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A Predictive Model To Find Hearing Loss In Children Using Machine Learning Algorithm

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ABSTRACT

Hearing is necessary for the development of language, speech, and cognitive skills. Hearing as one of the most important senses of human beings it enables to listen, laugh, and enjoy the quality of life of a person including childhood. Hearing loss may have the devastating effects on the development of a child's ability to learn, to communicate, and to socialize and connect with the world. Living quality of life is a constitutional right as well as human right of every individual. Indian constitution under Article 21 guarantees the right to life and liberty and right to health is an inherent to right to dignified life. Further it is provided under directives for social security, sickness and disability benefits to lead a dignified life. The right to life includes the right to health, a dignified and quality of life. To fulfil this right as fundamental right State requires that health care should be made available and affordable to all the people. Hearing loss to the person may impact on the development of a child's ability to learn, to communicate, and to socialize. It can be a devastating condition not only for the children but also their parents. But many children are having heard loss or sometimes deaf mutation by birth or after birth. Hearing impairment is an invisible handicap and hence its effects are not visible to others, so deafness in a child often goes unnoticed. In this paper, predictive model is proposed to find hearing loss and to give recommendations using machine learning techniques. A predictive model is developed for various regression algorithms and determined its performance metrics. Data set is collected in special education school, Tirupati, Andhra Pradesh children who are hearing impaired and taking speech therapy. Regression algorithms such as decision tree, support vector, Lassa, Random Forest and Linear regression. Based on the performance metric values, Lassa regression outperforms other algorithms on this live data. Comparison analysis is made and proved that Lassa regression algorithm is suitable for this dataset.

Keywords: Constitution of India, Machine Learning, Hearing loss, Lasso regression, right to life, child rights.

1. INTRODUCTION

Health is wealth. Constitution of India the supreme law of land (Indian territory) under article 21 guarantees right to life and personal liberty for everyone even for foreigners and the state has duty to ensure it. the right to health is an integral part to a dignified life. The right to health is inherent to a life with dignity. The Indian constitution mandates in its fundamental rights and Directive principles chapters that everyone has the right to a standard of living adequate for the health and wellbeing of himself and of his family, including food, clothing, housing and medical care and necessary social services, the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control and motherhood and childhood are entitled to special care and assistance. Part IV of the constitution under Directive Principles of State policy under Articles 38, 39, 42, 43, & 47 put the obligation directly on the state in order to ensure the effective realization of the right to health and it is applicable to the private sector employers. Throughout the world health care has now been a matter of great concern. Hearing is necessary for the development of language, speech, and cognitive skills. Effects of hearing loss on the development of a child's ability to learn, to communicate, and to socialize can be devastating. But

many children are having heard loss or sometimes deaf mutation by birth or after birth. Since exposure to a normal acoustic environment is required for maturation of peripheral and central auditory pathways, a significant reduction of sensory input induces both anatomical and physiological alterations of auditory pathways. If no auditory rehabilitation is done by per lingual period, the child develops permanent speech problems.

2. LITERATURE SURVEY

Children learn to converse and comprehend by hearing words and sounds. A youngster deafened by noises like these is not exposed to them. This may lead to issues with reading, speaking, succeeding in school, and social skills. India has enacted various laws to protect the right to health of people. This right includes protection and improvement of all aspects of environment and health & hygiene of general public, working conditions -health and strength of men or women workers, and the tender age of children shall not be abused. Further it deals with the protection that citizens are not forced by economic necessity to enter avocations unsuited to their age or strength.

Further, the constitution has provided various provisions for industrial hygiene of workers, prevention and control of occupational, epidemic and other diseases. To fulfil all these obligations the Government of India has adopted a multi-payer universal health care model that is paid for by a combination of public and private health insurance with government regulatory framework such as the Insurance Regulatory and Development Authority along with the element of tax-funded public hospitals. The above discussed provisions are protective provisions to maintain the health and wellbeing of the people, here in the present study the researchers discuss about the cases of defect of child such as hearing loss by birth for no violation of laws and detection procedures by using Technology that is Machine Learning Algorithm.

