**Cataloguing of Attention Deficit Hyperactivity Disorder (ADHD) among Children**

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***Abstract****:*

Children are the dream of parents. Children ADHD is a bygone and chronic disorder which leads to problems in children. If not solved in childhood stages will continue in future till adolescents. The disorder consequences are difficulty to study the tasks which are related to anxiety, depression and other psychological problems. Hence the disorder must be resolved in the early stage to control any type of consequences in future for our children.  The medical field is an eminent area in today’s world such as signal processing, Imaging, MRI, EEG etc. to diagnose and offer treatment. Even technology field too contributing to ADHD children by providing different techniques in different areas such as IoT, mobile, Robot, Application, virtual reality, augmented reality, machine learning techniques etc. to give diagnosis and treatment methods. The paper reviews and summarizes the set of features, diagnosis methods, treatment rules for ADHD children.

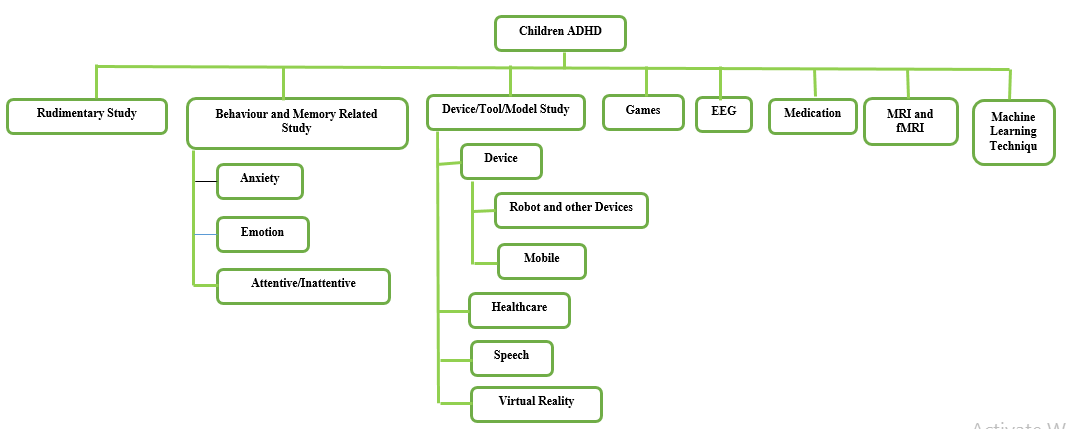
***Index Terms:* ADHD, Children, Attention, hyperactive, impulsive, diagnosis, data analytics, machine learning techniques**

**1. INTRODUCTION**

An ADHD syndrome is a critical medical disorder for children. An ADHD children’s brain and their activities are diverse compare to other children. The children lose their interest in any type of activities such as reading, writing, playing, etc. The disorder can affect child at various locations such as home, school, surrounding friends etc. Children may feel disturbed to concentrate on their interested topics, listen to instructions, many more. ADHD children never sit in a single place and quite, their mind always swings. ADHD children struggle more in their daily life to do any activity and it happens frequently. The most challenging factor is how to analyse the disorder by considering the symptoms of children and finally what is the remedy for child.

The review is a combination of various fields of solutions to ADHD disorder and describes the methods for disorder diagnosis, various children behaviours, and set of solutions to disorder. The problem can be solved using some of the treatment methods such as tools/applications/questionnaires/ game application/ analysis methods and many more. One among many solutions is robot technology, which assists child in various learning process. This is a break point for researchers who are willing to work on children ADHD. The important advantage of the assessment is to understand the current progress in the analysis of the disorder, better and improved solutions to the problem, new methods and techniques as solution to problem, advanced and past work, symptoms of the disorder. Some of the common ADHD symptoms are like hyperactivity, impulsive, inattentive, depression, anxiety etc. These are the well-known symptoms of ADHD in children, suppose the problem is not solved in early stage the impact is it will affect them in their adulthood too. An ADHD adult features are suicide attempt, anxiety disorder, psychiatric disorder, regular accidents, procrastination, commit violent activities etc. In medical field study of ADHD for children is a crucial factor which solves many children problems.

