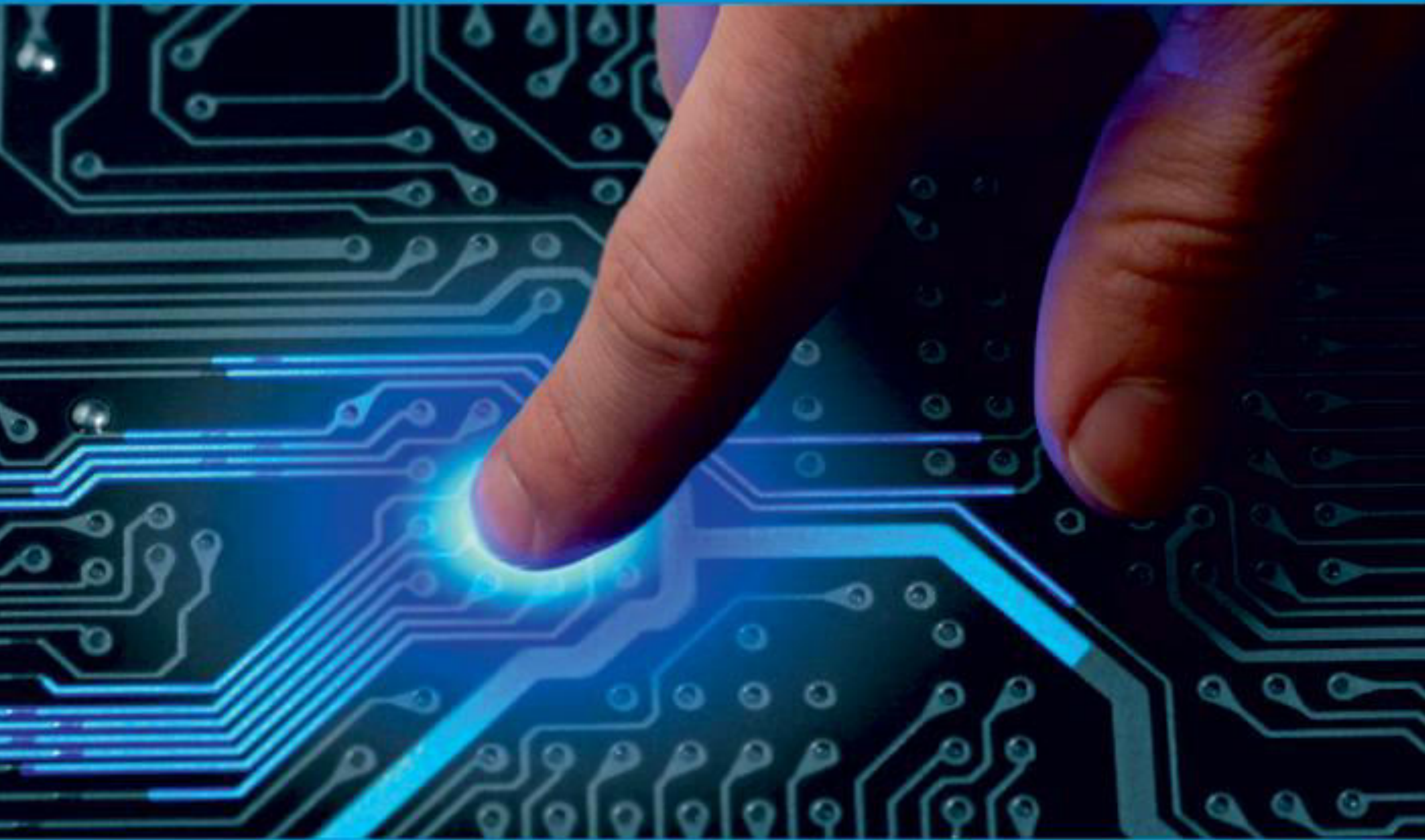
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 12, December 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.625