Children with hearing loss often encounter various challenges including delayed speech and language development, academic struggles, low self-esteem, and difficulty in forming friendships. Their ability to acquire vocabulary and understand sentences is compromised, making schooling particularly challenging for them. For any nation Children are the future, their health, welfare and wellbeing should be given aftmost importance. In this direction Constitution of India had provided as many provisions as necessary. To implement these provisions governments should make appropriate policies by giving at most priority. Because of their poverty and illiteracy shall not be place these tender aged at a disadvantaged position in their precious life. In this context it may be noted down that technology has robust choices in assisting to fill the gap to lead them a dignified and better life.

Supreme Court of India which is the temple of justice stressed in many cases about the child health because today's children are the tomorrow's citizens. If you suspect your child may have hearing difficulties, it's critical to have them checked but early intervention is essential for child development. Here in this juncture the financial constraints of parents play a vital role in helping the innocent child who has no fault in developing such ill health/ hearing loss. At this point the government's childcare policies must be available to the poor and needy parents to sort out their child's requirement with welltrained health care experts with affordable limits. This problem can be addressed with the help of latest technology like machine Learning Algorithms.

Objectives of the study

The present research has been undertaken with the objective of examining the fulfillment of constitutional mandates relating to children's right to health and assessing the potential of Machine Learning Algorithms in the detection, prediction, and analysis of hearing loss.

2.1 Hearing Loss

[1] Yuan, Huayun," A Study of Special Needs Children Entering Regular Classroom Learning", Journal of Education, Humanities and Social Sciences,2023, Vol:10, Pages: 133-138, DOI: 10.54097/ehss. v10i.6903.

The significance of integrating kids with special needs into regular classes is discussed in the paper [1]. The author gave recommendations for assessing the interaction between special needs children and ordinary classrooms, as well as the development of the latter, by taking into account the advantages and disadvantages of each viewpoint.

[2] Mathews, S., Karthikeyan, K., Arumugam, S. V., Kurkure, R., Paramasivan, V. K., & Kameswaran, M. (2023). Complication profile in a cochlear implantation- surgical audit in a large study population of low socio-economic status in a developing country. Cochlear Implants International, 24(6), 283–291.

Mathews et al., studied [2] and analysed hospital data from June 2013 to December 2020, encompassing 1,250 cochlear implant surgeries. The data includes gathering information from medical records including complications, management protocols, demographic details, and literature. They were categorized data into five age groups like 0–3, 3 to 6, 6–13, 13–18 and above 18 years. Complications were classified as major or minor, and their occurrence was divided into peri-operative, early post-operative, and late post-operative stages, with subsequent analysis conducted on the findings. For major complication rate was 9.04% and minor complication rate was 6% was determined in this paper.

A. Casoojee, A. Kanji, and K. Khoza-Shangase,"Therapeutic approaches to early intervention in audiology: A systematic review", International Journal of Pediatric Otorhinolaryngology, 2021, Volume 150, Article 110918.

In paper [3], the authors have done systematic review to assess the speech, language, and scholastic outcomes of children with hearing impairment undergoing Auditory Verbal Therapy (AVT) as an early detection method. The authors conducted in accordance with PRISMA guidelines and analysed relevant studies from databases including Google Scholar, Science Direct, and PubMed, focusing on English-language publications. Despite efforts to include the latest research, limited evidence hindered definitive conclusions regarding the effectiveness of AVT in yielding positive outcomes for children with hearing impairment. This paper presented the necessity for studies comparing AVT with standard speech-language processes, particularly in diverse linguistic and cultural contexts.