Multiplicity of diagnosis procedures, treatment process for ADHD children comprises of various fields. A literature review on ADHD children to compare child’s epilepsy, attention deficiency, sleep deficiency [1], summarizes the articles designated on ADHD study. The main objective of the study is to relate epilepsy, sleep, epidemiology, comorbidities, their diagnostics procedures are precisely described. The review concludes that the multiple symptoms related to ADHD must be measured thoroughly before initiating any kind of treatments. A research on hotspots of ADHD designed by Hou Jiang-hao [2] presents a list of significant parameters which are in boom to do research. The study even assists doctors to understand key parameters on current ADHD research. It involves 11873 number of PubMed research papers to analyse the data and to provide conclusion. A research on ADHD children’s experience and accepting their disorder is abstracted by Noam Ringer [3] and follows a meta synthesis procedure. Classification is made on systematic search, critical appraisal and an interpretative integration using a variety of sources of research publications. The study also presents detailed summary of work done in various locality with statistical analysis. A review survey on ADHD [4] comprises the technologies for treatment and diagnosis process of the disorder. The work concluded by providing a universal system design related to computer vision, neuropsychological assessments for the diagnosis and treatment method for ADHD. Till today a research is under progress on Children ADHD. A summary on children ADHD is depicted in Figure 1, which includes various areas/ methods/ techniques which are contributed towards the disorder. The idea behind the review is how the flow of the diagnosis, treatment methods are carried from the beginning. Here it is summarized that the work activities related to Rudimentary study involves starting from 2000 to till 2014. The next generation with multiple diversions are listed between the year 2015 till date. It includes various fields of study related to children ADHD and is showcased the work done during these days.

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**Figure 1. Taxonomy of Children ADHD in various fields**

**2. RUDIMENTARY STUDY ON ADHD**

An ADHD disorder was started in the year 1902. A British paediatrician called Sir George described the problem as “It is an abnormal defect/deficiency of moral control especially in children”. Also he tells ADHD children are still very intelligent. The study on ADHD in children continued till date. The section encompasses the summary of few research works related to ADHD in children during the interval 2000 to 2014. The classification method on ADHD using Deep Learning [5] by Deping Kuang is compared with multiple classes using NYU dataset. The Deep learning DBN (Deep Belief Network) method proves effective discrimination between ADHD control with subtypes. A research work on Sustained attention differences [6] presented by Gao Yang, in this study an Auditory and visual test with time series method is used for the comparison of various data. The result shows a significant difference among 20 ADHD and 20 Non ADHD children. A study on “The effect of ADHD on the life of an individual” [7] designed by Harpin, the study illustrates the discussion on ADHD which concludes that the disorder affects both professional and personal life. Hence this leads to increase in healthcare cost too. An author Hartmut Heinrich [8] introduced wavelet network for signal representation for well-deﬁned parameters. The work proves that the single sweep analysis method is a sensitive for clinical Event Related Potentials. A statistical analysis of brain surfaces in Gaussian fields using 2 dimensional manifolds [9] designed by Ravi Bansal, and demonstrated importance of statistical methods applying on the shape of amygdala hippocampus with ADHD. The analysis comparison result shows that the two groups were used for study are not statistically significant. Related to behaviour a study proposed by John [10] who worked on Technology and audio-video games are used to progress the ADHD children behaviour. The results are summarised using tasks behavioural improvements. The summary of all these works are listed in the Table.1 as a rudimentary approach for diagnosis and treatment method for ADHD.

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| **Table 1. RUDIMENTARY STUDY ON ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [5]Classification on ADHD | Deep Belief Network (DBN), Convolutional Neural Network (CNN) | Predict the ADHD subtypes | Classification | Feature Extraction and Classification | Improved performance | Effect of Imbalance in DBN in detail |
| [6] Sustained attention differences | auditory-visual continuous performance test and multiple time series sampling | Attention | continuous performance tests (CPT) | Auditory-visual continuous performance test | Significant difference | Experimental procedure is not set to run full-screen and subjects can see the time in the bottom of the screen. |
| [7] The effect of ADHD | Child Health Questionnaire (CHQ) | Multidisciplinary of ADHD | Comparison, Assessment | Higher scores indicative of greater functioning | Treatment of ADHD should be instituted | Not found stimulants influence growth |
| [8] Event-Related Potentials by Wavelet Networks | Extraction of latency and amplitude parameters | Event-Related Potentials signals | Classification | Gaussian functions, Wavelet Networks | Applied to an analysis of averaged responses. | Performance ned to be improved |
| [9] Statistical Analyses of Brain Surfaces | Brain images Comparison | Set of segmented brain images | statistical shape analyses | Analysis | Demonstrate the effectiveness of statistical methods | Conformity condition not be completely satisﬁed |
| [10] Computer Gaming and ADHD | Collection of brain activity (EEG) using electrodes on the scalp | Attention | Technology and video games | Technology‑based approach | Task and behavioural improvements were reported | Need to optimize the outcomes for users |

