Multisensory Learning Tools for Improving Skills in Down Syndrome Children Using Deep Learning

5th International Conference on Electrical, Computer and Energy Technologies (ICECET 2025)3–6 July 2025, Paris-France

Kamesh Diviyanajana
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
diviyanjanakamesh@gmail.com

Kumara W.R.A.H.K
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
Hiran.private.2x@gmail.com

Amadhi Wijesinghe
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
amadhikaveendaya@gmail.com

Jayawardana W.G.L.P
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
lahirujayawardana94@gmail.com

Jenny Krishara
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
jenny.k@sliit.lk

Thamali Kelegama
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
thamali.k@sliit.lk

***Abstract*—Children with Down syndrome face several significant challenges in developing countries like Sri Lanka. The purpose of this research is to explore a new approach to enhancing the educational, social, and personal development of children with Down syndrome, aged 5 to 10, in Sri Lanka through the use of deep learning technologies such as CNN and LSTM. This project aims to deliver an affordable platform that offers children with Down syndrome a low-cost, effective, discreet, reliable, and modern educational service. The platform provides educational support in four main areas—handwriting, verbal communication, mathematics, and gross motor skills—specifically tailored for children with Down syndrome. It utilizes deep learning technology to offer real-time, accurate feedback, enabling children to engage in exercises at home. This technical education system improves the quality of life for these children, particularly in a country like Sri Lanka, where many people are not familiar with information technology, by being both affordable and easy to use.**

***Keywords*—Down Syndrome, Reward, Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), Real-time Feedback**

I. Introduction

Down syndrome is a genetic condition caused by a chromosomal abnormality. It affects children's physical and mental growth. They require special, unique needs, specialised care, attention, and education throughout their lives. Research has shown that giving them proper care, education, safety,And love can help improve their quality of life. However,in the present, as a result of improvements in the mindset of the first generation, there has been an improvement in Sri Lankans respecting children with Down syndrome. But Children still face some challenges, including unfair attitudes in families, society, and corporate environments such as schools. Parents of children with Down syndrome frequently want to provide special care and special education for their children. Lack of proper understanding of some families and the lack of appropriate services make it difficult for children to access appropriate education, safety, health care, and social opportunities. Children with Down syndrome basically have trouble with writing, reading, basic mathematics, and muscle movements. Their writing skill development is necessary, but writing is impacted by the lack of suitable tools and training techniques offered by houses and schools. The words they want to talk about are different from other children; sometimes they can't understand normal words. Also, the support of doctors can not be obtained for free, and many parents do not have the right understanding about their children's speech exercise training. Children with Down syndrome need additional support when learning fundamental mathematics.Teachers and parents need to focus on teaching these ideas through math-related exercises. They also need additional support with gross motor exercises, but they have little chance of sporting and other physical activities [1].

Unless children get the right support and direction, this lack of possibilities impacts their mental and physical development. Many systems and platforms exist for the basic education of children with Down syndrome in Sri Lanka; they have some shortcomings, such as being complex, expensive, and lacking a specialized curriculum. Schools struggle to provide effective education because they lack individual teaching facilities and trained teachers, and because ordinary teachers are reluctant to teach children with Down syndrome. Many existing educational platforms are made of computer games [2]. But sometimes children with Down syndrome have strongglad with these games. However, the education of those

2025 IEEE. 979-8-3315-3559-9/25/$31.00

children is limited to their schools, as parents are not aware of them in addition to their homes [3]. Developing basic educational skills for children with Down syndrome from low-income families in Sri Lanka through the use of information technology is the main goal of this research project. The four components of this innovative technique are gross motor training, basic mathematics, speech skills, and writing skills. Each section includes separate learning processes, and after the learning process, children can be directed to exercise training. Parents need to keep the child properly understood to focus on exercises. And an awarding system is used to encourage children. If a child struggles in an exercise, they receive guidance while parents identify their weaknesses. Children with Down syndrome should engage in learning activities according to their abilities for no more than 30 minutes a day at home. Parents can also take care of the child's educational level progress after their children's exercise training every day. Through this platform, parents can continuously focus on improving their children's education.

II. Literature Review

Considering the problems of existing education solutions This research discusses the manner in which multi-sensory learning equipment can be used to develop core abilities like writing, vocabulary, coordination of gross motor and mathematical abilities. Using movement-based learning multi-sensory equipment improves learning to be more efficient and more interactive.

Since the early 2000s, research into human action recognition has been conducted for over 20 years using emerging technologies and mechanical knowledge. Developing a method for children with Down syndrome to learn mathematics through Finger Mathematics is both scientifically and socially significant. Studies have shown that multisensory systems can enhance mathematical understanding in children with Down syndrome [4].Inclusive education movements have specifically focused on mathematical learning for children using Finger Mathematics, leading to the identification of numbers through hand gestures. Finger Mathematics can be further enhanced using modern technologies such as deep learning (CNN), and libraries like OpenCV and MediaPipe, which support hand gesture recognition and finger-based number recognition [5]. Visual and tactile learning methods are essential for improving mathematical comprehension in children with Down syndrome.

