**Children ADHD Disease Detection using Pose Estimation Technique**

ABSTRACT:

Attention Deficit Hyperactivity Disorder (ADHD) is a common condition that affects the neurodevelopment of children and interferes with their academic performance, social relations, and emotional development. Early and Correct identification is very essential, considering that intervention at this point can make a difference. Conventional diagnosis is based on observations of behavior and self-reported questionnaires and is prone to inconsistencies and biases. With present day Technology, especially pose estimation, a new Frontier has been opened Pository. In this paper a study on the treatment of behavioral disorders associated with ADHD using pose estimation has been made. Using video data collected from structured activities, specific movement parameters including excessive movement on the restless impulsive gestures, postural stability were assessed. The initial analysis indicates that pose estimation can be a low-cost, easy and effective way of screening children for ADHD which can solve the problems associated with the screening.

INTRODUCTION

BACKGROUND STUDY:

Attention Deficit Hyperactivity Disorder, most commonly referred to as ADHD, is a condition that affects millions of children all over the globe. It causes symptoms such as difficulty paying attention, excessive body movement and acting quickly. Many children’s daily lives are greatly affected by these symptoms. These symptoms also tend to affect most of the children’s relationships, self-image, and even their ability to control their feelings. Even though the problem is very common, it is very difficult to evaluate ADHD. The clinicians usually conduct a structured interview, make the use of a behavioral checklist, and gather information from parents and teachers as well. These approaches have their merits but tend to be subjective, labor intensive, and culturally or socioeconomically context relative.  
  
With the evolution of technology into the health sector, researchers have advanced in investigating the possibility of using objective tools in the diagnosis of ADHD. Pose estimation, a relatively new technique in the field of computer vision has found applications in sports, rehabilitation, and in the study of neurodevelopmental disorders, among others. This is through the explanation of video-recorded movements of people with certain behaviors. Because of its nature, pose estimation can assist in subtle diagnosis of certain movements that are characteristic of ADHD, such as excessive movement with hands and legs.

PROBLEM STATEMENT:

The effective diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) in most cases occurs too late when fit goes beyond the child’s ability. In addition, many children residing in needy neighbourhoods do not see specialists in time for assessment. Therefore, there is reason to conclude that there shall be adequate support in terms of objective criteria that is easy to access and scale for early diagnosis. The current study sets out to address that need by seeking to determine the reliability of pose estimation in recognizing problem behaviours associated with ADHD.  
  
OBJECTIVES:  
This research has three main objectives:  
1. To explore through pose estimation, the movement and body postures relevant to behaviours associated with ADHD.  
LITERATURE REVIEW:  
Behavioural Markers of ADHD  
Children with Attention Deficit Hyperactivity Disorder (ADHD) are often observed to engage in physical behaviours that are atypical as compared to their age group. Studies have shown that hyperactivity tends to include heightened motor activity, an inability to stay still, and extreme changes of position. These behaviours, while evident in clinical environments, are often ignored or excused even without formal evaluation.  
  
Advances in Pose Estimation  
Pose estimation is a technology that incorporates artificial intelligence to study any kind of motion using skeletal points generated from video sequences. Other algorithms include OpenPose, Mediapipe, and DeepLabCut neural networks using joint angle features, movement paths, and velocity. Such devices are already in widespread use in health care- for the assessment of patients undergoing physiotherapy, for assessing fall risks and for studying movement abnormalities such as in Parkinson’s disease.  
  
Gaps in Current Research  
Generally, although pose estimation has been applied within sports and in rehabilitation science, very little causing Attention Deficit Hyperactivity Disorder research has been done in ADHD pose estimation. In the most recent studies in this line about ADHD and movement recording patterns advanced technologies, which involve children wearing sensors or accelerometers have been employed which can be very intrusive to the children. Pose estimation based on video data has a non-invasive alternative that is ideal for use in classrooms and clinics.3. To assess the accuracy, sensitivity, and practical application of pose estimation to screen for ADHD risk in everyday settings.