**3. BEHAVIOUR AND MEMORY RELATED STUDY**

**ANXIETY**

One of the resultant symptom of ADHD is anxiety. The section summarizes the research works related to children ADHD and anxiety. An author Anaïs Fournier [11] presented a comparison analysis on ADHD and non-ADHD neurotypical children patients using Five Point Test (FPT). Study includes ADHD children with three groups such as control, ADHD and ADHD with anxiety. Statistically shown children with anxiety disorder presented less designs, and also reflects excess of inhibition feature. A study on children anxiety designed by Emma Sciberras [12] using a technique called cognitive behavioural method. The data collection process is done using REDCap application. Work concluded that evidence shows whether the treatment for ADHD anxiety children using cognitive behaviour therapy approach improvements to anxiety or any broader outcomes. Jiyoon Shin [13] worked on psychometric features and factors of children ADHD anxiety property. It is proved that different varieties of factors and features encompass and reflect the dissimilarity among US and Korean people. A study on anxiety and depression [14] by Lian Tong shows the relationship between ADHD and sleep disorder when patient having anxiety or depression problem. The questionnaire procedure and analysing the accumulated data proves that children must follow regular proper bedtime and emotional management to reduce the ADHD problem. A work on anxiety for children [15] at the age of 15 diagnosed and predicted as suicidal ideation in their adulthood era. Compared the data values between Swedish, Sweden and Dutch twins. Work concluded that the anxiety factor if not solved in early stage it may leads to risk factors in their adulthood. A study by Vadood Javadi Parvaneh [16] is on anxiety disorder of a children. The method uses two criteria such as Beighton and Shiari-Javadi for the comparison purpose. It is proved that children those who have the anxiety disorder in such cases the occurrence of hypermobility is three times more. These are summarized and listed in the Table.2 as an anxiety related diagnosis and treatment method for children ADHD.

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| **Table 2. ANXIETY RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [11]Design Fluency in Children | Five point Test | Anxiety, Attention, troublesome | Biopsychosocial and psychiatric standardized evaluation | Questionnaires, cognitive assessment | Shows design ﬂuency is helpful | Requires develop tools to further study |
| [12] Treatment of anxiety in children | Cognitive Behavioral Therapy | Anxiety | Research Electronic Data Capture(REDcap) | Telephones parents, Interview | Improvements in anxiety | Need to test in clinic |
| [13]Child Anxiety | SCARED, KSADS-PL, CBCL | Anxiety Disorder | Korean SCARED | Assessment | Suggests it is a promising screening tool | Designed for Korean people |
| [14] Anxiety/depression in the relationship | Stratified random sampling | Anxiety/depression | Questionnaire | Children’s Sleep Habits Questionnaire | Bedtime management and emotional management may reduce sleep problems | Child report of sleep problems was not collected |
| [15] Anxiety at age 15 predicts psychiatric diagnoses | Parental and self-report | Anxiety, Depressive disorders | Regression analyses | CATSS, NPR | Anxiety leads to suicidal ideation | Needs to further empirically investigation |
| [16] Prevalence of generalized joint hypermobility | Beighton and Shiari-Javadi criteria | Anxiety Disorder, Hypermobility | SPSS software | Spence Children Anxiety Scale (SCAS) | hypermobility was higher in children | Practitioner should focus on somatic complaints |

**EMOTION**

An emotion is the prominent symptom of ADHD disorder. A work designed by Aliki Economides [17] and others on ADHD emotion recognition for primary students. Considered six basic emotional features for analysis and proved emotion examination deficit was found. A related work designed by Catharina A. Hartman [18] on emotion shows how stress affects mood and creates anxiety problems in children. It is concluded that the stress factor strongly influences the ADHD for children and their adulthood too. A propose called Callous-unemotional [19] used to prove an executive function influences on ADHD and ASD. The result highlights the significance of these factors in assessment of executive functions any variety of neuro related disorders. The summary of all these works are listed in the Table.3 as an emotion related diagnosis and treatment method for children ADHD.