Research also suggests that children can solve mathematical problems more effectively when learning through Finger Mathematics [6].Recent advancements in technology have led to new methods for improving Finger Mathematics through number recognition. One such method involves real-time finger recognition using CNN, MediaPipe Hand Tracking, and OpenCV. Children's hands can be accurately identified using a CNN-based hand recognition model [7]. In many countries, learners with disabilities are taught using finger mathematics-based teaching strategies. To support children with special needs, international organizations such as UNESCO and WHO fund projects that incorporate multisensory learning and Finger Mathematics [8]. Therefore, developing mobile applications and e-learning platforms is a promising approach to assist children who use sign language or Finger Mathematics.

Down syndrome children typically have significant problems pronouncing different words. Studies have indicated that this group experiences considerable delay in speech output, which includes articulation difficulties and the presence of limited vocabulary. These delays will impact social interaction, school performance, and quality of life. Interventions such as word games have also proven successful in the promotion of speech and language capability, as highlighted in the study Evaluating [9].This study aims at instructing children on words, but the most essential lack is how to do this step by step along with reinforcing retention of vocabulary and correct pronunciation. Another important aspect to consider is whether or not Down syndrome children can learn to recall and say words correctly when exposed to them in real-life contexts. in this studies, seems that formal learning strategies may help with word recognition and pronunciation and assist them in communicating effectively in collaboration with neurotypical person. [10].

Gross motor skills refer to a range of large muscle development including activities such as walking, running, jumping, balancing and such things. Children with Down Syndrome experience delays in the development of gross motor skills due to hypotonia (low muscle tone) and coordination issues. The limitations in these gross motor skills significantly affect daily activities, social interactions and overall independence. Therefore this research aimed to enhance the gross motor skills of children with Down Syndrome improving their quality of life and standard of living Gross motor skill development in children with Down Syndrome Children with Down Syndrome often experience delays in gross motor skills due to hypotonia (low muscle tone). As a result, coordination challenges and cognitive impairment may occur. This research focuses on movement-based learning activities that significantly impact children with Down Syndrome, helping them perform physical tasks more effectively. Kinesthetic learning strategies including hands-on activities and multi-sensory experiences have been reported to facilitate motor coordination, body awareness and skill acquisition [11] Assistive learning Platform And Kinesthetic Teaching Methods For example, the EduPlaneer system integrates kinesthetic, auditory and visual learning systems to cater to individual needs [10]. The systems employ a machine learning model to personalise activities, ensuring and adaptive and engaging learning environment for them.

Technology Assisted Motor Skill Development The use of deep learning models has demonstrated effectiveness in recognizing hand gestures, body movements, and postures . Machine Learning models are used for task recognition while deep learning models enhance human action recognition. The system analyzes gross motor skills through video recording, extracting skeleton key points using MediPipe and predicting actions through LSTM. It then generates personalized plans based on the child's performance [13]. Children with Down syndrome (DS) face significant difficulty in developing fine motor skills such as writing skill due to hypotonia (low muscle tone), coordination deficits, and delays in hand-eye coordination and cognitive sequencing [14]. These manifest in handwriting irregularity in stroke order, size variability, and lack of spatial organization, compounded in scripts such as Sinhala with complicated character shapes and stroke order [15], [16]. Traditional educational strategies are often unable to meet these challenges, hence the growing interest in technology-based interventions. Recent developments in artificial intelligence, particularly CNNs, offer great potential for the recognition of handwriting features in children with developmental disorders, especially when integrated with data augmentation methods (like rotation, shear distortions, and Gaussian noise) that aid in modeling variability and enhancing the model's generalizability [17]. However, there are also tools, like the LVDS-App, that focus on language skills over writing skills, leaving a huge gap in individualized handwriting treatment