Methodology:

**1. Dataset**

The dataset comprised video recordings of 100 children aged 6–12 years, evenly split between 50 ADHD-diagnosed participants and 50 neurotypical peers. Recordings captured children performing three types of structured tasks:

1. **Stationary Tasks** (e.g., writing, drawing): To assess restlessness and sustained attention.
2. **Dynamic Tasks** (e.g., puzzles, sorting objects): To evaluate impulsivity and motor control.
3. **Interactive Tasks** (e.g., group games): To analyze social and behavioral regulation.

Participants were recruited from schools and clinics, ensuring diversity in age, gender, and socioeconomic background. ADHD diagnoses were verified using DSM-5 criteria by licensed clinicians.

**2. Data Pre-Processing**

1. **Video Processing:** High-resolution recordings were standardized by normalizing frame rates and stabilizing video quality.
2. **Pose Estimation:** Skeletal data was extracted using **OpenPose**, identifying 18 body keypoints (e.g., head, shoulders, hips, knees, elbows).
3. **Noise Reduction:** Unnecessary background movements were filtered to isolate participant behavior.
4. **Normalization:** Keypoint coordinates were scaled and aligned to eliminate variations due to camera angles or participant height differences.

**3. Feature Engineering**

Key features were extracted from the pose estimation data to quantify movement patterns:

* **Movement Frequency:** Number of positional shifts per unit time.
* **Postural Deviations:** Extent of deviation from a stable position during seated tasks.
* **Impulsivity Indicators:** Sudden, unprompted gestures during structured activities.
* **Velocity and Acceleration:** Speed and acceleration of limb movements.
* **Focus and Gaze:** Head and neck alignment relative to task objects.

Temporal segmentation was applied to divide tasks into smaller epochs, facilitating a more granular analysis of behaviors.

**4. Model Selection**

Two primary models were considered for classification: **Support Vector Machines (SVM)** and **Decision Trees**, along with a **Random Forest** for ensemble comparison.

1. **Support Vector Machine (SVM):**
   * Kernel-based method (RBF kernel) for handling non-linear relationships in movement data.
   * Effective for high-dimensional data, ensuring separation between ADHD and neurotypical patterns in feature space.
2. **Decision Tree:**
   * Simplicity and interpretability allowed for a straightforward understanding of feature contributions to ADHD detection.
   * Splitting criteria such as Gini Index and Information Gain were optimized.
3. **Random Forest:**
   * Ensemble approach combining multiple decision trees to improve generalization and reduce overfitting.
   * Feature importance scores highlighted key behavioral markers.

All models were evaluated on their ability to classify ADHD-related movement patterns accurately.

**5. Model Training**

1. **Data Splitting:** The dataset was divided into 70% training, 15% validation, and 15% testing subsets.
2. **Hyperparameter Optimization:**
   * For SVM: Parameters like C (regularization) and gamma (kernel coefficient) were optimized using grid search.
   * For Decision Tree and Random Forest: Tree depth, number of estimators, and minimum samples per split were tuned.
3. **Feature Selection:** Recursive Feature Elimination (RFE) was used to retain the most predictive features, enhancing model performance.

**6. Evaluation and Validation**

Model performance was evaluated using:

* **Accuracy:** Overall proportion of correctly classified instances.
* **Precision and Recall:** Ability to correctly identify ADHD and avoid false positives.
* **F1-Score:** Balance between precision and recall.
* **Confusion Matrix:** Insight into true positives, true negatives, and errors.

**Cross-validation** (k=5) ensured that the models were robust and generalizable. A comparative analysis of SVM, Decision Tree, and Random Forest performance was conducted to identify the most reliable model.

Result analysis:

The study aimed to evaluate the effectiveness of pose estimation features combined with machine learning models for detecting ADHD-related behavioral patterns. The key findings and their analysis are presented below.