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| **Table 3. EMOTION RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [17] Specific Learning Disorder | Emotional facial recognition test was administered | Emotion recognition | DSM-V,DSM-III | Comparisons, ANOVA | Discussed considering past research and future directions | Many did not investigate all six basic emotions |
| [18] Stress Exposure and the Course of ADHD | TRAILS population sample was divided into screen positives and negatives | Stress, Emotion dysregulation, anxiety, depression | Multivariate latent class growth analysis | TRAILS (Tracking Adolescents’ Individual Lives Survey) | Stress–facilitating and sustaining role in the persistence of ADHD | Does not allow inferences of causality |
| [19] Callous-unemotional traits moderate executive function | Data were analysed in Brain Vision Analyzer | Callous unemotional traits | Questionnaire(SDQ) and Assessment (DAWBA) | Inventory of Callous-Unemotional Traits | CU traits provide a relative cognitive strength in conflict monitoring | Not included if they had any psychiatric diagnosis |

**ATTENTION**

A crucial feature of ADHD is attention. Some set of research work related to attention and inattention were discussed here. A study on target shooting game related to sports [20] carried out by Annegrete Gohr Månsson considering attention, impulsive and hyperactivity. The result shows effects on ADHD children those when they participate in target shooting game and also how it effects their quality of life too. A study on children ADHD attention [21] using a special attentive visual device, which involves head tracking system. Study results that color and highlighting are a significant factor, even tracking modality also matters. A work related to attention by Fatemeh Fahimi [22] proposed detection of attention of ADHD children. The study demonstrated that the features such as relative beta, TBE and TBAR are all significant measures to detect the level of attention. The summary of all these works are listed in the Table.4 as an attention related diagnosis and treatment method for children ADHD.

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| **Table 4. ATTENTION RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [20] Influence of participation in target shooting sport | ADHD-RS-IV, SDQ, and KIDSCREEN-27 questionnaires | Inattentiveness, Impulsivity | Questionnaire | Mixed method approach | Influence children’s psychological wellbeing and quality of life | Children are supervised at all times by a designated adult instructor |
| [21] Extending Attention Span | Randomly selected a school for conducting the study | Attentive User Interface | Questionnaire survey for the teachers | A webcam and mouse | Results are in line with previous studies | Absence of female subjects |
| [22] Personalized Features for Attention Detection | The data are recorded using a dry EEG headband | Attention | Applied wavelet decomposition method | Mutual Information (MI), theta beta ratio (TBR) | Investigate the changes in EEG features | Need to investigate the changes in EEG features |

**4.DEVICE /TOOL/MODEL**

**ROBOT**

An ADHD children have a symptom such as attention, hyperactivity and impulsive nature. Varity of solutions are introduced to the fields of medical field. Among many robot and some kind of innovative devices are presented to ADHD children. A research on developmental disability designed by Felix Jimenez [23] and others. It is a learning technique between robots and children those who have symptom of developmental disorder. A robot device is set up to interact with children in real time, and the result shows that there is an improvement in ADHD children concentration. A technology designed by Oscar Navarro [24] which introduces a device to track eye movement for children those who are suffer from attention problem. Study concluded that children those who sustain the features of attention deficit and hyperactivity features have more fixations compare to other participants. A study [25] designed by Isabela M. Mercado-Aguirre to evaluate ADHD children. A device called Emotive headset is designed to keep track of brain EEG signals, these are recorded to analyse further. The device is cost effective tool, ease of use and comfort to collet brain signals. The summary of all these works are listed in the Table.5 as a robot related diagnosis and treatment method for children ADHD.