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.625| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Machine Learning in Early Detection and Analysis of Autism Spectrum Disorder(ASD)

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ABSTRACT: Our project describes a new method for detecting autism spectrum disorder (ASD) using advanced machine learning algorithms. Our approach involves using a range of models such as logistic regression, KNeighbors classifier, decision tree classifier, GuassianNB, SVC, RandomForest, XGBoost classifier, NeuralNetwork SKLearn, and Neural Network Keras. The main aim of the project is to accurately predict ASD by training these models on supervised data. Our approach includes creating a flexible web interface aimed at medical professionals and the public, which allows for ideal data input to predict ASD probability. To improve accuracy, we use advanced techniques like GridSearchCV and Pipeline during the refinement phase of the model. Our project aims to address the challenge of the lack of comprehensive medical tests for ASD and promote early intervention for ASD in the healthcare domain. Utilizing RandomForest algorithm, the accuracy has been elevated from 64 to 96 through the application of GridSearchCV and pipeline methods.

KEYWORDS: GridSearchCV, logistic regression, KNeighbors classifier, decision tree classifier, GuassianNB, SVC, RandomForest, XGBoost classifier, Neural Network SKLearn, and Neural Network Keras.

I. INTRODUCTION

Autism spectrum disorder (ASD) is a complex neurological condition that affects how individuals think, behave, and interact with others. People diagnosed with ASD often show repetitive behaviors, face social challenges, encounter difficulties in communication, and have a limited range of interests. These aspects can make daily life complicated not only for those with ASD but also for their families. This highlights the importance of identifying ASD as early as possible and providing timely intervention to improve the quality of life for individuals and their loved ones.

One of the major challenges in addressing ASD is the diagnostic process. Currently, most methods used to diagnose this disorder are subjective and involve extensive assessment periods. As a result, many individuals do not receive a diagnosis until their symptoms have already noticeably impacted their lives. This delay can prevent them from accessing necessary support and resources that could significantly aid their development.

In response to these challenges, this project aims to design a machine learning tool that can assist in the early detection of ASD. The focus will be on making this tool both eco-friendly and easy to use. Different machine learning algorithms will be explored, including logistic regression, decision trees, support vector machines (SVM), random forests, and convolutional neural networks (CNN). The goal is to determine which of these algorithms can effectively identify signs of ASD in a timely manner.

A crucial aspect of this project will be optimizing the hyperparameters of the random forest model. This step is essential to enhance the model's performance and accuracy in detecting ASD effectively. To make it easy for users to enter data into the system and receive results, developers will create a web application. This application will provide a user-friendly interface where families and healthcare providers can interact with the machine learning tool, ensuring that the process is accessible for everyone involved. Together, these efforts aim to improve the lives of those affected by autism spectrum disorder through early detection and intervention.

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II. LITERATURE SURVEY

In the paper [6], the authors introduce a machine-learning framework for autism assessment utilizing logistic regression. They utilize data from AQ-10 adult and adolescent assessment methods and employ search methods to identify significant features, achieving high sensitivity, specificity, and classification accuracy. While this addresses the scarcity of autism datasets and enhances research quality, limitations include potential biases in data collection and subjectivity in relying on domain expert code. Additionally, the assumption of a consistent relationship between features and autism may restrict its generalizability.

In the paper [16], the study aims to distinguish speech sounds of children with ASD from typical children, achieving high accuracy. However, the study relies on public datasets, raising concerns about data quality and representativeness. Moreover, the selected feature selection methods may introduce bias or overlook crucial features necessary for accurate ASD diagnosis.

In the paper [17], the study addresses Autism Spectrum Disorder (ASD), a neurological condition impacting socialization and learning. The paper presents a method utilizing Kernel Extreme Learning Machine (KELM) optimized by the Giza Pyramids Construction (GPC) algorithm for accurate ASD classification, achieving high accuracy. The GPC data processing step enhances the performance of the KELM model, aiding in automation of ASD diagnosis.