2.2 Machine learning

The sense of hearing, as we all know that one of the five fundamental human senses is hearing. This has the ability to identify and interpret sounds. But some of the people are affected with hearing loss partially or fully. Partial means low sense of signal to ears and may be cured with necessary medications but the hearing loss problem must be identified first. Fully hearing loss may not be cured with medications but may have alternate solutions like speech therapies, cochlear implantations with hearing aids. So, this is a serious health issue that affects both adults and children and is also increasing. Despite sufficient awareness, there is a dearth of knowledge about hearing loss, delay occurs in diagnosis and treatment because physicians rely on their clinical expertise and a primarily symptomatic approach to diagnose patients, which can lead to delays in consultation and subsequent longer wait times for other patients. This can result in stress and frustration for those waiting. For early diagnosis, machine can be trained to identify the hearing loss of a person based on various medical examinations, ENT doctors' suggestions in order to identify the hearing loss problem quickly.

2.3 Machine Learning Approaches to Hearing Loss

So better machine learning approaches are needed to identify or to predict the person or child who suffers from hearing loss problem. In this paper, prediction of hearing loss problem of a child is focused. The following discusses about various approaches proposed by many authors using machine learning approaches.

[1] V. Pai K and P. S. Thilagam, "Hearing Loss Prediction using Machine Learning Approaches: Contributions, Limitations and Issues," *2022 IEEE 3rd Global Conference for Advancement in Technology (GCAT)*, Bangalore, India, 2022, pp. 1-7, doi: 10.1109/GCAT55367.2022.9972110.

In paper [1], survey of machine learning approaches for predicting hearing loss is done by examines datasets, machine learning methods, their results, as well as the challenges and future directions. The survey reveals the complexity of the problem, the obstacles to improvement, and suggests focusing on analysing data from newborns, infants, and young children in future research.

[2] V. Pai K and P. S. Thilagam, "Hearing Loss Prediction in Newborns, Infants and Toddlers using Machine Learning," *2022 IEEE North Karnataka Subsection Flagship International Conference (NKCon)*, Vijaypur, India, 2022, pp. 1-7.

V. Pai K and P. S. Thilagam [2], data is collected from audiologist and then applied various machine learning algorithms like XGBoost, Random Forest, Support Vector Machines, and Naïve Bayes. They prepared two sets of data one is balanced that is same number of records for each class value and while the other represents the population's prevalence of hearing loss in conjunction with noise levels (imbalanced). They proved that maximum accuracy for Support Vector Machines is 100% for a balanced dataset and 94.10% for an imbalanced data

[3] S. Udbhasa *et al*., "Interactive, Visual-Learning based Tool for Hearing Impaired children to Improve Language and Cognitive Skills," *2023 International Conference on Information Technology (ICIT)*, Amman, Jordan, 2023, pp. 416-421.

In paper [3], S. Udbhasa *et al*. discussed prevalence of hearing impairment worldwide, especially in newborns. For language acquisition, they proposed visual-based and interactive learning tools to assist hearing-impaired children. Machine learning algorithms are used in their proposed system to tailor content, assess progress, and incorporate features. For object detection and lip movement analysis, YOLO5 and LipNet are used respectively. To find initial status and progress regression algorithms are applied in this paper. YOLO model has accuracy of 90.3% and LipNet model has 92.2% accuracy for lip movement analysis. An accuracy of 92.8% is found in multivariate regression models.

[4] M. Bozkurt, F. Oncel, C. Gurpinar, H. Kose and G. Unal, "Facial Expressions Detection of Children with Hearing Impairment," *2022 30th Signal Processing and Communications Applications Conference (SIU)*, Safranbolu, Turkey, 2022, pp. 1-4, The objective of this research is to create an effective emotion classification system tailored for children with hearing impairment (HI). Due to the limited availability of data from children, training Convolutional Neural Networks (CNN) from the ground up requires a substantial dataset. Thus, the study explores the use of transfer learning by fine-tuning pre-trained CNN models to classify children's emotions. Through experimentation, it was found that the most precise classification was achieved by fine-tuning the dataset of children, containing three emotion labels, using a pre-trained model initially trained on data from adults with eight emotion labels.