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| **Table 5. ROBOT RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [23] Effects of Collaborative Learning | Robot that teaches children | Development Disability | The robot and children engage in collaborative learning | Experimented in “Hikari Kids” | Robot prompts gray zone children to improve their concentration | Need longer-term experiment |
| [24] Experience of use of eye tracking technology | Reading Test | Attention problems | Specific space designated for the Orientation Team |  | Some differences in the observation process of students. | Less number of participants |
| [25] Acquisition and Analysis of Cognitive Evoked Potentials | EEG signal from the EPOC+ is acquired | Brain activity of the patients | Psychology Laboratory of Universidad Tecnológica de Bolívar | Questions were answered | Abnormalities were detected | Not shown ERP wave |

**MOBILE**

Another era of solution for children ADHD is using mobile devices. A study [26] on ADHD applications using mobile device is designed by N. Pandria. It is a WHAAM mobile application which provides a good framework calculating and measuring ADHD children behaviour parameters. A work related to mobile application called iCare ADHD designed by Jarernsri Mitrpanont [27] and others to assess the children. It has several advantages such as to assess child may have ADHD symptom, supports early state treatment, assists psychiatrists by providing the information. In addition, assists doctors to give treatment for ADHD child. The summary of all these works are listed in the Table.5 as a mobile related diagnosis and treatment method for children ADHD.

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| **Table 6. MOBILE RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [26] The Future of Mobile Health ADHD Applications | Functional Behavioral Assessment (FBA). | Child behaviors | WHAAM application | Mobile Application | Provides a framework for counting and measuring behavior’s parameters | Can be enhanced using mobile new technologies |
| [27] iCare-ADHD | ADHD Screening, Diagnosis, Treatment, Follow up | Possibility of occurrence of ADHD symptoms | Questionnaires, Java, XML | iCARE-ADHD prototype is developed | Supports the doctor treatment and follow up process | Performance can be improved |

**HEALTHCARE**

Another feature of ADHD diagnosis and treatment method is healthcare. Many applications are designed using set of questionnaires, checklists etc. A research TAND [28] related to checklist is a screening tool for ADHD patients. The results determine that this is an agreeable, possible mode in clinic. A study on smart home [29] setup is an environment for ADHD children to do their regular homework. The solution provides a novel procedure therapy for ADHD children in assistance with IoT technology. The summary of all these works are listed in the Table.7 as a healthcare related diagnosis and treatment method for children ADHD.

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| **Table 7. HEALTHCARE RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** | |
| [28] The TAND checklist | Data were analyzed using the Statistical Package | Neuropsychiatric Disorders | Brain MRIs and clinical/instrumental disease-specific | TAND Checklist | Explores the use of tool in patients with NF1 for the first time | Enhancement to adults | |
| [29] Smart-Home Environment | Interaction of children | Attentional pathologies | Robotic assistant | Smart-Home, Intelligent environment | Ready for a clinical pilot | Translating the type of required interaction for pervasive therapy into intelligent things | |

**SPEECH**

A research related to speech therapy designed by Chinnaaiah [30] in assistance with Embedded system worked on children voice level. The model examines the children voice pitch level and it is compared with the standard. If there is any difference the system instructs child to adjust the voice pitch. The system can be enhanced using mobile and android devices.

**VIRTUAL REALITY**

Virtual Reality (VR) is the advanced technology in computer field. Which includes simulated environment for users to feel it has completely a new world. A study related to VR designed by M. Ibrahim [31] for ADHD children. It is a type of classroom virtually designed for ADHD disorder patients. The proposal result shows that ADHD students can get significant advantage of the virtual classroom. Another research proposed by Ummay Faseeha [32] in virtual gaming especially for ADHD children. It is a combination of game called Mind race and EEG signal headset device to measure brain waves. The resultant of the work shows it is an entrainment treatment method for ADHD children to improve their concentration, attention and focus. An application for ADHD children [33] with amplified reality designed by Pei-Hua. It is an interactive augmented reality procedure designed for positive interaction and even when difficulty level increases sustain the continuous response need to maintain. The summary of all these works are listed in the Table.8 as healthcare related diagnosis and treatment method for children ADHD.