In the paper [2], the study explores utilizing social nonverbal interactions captured in videos with deep neural networks to differentiate children with ASD from typically developing peers, achieving 80.9% accuracy. It observes a correlation between prediction probability and the severity of autistic symptoms. However, the study is limited by a small sample size, context limitations, definitional subject matter, scalability challenges, and a focus on specific aspects rather than providing a comprehensive understanding of ASD.

In the paper [10], the study presents a machine learning framework for early detection of ASD, utilizing feature measurement and various ML algorithms on standard ASD datasets. While demonstrating efficient methods, the study lacks detailed comparison with previous work and generalization to diverse datasets, which may limit its power. Additionally, notable limitations include biases in feature selection and the need for revalidation in different populations and clinical settings.

In recent years, machine learning techniques have been used to analyze facial expressions for early diagnosis of ASD in children. Jaine et al. [19] focused on facial features, especially the eye regions, using images from YouTube videos. They applied decision trees and K-nearest neighbors (KNN), achieving a peak accuracy of 74.84%. The researchers suggested that filtering the dataset by factors like age, gender, or autism severity could further improve results.

Vaishali R, Sasikala R. et al. [3] have proposed a method to identify Autism with optimum behavior sets. In this work, an ASD diagnosis dataset with 21 features obtained from the UCI machine learning repository experimented with swarm intelligence based binary firefly feature selection wrapper. The alternative hypothesis of the experiment claims that it is possible for a machine learning model to achieve a better classification accuracy with minimum feature subsets. Using Swarm intelligence based single-objective binary firefly feature selection wrapper it is found that 10 features among 21 features of ASD dataset are sufficient to distinguish between ASD and non-ASD patients. The results obtained with this approach justifies the hypothesis by producing an average accuracy in the range of 92.12%-97.95% with optimum feature subsets which are approximately equal to the average accuracy produced by the entire ASD diagnosis dataset.

Li B, A. Sharma, J Meng, S. Purushwalkam, E. Gowen (2017) et al. [11] have used machine learning classifiers to detect autistic adults by imitation method. The goal of this study was to investigate the fundamental problem related to discriminative test conditions and kinematic parameters. The dataset contains 16 ASC participants who have a series of hand movements. In this 40 kinematic constraints from 08 imitation conditions has been extracted by using machine learning methods. This research shows that for a small sample, there is a feasibility of applying machine learning methods to analyze high-dimensional data and the diagnostic classification of autism. The sensitivity rates achieved by

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RIPPER which have the features Va (87.30 %), CHI (80.95%), IG (80.95%), Correlation (84.13%), CFS (84.13%), and "no feature selection"(80.00%) on the AQ-Adolescent dataset.

Fadi Thabtah et al. [8] have proposed an ASD screening model using Machine Learning Adaption and DSM-5. A screening tool has been used to realize one or more goals in ASD screening. In this paper, the researcher discussed the ASD Machine Learning classification with their pros and cons. The researcher tried to highlight the problem accompanying with existing ASD screening tools and the consistency of such tools using the DSM-IV instead of the DSM-5 manual.

J. A. Kosmicki1, V. Sochat, M. Duda and D.P. Wall Et al. [14] have supposed a searching method for a least set of traits for autism detection. In this, the authors used a machine learning approach to evaluate the clinical assessment of ASD. The ADOS was performed on the subset of behaviors of children based on the autism spectrum. ADOS having four modules. In this work, 8 different machine learning algorithms were employed, involving stepwise backward feature identification on score sheets from 4540 individuals. It uses 9 out of the 28 behaviors from module 2 and 12 out of the 28 behaviors from module 3 to identify an ASD risk with an overall accuracy of 98.27% and 97.66% respectively.