The authors in paper [4], efficient emotion classification system is developed for hearing impaired children. A fine-tuned pre-trained convolutional neural network model is proposed using transfer learning to classify children's emotions as facial emotions play a critical part in daily life especially for hearing impaired persons or child to understand and analyse emotions. The model is experimented with 3 emotion labels to children and eight emotion labels to adults' datasets. Through their research, it is proved that accuracy is improved.

[5] Abd Ghani, Mohd Khanapi, Nasir G. Noma, Mazin Abed Mohammed, Karrar Hameed Abdulkareem, Begonya Garcia-Zapirain, Mashael S. Maashi, and Salama A. Mostafa. "Innovative Artificial Intelligence Approach for Hearing-Loss Symptoms Identification Model Using Machine Learning Techniques" 2021, *Sustainability* 13, no. 10: 5406.

Abd Ghani et al., [5] proposed an expert system model using machine learning algorithms to diagnose symptoms of a patient's who are suffering from hearing problems. Initially Frequent Pattern Growth (FP-Growth) algorithm, with the multivariate Bernoulli naive Bayes classification model is used for feature engineering. After several experiments, the hybrid approach of FP-Growth and naive Bayes algorithms identifies hearing-loss symptoms, minimal error rate efficiently and exhibited an average accuracy rate of 98.25% and an average error rate of 1.73%.

3. METHODOLOGY

In this paper, a predictive model is proposed using machine learning algorithm on live data from special education school children who are getting speech therapy. This hearing loss dataset is considered for research which includes various attributes about children with hearing loss, such as age, gender, percentage of hearing loss, left or right or both sides affected, genetic factors, complications in prenatal or postnatal or during birth, alcohol consumption of parent, economic status, family history, any genetical disorder, sibling status, parent consanguineous marriage and other contextual details.

After collecting the data, data is cleaned by removing unnecessary attributes. To remove irrelevant attribute, correlation test is conducted between each input feature to output variable by doing feature Importance Analysis with Decision Trees and Random Forest algorithms. For example, hearing loss of a person in a

family may have impact on hearing loss of a child in that family and proved that there is a positive correlation between them.

This process is done systematically and removed less correlation or no correlation attributes. The data has categorical values like yes or no or Boy/Girl which are converted into numerical values like 0 or 1. For this One-Hot encoding technique is used. The most significant attributes are identified such as the percentage of hearing loss, left or right or both ears affected, genetic factors, complexities during prenatal or postnatal or during birth, economic status, family history of hearing loss, genetical disorder, sibling status, parent consanguineous marriage.

After this task, unsignificant records are removed which has missing values that is having null values. Likewise, data is cleaned and significant records are identified for further process. In this paper, regression technique is adopted to develop predictive model in order to determine whether the child has hearing impaired or not which can be detected quickly and easily. Regression technique is nothing but a supervised machine learning algorithm. The model finds the patterns from the data that is how output variable is dependent on one or more independent variables. There are many algorithms based on regression which helps to determine relationships between output variable to inputs and which helps to fits a model for the selected datasets for prediction.

With pre-processed data, various regression algorithms are applied and determined the most suitable model for hearing loss dataset. The most prominent algorithms are Decision tree regression, support vector machine regression, Lasso regression, Random Forest regression and linear regression are considered and built the five models. Train the Hearing loss data set using these five regression-based algorithms. All five model are evaluated and tested in order to predict whether the child has hearing loss or not. For each model, the results are analysed based on five metrics. The five metrics are Adjusted R-squared, Root mean Squared Error, mean squared error, Mean Absolute error and R-squared. Comparison of these metric values proved that Lasso Regression algorithm is giving more accuracy than other models. This predictive model has an Gradio Interface for users to input data and receive risk assessment results and recommendations. The whole process is also depicted in the following figure.