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| **Table 8. VIRTUAL REALITY RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [30] A Versatile Assistive Device for ADHD with speech Therapy using Embedded System | Collection of child voice | voice | ArduinoUNO Board | Speech Analysis | Device is more flexible and wearable | Applications for mobile platforms |
| [31] Synchronous virtual classroom | Interaction between teacher and students | Attention | Learning Management Systems (LMS) | Information and Communication Technologies (ICT) | Improve the teaching process for these students | Infrastructure and availability of assistive tools |
| [32] Virtual Gaming | Interaction with patients | Attention | BCI system | Video game named “Mind Race” and the EEG | Aims to provide entertainment-therapy to the patients | Advanced technology to control game by brain |
| [33] Application of amplified reality | interviews, teaching, actual measurement research, and post-test questionnaires | Interactivity | Head-Mounted Display (HMD) | Augmented reality | Interactive building blocks to attract the attention of young children | Related to Italian CHICCO-APP interactive building blocks |

**5.GAMES**

Games are the intellectual activities for children, which provides entertainment, logical thinking, coordination, brain thinking speed, attention, concentration etc. A research BCI videogame [34] designed by John E. Muñoz for ADHD children. It is called ‘The Harvest Challenge’ game which as set of aspects such as planning, waiting, follow instructions, achieve objects abilities. Results shows a sustained attention in ADHD children with beta and theta waves. A study on gamification [35] for ADHD children in e-learning process designed by Arman Syah Putra and others. The game is the combination of body movement, sports, logical thinking, in addition there are five methods which are proposed to play game. The study proves that ADHD hyperactive children can become calm and learns good lessons through the game. An augmented reality game designed by Diego Avila-Pesantez [36] to improve ADHD in children. The game prototype uses an interface called Kinect, which results in attention and their frustration tolerance were improved. The summary of all these works are listed in the Table.9 as games related diagnosis and treatment method for children ADHD.

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| **Table 9. GAME RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [34] Design and Creation of a BCI Videogame | Video game generates EEG signal | Neurofeedback | Health, engineering and multimedia design. | Videogame | Measured by low cost brain computer interface | Therapy not a short and recurrent procedure. |
| [35] Gamification in the e-Learning Process | Users learn quickly and quickly handle | Brain, think, body, move, sport and logic | Game design | Logic game | Benefits Engagement, Attention Span, Mental Flexibility etc | Further research can be done by combining thought, bodywork, motivation |
| [36] Towards the Improvement of ADHD Children | Serious games | Methodical game design approach along with natural user interface (Kinect) | Augmented Reality Serious Games | Using the traditional & ATHYNOS game | Promotes voluntary participation | Necessary to implement more Augmented Reality Serious Games (ARSG) |

**6.EEG**

An Electroencephalography (EEG) historically plays significant role in to extract brain signal waves. A study cognitive capability using EEG signal [37] is a novel approach to study and improve the capability of ADHD children. A neural network procedure is introduced to differentiate ADHD and non ADHD patients, it is proved lower parameters for non ADHD participants. With EEG signal recordings [38] ADHD is detected by processing transfer learning method. Uses a convolution neural network method to achieve 94.39%, 97.83% and 91.80% among accuracy, sensitivity and specificity respectively. A research work Neurointerfcae [39] designed to assists ADHD children. It is proved that using some playful method children can learn the required techniques to against syndrome. The summary of all these works are listed in the Table.10 as EEG related diagnosis and treatment method for children ADHD.

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| **Table 10. EEG RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [37] An Approach to Measure and Improve the Cognitive Capability | Comparative analysis | Behavioural, Educational evaluation. | EEG signals of non – ADHD and ADHD participants | Single map analysis | Root cause for the syndrome epilepsy and fever | New methodology or techniques of teaching |
| [38] Use transfer learning to promote identification | Recorded EEG signals | image classification | Pre-trained a VGG-16 model | Subjects and EEG recording | Accuracy of 94.39%, sensitivity of 97.83% and specificity of 91.80%. | Overall accuracy of the ten-class classification was 83.66% |
| [39] Development of a Neurointerface | Signal processing | Concentration | Game Design | Game written in Unity | It is assumed that children with ADHD in a playful way to learn the necessary skills | Expected to provide an accurate calculation |