M. S. Mythili, A. R. Mohamed Shanavas et al. [13] have a study on ASD using Classification Techniques. The main aim of this paper was to detect the autism problem and the levels of autism. In this Neural Network, SVM and Fuzzy techniques with WEKA tools are used to analyze the student's behavior and their social interaction.

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© 2024 IJIRCCE | Volume 12, Issue 12, December 2024| DOI: 10.15680/IJIRCCE.2024.1212095

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Title	Author(s)	Methodology	Dataset	Observations/Findings	Disadvantages/Research Gaps
A Novel Machine Learning Based Framework for Detection of Autism Spectrum Disorder (ASD)-2022	Hamza Sharif and Rizwan Ahmed Khan	Machine Learning, Autism Detection Framework	ABIDE Dataset	Proposed a novel machine-learning framework for autism detection. Accuracy of 94.73%	Lack of specific dataset information, need for benchmarking against various existing frameworks.
Using 2D video-based pose estimation for automated prediction of autism spectrum disorders in young children-2021	Nada Kojovic , Marie Schaer	2D Pose Estimation, Autism Prediction	Video-based Datasets	Explored automated prediction of autism in young children using 2D video-based pose estimation. Accuracy of 91.87%	Lack of specific details on the pose estimation algorithm used, need for extensive validation on diverse video datasets
Study of Mechanisms of Social Interaction Stimulation in Autism Spectrum Disorder by Assisted Humanoid Robot-2017	Marco Del Coco, Marco Leo , Pierluigi Carcagnì, Francesca, Letteria Spadaro,Liliana Ruta, Giovanni Pioggia, and Cosimo Distante	Humanoid Robot Interaction, ASD Mechanisms	Humanoid Robot Interaction Data	Studied social interaction stimulation mechanisms in ASD through interactions with a humanoid robot	Lack of specific details on the humanoid robot used, need for a broader range of humanoid robots and diverse interaction scenarios.
Robot AssistedAutism Spectrum Disorder Diagnostic Based on Artificial Reasoning-2019	Anselmo Frizera-Neto1,Teodiano Freire Basto	Robot-Assisted Diagnostic, Artificial Reasoning	Diagnostic Data	Developed a diagnostic system for ASD using a robot and artificial reasoning.	Lack of specific details on the artificial reasoning method, need for a broader range of diagnostic data, and performance evaluation on various robot platforms.

III. EXISTING METHODS

I. Machine Learning Techniques

The application of machine learning has greatly enhanced the precision and efficiency of Autism Spectrum Disorder (ASD) identification. The following techniques are commonly employed:

A. Logistic Regression

This method serves as a fundamental yet effective approach for binary classification, utilized to determine whether an individual is part of the ASD spectrum based on essential diagnostic characteristics.
Example: Data regarding behavioural traits, such as social responsiveness or repetitive actions, is analysed to calculate the likelihood of ASD.

B. K-Neighbours Classifier (KNN)

KNN is a non-parametric technique that categorizes data points by referencing the nearest training examples within the feature space. It is particularly beneficial for ASD identification in smaller datasets where the similarity between individuals is a key factor.

C. Decision Tree Classifier

This classifier offers an interpretable framework for classification tasks by segmenting data according to the significance of various features. It is frequently utilized to uncover hierarchical trends in behavioural data or clinical assessments.

D. Gaussian Naïve Bayes (GaussianNB)

This method presumes a normal distribution of features and is effective in contexts where features are independent of one another. It is applied in ASD research for classifying individuals based on straightforward and independent diagnostic indicators.

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E. Support Vector Classifier (SVC)
SVC is employed for classification by identifying the hyperplane that most effectively distinguishes between ASD and non-ASD cases. It is particularly adept at managing non-linear relationships in datasets through the use of kernel functions.

F. Random Forest Classifier
This robust ensemble learning technique amalgamates multiple decision trees to enhance accuracy and mitigate overfitting. It is widely utilized in ASD detection to manage high-dimensional datasets and assess feature significance.