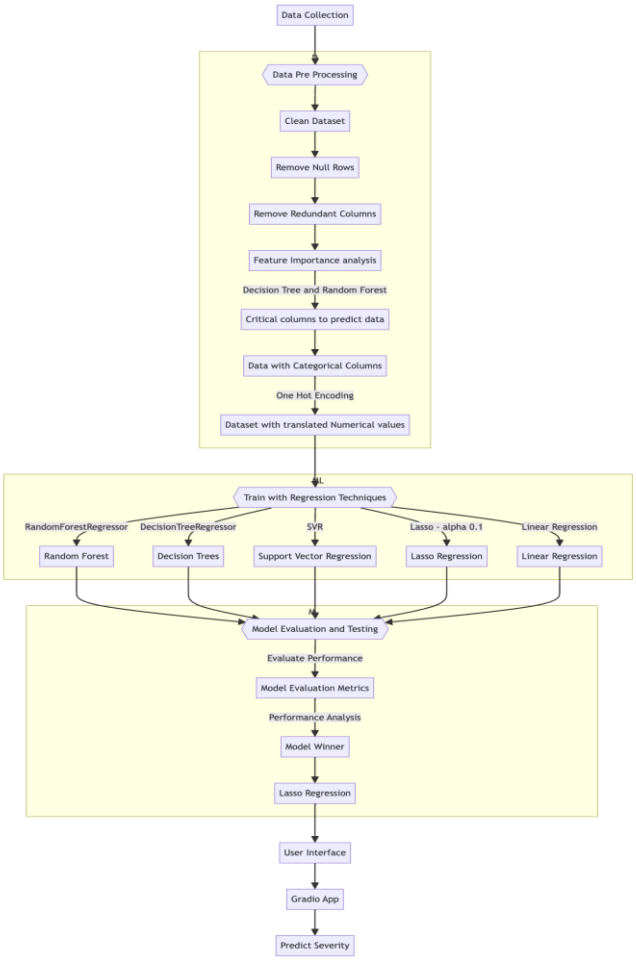


Figure 4.1: Proposed Predict Model for Hearing Loss dataset

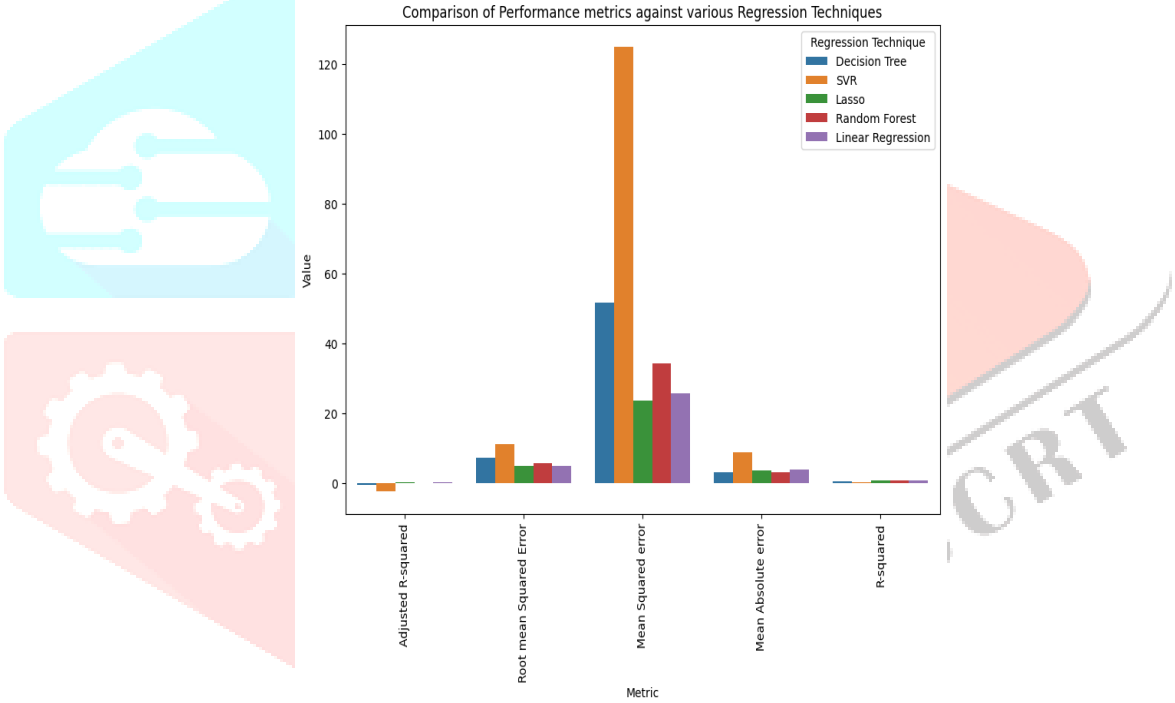
4. COMPARISON ANALYSIS

The following table gives five metrics and their values over five regression-based algorithms

Regression Technique	Adjusted R-squared	Root mean Squared Error	Mean Squared error	Mean Absolute error	R-squared
Decision Tree	-0.41	7.19	51.79	3.21	0.67
SVR	-2.40	11.17	124.78	8.81	0.21
Lasso Regression	0.355	4.85	23.60	3.73	0.85
Random Forest	0.06	5.85	34.25	3.11	0.78
Linear Regression	0.29	5.08	25.82	3.96	0.84

It is clearly showing that Lasso regression gives 85% R squared value and also giving less error rate for Root mean squared error, Mean Squared error and Mean Absolute error compared to Decision tree, Support vector machine, random Forest, linear regression.

From the above table data, a graph is drawn and is given as follows:



Also, Execution time is computed and compared. The following graph gives information on execution time taking by each model on hearing loss dataset.

From the above graph, Lasso algorithm is taking less execution time.

5. CONCLUSION AND EXPLANATION

As everybody believes that Healthy citizens are the greatest asset of any country. Where the children are active the nation is healthy and wealthy. Moreover, physical and mental health is most important to live happy life of a person. But many people are suffering from one or more diseases which can be cured or may not be cured. Hearing loss is one, such uncured diseases if he or she has completely hearing impaired. for this problem one can get appropriate speech therapies along with cochlear implantations, hearing aids in case the problem is identified at early stage. People are diagnosed. Growing technology is an advantage of this era, so early prediction with machine learning will help the parents and guardians to identify hearing loss in child and this may be affordable even to the poor people who are lesser opportunities to access to good health. In this