**7.MEDICATION**

An ADHD requires medical treatment when it crosses the limit. A work related to medical treatment for ADHD [40] designed by Maria Keilow to improve the children’s academic performance. The result shows that the medical treatment for ADHD reduces the negative consequences of patients. A research work related posture balance [41] with medication and without medication. A mobile device is used to evaluate gestures. Result strongly recommends that medication is the effective solution for ADHD children. A related work to medicine uses Melatonin [42] effects on ADHD children. The research method uses a novel method called growing neural forest and concludes that it’s impossible to make a difference among patients before and after medicated. A research work and treatment provided at home [43] uses medicine methylphenidate. It uses procedures such as artificial neural network, neuro feedback, and it is drug controlled trail in children, moreover treatment is provided at home. The summary of all these works are listed in the Table.11 as medication related diagnosis and treatment method for children ADHD.

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| **Table 11. MEDICATION RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [40] Medical treatment of ADHD | Estimate the effect of medical treatment on school-leaving GPAs | Behaviour | DPT, APT, CPT | Danish administrative registers collected by Statistics Denmark | Increased efficiency of medical treatment of ADHD can alleviate a substantial part of the GPA gap | Medicine exerts a profound influence on the educational outcomes of children |
| [41] Postural Balance Performance of Children | Data was collected via a Bluetooth link | Postural balance | Matlab script | Subjects were recruited from the visitors of Tehran Institute of Psychiatry | Portable balance assessment tools helpful | Further research is needed |
| [42] Use of an ANN to Value MTF | Therapeutic intervention | Sleep disorder | A multimodal treatment regimen designed | Artiﬁcial neural networks (ANNs | ANN methodology as an important tool | Particular situations not considered a priori |
| [43] Personalized at-home neurofeedback | Clinical trial, Demonstrate the non-inferiority of a personalized Neurofeedback Training device | Neurofeedback | NFT group (Neurofeedback Training Group) and MPH group | Study is a prospective, multicentre, randomize, reference | Shown this is the first non-inferiority study | Clinicians were not blind to group assignment |

**8.MRI and fMRI**

Magnetic Resonance Imaging (MRI) is a medical technique, in which patient has to take up radiology test, it is a scanner which generates radio waves of the organ. A study T2 MRI [44] designed to check iron content in brain. The result shows a significant difference among ADHD and non ADHD patients, also no correlation was establishing. An investigation [45] procedure of MRI scan used to measure the brain volume and its regions, to find fractal area among ADHD and healthy children. The technique is a novel method to diagnose the disorder and also proves that the symptoms are because of structure of the brain. A study on fMRI [46] to sparse coding based on network analysis for ADHD. The result shows an improved performance of classification when compared with independent component analysis. The summary of all these works are listed in the Table.12 as MRI and fMRI related diagnosis and treatment method for children ADHD.

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| **Table 12. MRI and fMRI RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [44]T2\* Magnetic Resonance Imaging | Selection of appropriate axial image | Brain iron content | T2\* MRI tool | T2\* MRI to assess brain iron content | T2\* represents a reliable tool | Not for ADHD severity |
| [45] Investigation of Brain Volume and Brain Regions | Brain volume and the calculated fractal dimension | Brain regions’ fractal dimensions | SIEMENS TRIO 3- Tesla scanner | Statistical analyses using Statistical Package for Social Sciences (SPSS) | Used in transcranial electrical current stimulation (tECS) | Needs more investigations |
| [46] Deriving ADHD Biomarkers | Classification Based on Functional Connectivity | Brain ROIs are localized from the learned dictionary | Novel data-driven temporal sparse coding framework | Dataset acquired in the NYU Child Study Center | Improved performance | Framework could be tested and applied in other brain diseases |