G. XGBoost Classifier
As a sophisticated ensemble technique grounded in gradient boosting, XGBoost is recognized for its exceptional accuracy and efficiency. It is well-suited for ASD datasets characterized by imbalanced classes and intricate feature interactions.

II. Hyperparameter Tuning
GridSearchCV:
This method represents a structured approach to hyperparameter optimization.

IV. PROPOSED METHODOLOGY

I. Data Collection
Of the 1054 records in the dataset, 728 are positive cases, meaning that ASD is present, and 326 are negative instances, meaning that ASD is not present. The dataset has 319 females and 735 males in total.
Machine learning algorithms for the early detection of ASD are developed and trained using this dataset.

II. Data Preprocessing
To make sure that missing values don't impact the analysis, a variety of strategies are employed during data preprocessing. Using methods like smoothing or filtering, outliers are eliminated to preserve data integrity and lower noise. For additional processing, the data is also transformed into a format that machine learning algorithms can use.

A. Feature Selection & Engineering
Exploratory Data Analysis (EDA): Use correlation matrices, statistical analysis, and visualizations to find important aspects. modifying or adding additional characteristics to improve the prediction ability of the model.

B. Model Development
A variety of machine learning techniques, including GaussianNB, RandomForest, XGBClassifier, SVC, KNeighborsClassifier, DecisionTreeClassifier, and Logistic Regression, are combined to create predictive models. Taking into account a thorough investigation of the data and the creation of a potent predictive model, each algorithm offers unique advantages and insights. Overall performance indicators, such as F1-Score, recall, accuracy, and precision, are used to carefully assess the trained models.

C. Model Evaluation
In order to evaluate the accuracy, usefulness, and possible impact of early ASD identification and intervention, we will employ standardized metrics of independent testing data.
In order to assess accessibility and user experience, functional testing will cover a variety of functional units, with ongoing improvement based on data gathered. In order to evaluate the tool's effect on early ASD identification and intervention, taking into account practical research findings and usefulness, we will also carry out an impact study.

I. Final Scoring and Feedback
Performance of the Model: The findings show that the model can effectively and accurately detect cases with ASD. The 82.47% probability score highlights the trained model's resilience and capacity for accurate prediction.
Comments on the Outcomes: The model's sensitivity to the input data is highlighted by the high probability score. Nonetheless, the following areas need more attention: validation across a range of datasets to improve the

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generalizability of the model. Preprocessing and feature selection methods are optimized to reduce overfitting and possible biases.

Limitations and Recommendations: Despite the model's high prediction score, a thorough assessment of its performance across a range of metrics, including accuracy, recall, and F1-score, is necessary to guarantee a fair trade-off between false positives and false negatives. Furthermore: To increase the model's clinical usefulness, real-world testing and input from medical professionals are essential.

Conclusion: The results validate the effectiveness of machine learning methods for identifying ASD. The model has the potential to be a very useful tool for supporting early diagnosis and intervention techniques for autism spectrum disorder with further assessment and iterative improvements.