paper, Regression based algorithms are models that are constructed, tested and proved that Lasso regression algorithm outperforms other algorithms. From the comparison analysis it is proved that Lasso regression based predictive model is good for hearing loss dataset. In the future, neural networks models can be determined.

Explanation of findings- Providing complete and high-quality health care services has very important role to enables people to understand the factors related to personal and social health and to make decision regarding choice of suitable healthy behaviors in order to achieve healthy life. For this reason, demographic and clinical data of person are collecting, this huge volume of data can be known as a valuable resource for analysing, exploring and discovering valuable information and communication. This study using forum rules techniques in the data mining has tried to identify the affecting factors on hearing loss after birth in India.

Since hearing loss is the most common sensory defects in humans and one person/baby in a thousand babies are acquiring hearing loss (1), one in thousand babies acquiring hearing loss is a huge number, it is not peculiar to India but this hearing loss cases are existing around the world. With the technological advancements, especially in information technology field indigenous scientific achievements has come to the aid of medical and data mining technology, which can be used to obtain new knowledge between huge amount of raw data of deafness (2, 3, 4). [The Usage of Association Rule Mining to Identify Influencing Factors on Deafness After Birth, AIM-23-356.pdf]

How to calculate and detect degree of deafness among individuals
Row Details of content of fi eld (List of fi elds after pre-processing)
(1) Gender of patient: male & female
(2) deaf in siblings
(3) Hearing Loss in right ear
(4) Hearing Loss in left ear
(6) Use of assistive devices such as hearing aids
(7) *consanguinity* in parents

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