**9.MACHINE LEARNING TECHNIQUES**

A Machine Learning (ML) approach provides a diagnosis and treatment method for ADHD. A study on ADHD [47] using ML approach for distinction ADHD and Obstructive sleep apnea designed by Kuo-Chung Chu. The study proposes difference among 17 items with 3 groups, also proves CART model is better compare to others. An extreme learning method for ADHD [48] proposes classification using novel feature extraction procedure. The result shows novel method achieves a better classification result compare to the existing classifications techniques. A research work proposes deep learning [49] based EEG to differentiate ADHD and non ADHD children. The result concludes that the novel approach provides a promising support to doctors to diagnose ADHD in children. A cross cohort method [50] using feature selection framework for ADHD designed by Dongren Yao. A new framework is compared with existing alternative methods and proved this is the better one compared to other techniques and achieved an accuracy of the framework as 70%. The summary of all these works are listed in the Table.13 as ML related diagnosis and treatment method for children ADHD.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Table 13. ML RELATED STUDY ON CHILDREN ADHD** | | | | | | |
| **Research Work** | **Procedure** | **Target Features** | **Platform Used** | **Methodology** | **Outcome** | **Drawback** |
| [47] Machine Learning Approach | CBCL, DBRS | Behavior, sleep | Machine Learning, Confusion matrix | Questionnaires,  CART model | Better computational efficiency | Collection is very difficult |
| [48] ELM-Based Classification | Supervised Classification via KELM | Brain fMRI dataset | Local Binary Encoding Method | Novel local feature extraction method LBEM | Achieved better classification performance | Evaluate local features |
| [49] Deep Learning Based on Event-Related | EEG Recording and Analysis, Deep Learning | EEGNet | Low resolution brain electromagnetic tomography (sLORETA) | interviews, questionnaires, and IQ and attention testing, | Classiﬁcation accuracy was high(i.e.,up to 86%). | Work to be done to increase the reliability |
| [50] ADHD Classification Within And Cross Cohort | Nested cross-validation strategy | 1D-convolutional neural network | Gradient Boost, Random Forest, Extra Tress, and XGBoost | FS\_RIWEL | Performance is better, 70% accuracy was achieved | Different model counts not the same score on these features |

**10. SUMMARY OF ADHD PROBLEM**

A survey on Children ADHD is summarized in this work. The research related to ADHD was started in the era 1902. The paper comprises the children ADHD. It encompasses the research works during the period of 2000 to till date. Numerous fields contributed their work towards children ADHD. It is depicted in figure 2, shows year wise work done in the field of children ADHD. The survey includes significant work done in various fields year wise. The work done related to children ADHD is shown in figure 2, which illustrations the number of research work is done with respect to year.

**Figure 2 Analysis of the work done on children ADHD**

**11.DISCUSSION**

In medical field various technologies were providing solution to children ADHD. Such as electronic devices, IoT, Augmented reality, virtual reality, video games, headset and many more. Some set of applications for instance machine learning techniques, big data, questionnaires, etc. Among many methods big data and machine learning techniques plays a unique solution to ADHD disorder. These fields are encompassed with many areas such as medical EEG signal, support vector machine beta-theta-sigma signals, principle component analysis and many more. The incorporation of medical and technology together provides fruitful result in medical field for ADHD diseases. Some of the techniques are classification [51][52], prediction models [53][54] present an excellent solution to ADHD.

The combination of Big data and machine learning techniques plays a vital role in health care field. In big data the complexity lies in different types of information which are emerged from variety of sources. The growth of big data technology practice is escalating every day. In hospitals the records of patients are in multiple formats such as electronically scanned or captured documents, clinical records, using mobile applications, electronic sensors, social media applications, patients record summary, pharmaceutical records, tele medicines etc. It is required to use robust technology which has provision heterogeneous sources of data formats. In this approach big data and machine learning tools/techniques contributes to health care filed. Some of the common algorithms such as Logistic Regression, Naïve Bayes, Stochastic Gradient Descent, K-Nearest Neighbours, Decision Tree, Random Forest, Support Vector Machine can have incorporated in analysis procedure.

**12. CONCLUSION**

A review on children ADHD is proposed to understand the current work done in this filed. A work related to [55] ADHD diagnosis and treatment method includes the both children and adult. This is a novel approach for children ADHD. The work shows several fields are participating to contribute their research ideas/proposals/hypothesis in the field of children ADHD. The medical field is an distinguished area in today’s world such as signal processing, Imaging, MRI, EEG to diagnose and provide treatment. Even technology field too contributing to ADHD children such as IoT, mobile, Robot, Application, virtual reality, augmented reality, machine learning techniques to provide diagnosis and treatment methods. The paper reviews and summarizes the set of features, diagnosis methods, treatment procedures for ADHD children.

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