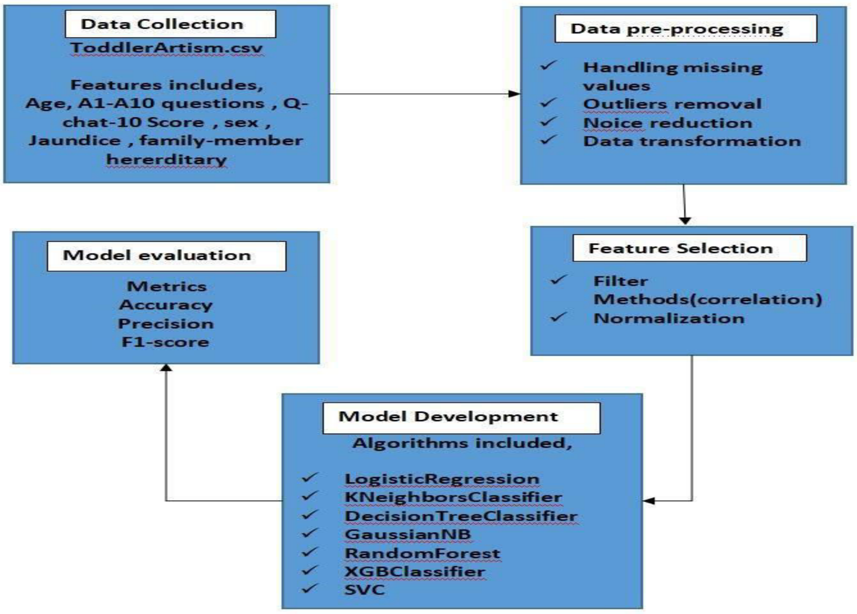

Fig 1. Flow chart of proposed methodology 1

V. EXPERIMENTAL RESULTS

Promising results were obtained when the suggested machine learning model for the detection of autism spectrum disorder (ASD) was tested on a collection of input features. The specifics of the experimental results are listed below: Model Predictions :A probability score that indicates the possibility of ASD occurrence is produced by the model. For example: Predicted Probability: around 82.47%, or 0.8247. This probability suggests that there is a high chance that the person in question has ASD. The categorization choice is binary based on this confidence score: The model predicts that the person has ASD if the likelihood is greater than or equal to 0.5. The absence of ASD is predicted by the model if probability is less than 0.5.

Regarding the example given: The forecast is "Victim having Autism Spectrum Disorder." Insights into Model Performance .The trained model's sensitivity and resilience are demonstrated by its high confidence score of 82.47.This outcome shows how well the model can use the input features to differentiate between people with and without ASD.

Logic for Classification Decisions: The following are part of the experimental procedure: Estimating Probability: Applying the trained model's predict_proba technique. Binary Classification: The final classification is made using the predict approach. Regarding the assessed dataset: Expected feature formats are reflected in the DataFrame input representation. The result validates the prediction logic's efficacy.

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Observations and Implications: Although the results highlight the need for verifying the model on larger and more diverse datasets, the model's sensitivity to input features guarantees useful predictions. In order to evaluate trade-offs between false positives and false negatives, a thorough analysis utilizing performance metrics such as accuracy, recall, and F1-score is essential, even though the prediction score is crucial.

In conclusion :The machine learning model's effectiveness in detecting ASD is supported by the experimental findings. Clinical applicability and additional improvements require ongoing assessment on various datasets and integration with domain-specific input.

VI. FUTURE WORK

The following areas for improvement and expansion are identified to further enhance the educational application:
1. Broadened Data Sources: Integrating data from a more diverse array of sources and geographic areas can enhance the model's precision and applicability.
2. Enhanced Model Interpretability:Creating techniques to elucidate model decisions and outputs can assist healthcare professionals in comprehending and trusting the predictions more effectively.
3. Real-Time Data Integration: Implementing real-time data updates and ongoing learning capabilities can ensure that the model stays current with the latest research and trends in ASD.
4. Multi-Platform Compatibility: Ensuring that the web application functions seamlessly across various devices and operating systems can improve its accessibility and user reach.

VII. CONCLUSION

This project aimed to employ machine learning and deep learning methodologies for the detection of autism spectrum disorder (ASD). Various performance evaluation metrics were utilized to assess the models designed for diagnosing ASD across three distinct age groups: children, adolescents, and adults, specifically focusing on non-clinical cases. When juxtaposed with findings from other contemporary studies, the results indicate a strong potential for enhancing the prediction model. Furthermore, random forest sampling has proven effective in identifying the presence or absence of autism spectrum disorder, as well as in calculating the mean percentage. By implementing the Random Forest algorithm, accuracy improved significantly from 64% to 96% through the use of GridSearchCV and pipeline techniques. Although these methodologies were already established, they were skillfully adapted to meet the requirements of the project.

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