**1. Model Performance**

Three machine learning models—Support Vector Machine (SVM), Decision Tree, and Random Forest—were trained and evaluated using the extracted movement features. The performance metrics are summarized in the table below:

| **Model** | **Accuracy (%)** | **Precision (%)** | **Recall (Sensitivity) (%)** | **F1-Score (%)** |
| --- | --- | --- | --- | --- |
| SupportVectorMachine (SVM) | 84.5 | 83.0 | 85.0 | 84.0 |
| Decision Tree | 78.5 | 77.0 | 80.5 | 78.5 |
| Random Forest | 89.0 | 87.5 | 90.0 | 88.7 |

* **Random Forest** achieved the highest accuracy (89%), precision (87.5%), and recall (90%), highlighting its ability to generalize better than the other models.
* **SVM** performed well with an accuracy of 84.5%, leveraging its strength in high-dimensional feature spaces.
* **Decision Tree** exhibited the lowest performance, likely due to its sensitivity to overfitting and lack of ensemble advantages.

**2. Feature Importance Analysis**

The Random Forest model provided insights into the importance of various features in classifying ADHD and neurotypical participants:

| **Feature** | **Importance (%)** |
| --- | --- |
| Movement Frequency | 32.4 |
| Postural Deviations | 25.8 |
| Impulsivity Indicators | 18.7 |
| Gaze Focus | 14.2 |
| Velocity and Acceleration | 8.9 |

* **Movement Frequency** emerged as the most significant feature, consistent with ADHD’s hallmark symptom of hyperactivity.
* **Postural Deviations** were particularly useful in distinguishing restlessness during stationary tasks.
* **Impulsivity Indicators** and **Gaze Focus** also contributed meaningfully, reflecting challenges in behavioral regulation and attention.

**3. Statistical Comparison**

A two-sample t-test was conducted to compare movement metrics between ADHD and neurotypical participants. Key findings include:

* **Movement Frequency:** ADHD participants exhibited significantly higher movement frequency (p < 0.01), especially during stationary tasks.
* **Postural Stability:** ADHD participants showed greater deviations from a neutral posture (p < 0.05).
* **Impulsivity:** Unprompted movements during tasks were more prevalent in the ADHD group (p < 0.01).

**4. Comparative Analysis with Baseline Methods**

To validate the model’s utility, its performance was compared with traditional ADHD diagnostic tools such as behavioral questionnaires:

* **Behavioral Questionnaires:** Achieved an accuracy of 76%, highlighting their subjectivity and dependence on observer bias.
* **Pose Estimation-Based Models:** Random Forest improved classification accuracy by 13%, offering a more objective and automated approach.

**5. Observations**

1. The pose estimation framework effectively captured ADHD-specific movement patterns, demonstrating its potential as a non-invasive diagnostic aid.
2. The Random Forest model’s ensemble nature and feature interpretability make it suitable for real-world applications.
3. Despite promising results, certain challenges were noted:
   * Some neurotypical children with high energy levels were occasionally misclassified as ADHD.
   * Movement artifacts in dynamic tasks introduced noise, requiring further refinement of preprocessing techniques.

**6. Limitations and Future Scope**

1. **Dataset Size:** The relatively small sample size limits generalizability. Future studies should expand to larger, more diverse datasets.
2. **Task Variability:** Additional activities, such as unstructured play, could further validate findings.
3. **Real-Time Implementation:** Developing a real-time pose estimation system would enhance practical utility in clinical and educational settings.

Conclusion:

This study highlights the potential of using pose estimation and machine learning for detecting ADHD in children. By analyzing movement patterns during everyday activities, we can objectively identify behavioral markers associated with ADHD, such as increased movement frequency, postural instability, and impulsivity. The Random Forest model, in particular, demonstrated high accuracy, precision, and recall, making it a promising tool for clinical and educational settings.

Unlike traditional diagnostic methods, which often rely on subjective assessments and parent or teacher reports, this approach provides an objective, data-driven framework. It offers a way to complement existing methods, reducing bias and enhancing early detection. Early identification of ADHD is crucial, as it allows children to access interventions and support that can significantly improve their academic, social, and emotional outcomes.

However, this study also underscores the need for further research. A larger, more diverse dataset would improve the model's robustness, and incorporating additional tasks could broaden its applicability. Real-time implementation of this system could make ADHD screening more accessible in schools, clinics, and even home settings.

In conclusion, integrating technology like pose estimation into behavioral analysis is a step toward revolutionizing how we understand and address neurodevelopmental disorders. While challenges remain, this study opens doors to more precise, efficient, and equitable approaches to ADHD detection, ultimately benefiting children, families, and the broader community.