neural Network Model

Apart from the analysing, the information processing is taken part with computational and technology sources. The computer simulation and Artificial Intelligence are very useful methods to get the identification of the Down syndrome and their mental and cognitive attributes. A survey over 50

Table 1. Artificial Intelligence techniques: Cognitive Analysis

Article details	Topic	Methodology used
Aida Catic et al 2018 Application of Neural Networks for classification of Patau, Edwards, Down, Turner and Klinefelter Syndrome based on first trimester maternal serum screening data, ultrasonographic findings and patient demographics	To identify affected fetuses early in pregnancy through amniocentesis with accurate genetic testing.	**Artificial Neural Network**
Amanda Saksida et al 2021 The Influence of Hearing Impairment on Mental Age in Down Syndrome: Preliminary Result	Analyzing whether hearing impartment has connection with cognitive problem of Down syndrome individuals.	-
Falin H.E et al 2021A Machine learning model for the prediction of down syndrome in second trimester antenatal screening	Trimester antenatal screening using Machine learning random forest model	**Artificial Neural Network**
Jamie O. Edgin et al 2013 Cognition in Down syndrome: a developmental cognitive neuroscience perspective	The assessment of several functions of this region seems relatively less impaired than other aspects of cognition. Spatial position and implicit memory are also less affected than object in location binding or episodic memory.	-
Houssem Turki et al 2014 Using Dynamic Bayesian Networks for the Prediction of Mental Deficiency in Children with Down Syndrome	Proposed a new approach to knowledge extraction from temporal data.	**Artificial Neural Network**

individuals with down syndrome processed under the observance of the psychologists and teachers of the homogeneous schooling system. The psychological traits of the individuals were evaluated in the technical part of the model using artificial intelligence The neural network model for Down syndrome learning process represent the patterns of statistical data. The model process the data of learning process. On the basis of the analysed applications and technology accessibility the intermediate layer reveals the different abilities, memory, decision making, logic and learning complexities. The research classifies the results of application into three parts that are mild, moderate, and severe. Classifications are further sorted into statistical range between maximum to minimum IQ level (20-75%). The model shapes out the technical roadmap of the scenario. The input is processed using applications to get the behavior output.

3. DISCUSSION

The research model used various phases to highlight the existing cognitive strengths of partially damaged or disabled people. The three major components of cognitive psychology cognitive Neuroscience, Human psychology, and Information Processing. As per the neuroscience perspective, the thinking abilities depends on working memory. The domain of cognitive psychology focuses on study of higher mental functions with particular emphasis on the ways

in which people acquire knowledge and use it to shape and understand their experience in the world. Different qualitative methods were approached for dataset, that includes, interview, interactive research activity and survey for evaluation Problem-solving and Learning and identification of the mental and rethinking abilities of the DS individuals. Different attributes thinking, perception, attention, sensing, and reasoning analysed and information processing taken place for computational and technology. Computational intelligence system PDSR used to evaluate the mental skills. Research activity based on interactive smart technology was arranged to analyse the intelligence, learning ability and rethinking ability of the Down syndrome people. The individuals participated in event with parents to access the computer and smart technology. The interactive Software approach provided learning environment for the different age group of Down syndrome individuals. Graphical environment of the software attracted and caught their attention. The software provides interesting learning and enhancing logic and reasoning of the individuals.

Considering the investigation for actual mental level and/or age of mentally retarded Down syndrome individuals, the process of analyzing limited mental challenge is explained as follows: firstly, identification of down syndrome and cognitive traits are investigated by the team of psychiatric team with the help of a survey. Secondly, the gathered information processing was initialized; changes in behaviour, psychology and communication skills and are examined by computer information processing; and finally, when down syndrome changing behaviour and facial expression data is used to identify down syndrome. In particular, the detection of these facial, psychological, cognitive structure and behavioural levels helped for technological portion of model in evaluation of mental level of individuals.

However, diagnosing actual mental age of Down syndrome is one of the most challenging tasks in psychological and clinical studies, and thus right solution precisely falls within the area of machine learning. Hence, such methods cannot always accurately and rapidly investigate ratio, rather than a prescribed intelligent quotient (IQ) level in the manner of conventional ratio. Moreover, artificial intelligence techniques i.e., neural network and software approach can help psychiatrics and medical practitioners to provide more accurate and efficient diagnoses of mental age level.

Hence, the usual AI model based application software in this area is in investigating mental level based on ANN. Interactive software approach can accurately evaluate the mental level in processing the psychological traits information process through an artificial neural network model. In the background study of past decade, different AI techniques were analysed in investigating the cognitive strengths and improving the academics using software approaches and other tools.

The cognitive traits thinking, memory, logic, communication and behavior of the individuals with low learning and communication capabilities on getting aid in shape of illustration, assistive technology, and visual support. The information is processed via usability of the computers and simulation process. Down syndrome individuals learn better when they can see things illustrated in table 2.

4. CONCLUSION

During the artificial intelligence age of last decade an essential number of studies are addressing the use of Artificial Intelligence techniques to support people with cognitive impairment in social life, academic and employment needs. This article illustrated upon the valuable studies that tried to solve problems in evaluating and diagnosis of mostly researched cognitive impairment i.e., Down syndrome. Wherein, artificial intelligence neural network model-based techniques and software approach were

Table 2. Information processing via computer of the psychological traits

Psychological attributes	Individuals
Understanding communication level	23
Perception	22
Attention	41
Sensing	15
Reasoning	23
Social rules	31
Judgement and decision making	25
Quick problem solving	14
Dependency and low self-esteem	11
Responding	5
Remembrance	32
Fine-motor skills	7

implemented to bring down syndrome analysis and seek ratio of their mental approach and to further strengthen with software. Based on the literature's recommendations and gap presented in this work, it was concluded that the actual mental age of Down syndrome individuals can be obtained using conventional and artificial intelligence approach. Moreover, the interactive software approach can be the good source of representing a domain for such individuals in enhancing the mental approach. Similarly, DS individuals improve cognitive traits, learning, mathematics skills, decision-making through interactive software approach.

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Dr. Syed Asif Ali and M. Irfan Leghari declare that they have no conflict of interest to disclose.

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