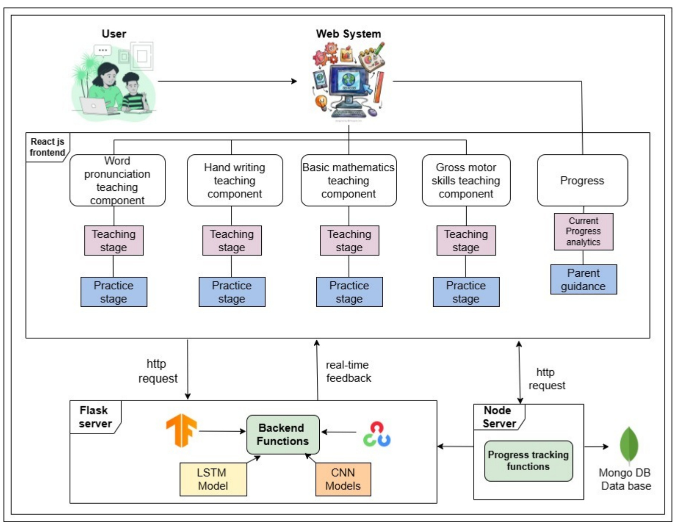

Fig. 1. System Diagram

III. METHODOLOGY

A. Gross motor skills development

This research introduces AI-driven technology-assisted systems designed to enhance gross motor skills in Down syndrome. Mainly using deep learning techniques and develop a human action recognition model for pose estimation. Participants are instructed to record videos of their child performing random gross motor skills to identify their levels. Videos can be captured in real time via the platform's interface or uploaded from existing recordings. MediaPipe is used for real-time pose estimation to extract three-dimensional (x,y,z) key points for 33 skeletal landmarks in real-time from live camera feeds or uploaded videos. Then the recorded video/uploaded video standardises these variable-length sequences by padding/truncating to a fixed maximum length. After collecting the data, preprocess it to standardize and prepare the dataset for training. The stored pose sequences were loaded and aggregated into structured arrays for coordinates x and y. By using Bidirectional LSTM enhances temporal movement understanding with two layers, process the pose sequence in both forward and backward directions. The architecture consisted of LSTM layers with 64, 128 and 6. There's a dropdown layer to prevent overfitting. The training is over 50 epochs to classify actions and predict the child's level. Each activity is assigned a confidence score (0-100) based on its similarity to ideal executions. There are 3 levels: for easy (1-40), medium (41-79), and hard greater than 80%. If the system identifies the score as 0, it indicates there's no skeleton data that has been identified. In such cases, the system will give another chance to child to act. After the participant uploads the video, they identify what the action is and what level the child has to belongs to. Based on the level system will provide gross motor skill activities. By using machine learning and deep learning models, this research aims to deliver an interactive technology-based tool for children with Down Syndrome to enhance their gross motor skills through personalized approaches. Throughout the training process, accuracy and loss metrics were tracked. The trained model can identify human actions based on the pose landmarks.

B. Word pronunciation development

For this study learning platform which effectively supports Down syndrome children in education. The research start point involved obtaining and preparing speech file recordings from children with Down syndrome and typical children in the 5-10 age group from the Kaggle open-source datasets. The researchers divided audio samples into four pronunciation levels: low, medium, moderate and high that reflected both accuracy and audibility. All audio files received uniform processing that standardized them to 16kHz mono format followed by padding and trim procedures that produced 2-second clips. Data augmentation by pitch adjustment and noise addition improved dataset robustness. For this study learning platform which effectively supports Down syndrome children in education. The research start point involved obtaining and preparing speech file recordings from children with Down syndrome and typical children in the 5-10 age group from the Kaggle open-source datasets. The researchers divided audio samples into four pronunciation levels: low, medium, moderate and high that reflected both accuracy and audibility. All audio files received uniform processing that standardized them to 16kHz mono format followed by padding and trim procedures that produced 2-second clips. Data augmentation by pitch adjustment and noise addition

improved dataset robustness.

A dedicated LSTM neural network at the heart of the system operated on spectrograms through a sequential process beginning with a 64-unit LSTM layer focusing on temporal aspects followed by a 32-unit dense layer doing feature compression alongside time-distributed layers handling sequence reconstruction. The model demonstrated 89.2% classification accuracy because of its training process which included Mean Squared Error loss together with dropout regularization and early stopping implementation. The platform provided guided children with interactive training that consisted of three learning levels: word presentation paired with video mouth animation followed by recording practice time and individualized feedback enhanced by gamification elements. The system proved its effectiveness through assessments linked to traditional speech therapy plus regular tracking of student progress while ensuring users experienced usable content that considered limited-tech accessibility needs.

C. Teaching basic mathematics by finger maths

This section is about teaching basic math to children with Down syndrome. This research introduces mathematical concepts (identified key areas)—number recognition (0-10), sequences (1, 2, 3), addition (e.g., 3+2=5), and subtraction (e.g., 5-3=2)—to children with Down syndrome aged 5-10 in a React.js frontend environment. Each key area consists of a two-stage learning method: teaching phase (with images and Sinhala/English audio) and training phase (real-time finger recognition). CNNs, MediaPipe, and OpenCV mechanisms have all been used for this purpose, and the exercise strength has been developed by the training model. To train the CNN model, 'Sign language datasets for hand gesture recognition for numbers' The Kaggle dataset (including 16,500 images) used classes (numbers) from 0 to 9 and Unknown. The value of pixels for the efficiency of the model is normalised to the range of [0, 1], and the images are 64*64 pixels standard size together. Model evaluation is divided into 80% for training and 20% for testing. The CNN model can detect finger handling through the hand, which can accurately detect the fingers showing the children with Down syndrome.

This model has several layers, with 64*64 RGB images inputted into the initial layer, where features are extracted via convolutional layers. The batch normalisation method has been used in convolutional layers to increase training and model performance. MaxPooling layers have been used to map important features. Fully connected layers operate on a single vector created by the flattened layer created from the multi-dimensional feature maps. The softmax activation function is used to classify one finger motion (0 to 9 or unknown) of the last output layer. Also, the Adam optimiser has been used for a quick analysis method. The model uses a total of 7 key parameters: 32, 64, and 128 filters in three Conv2D layers; a (3,3) kernel size; ReLU activation; 128 units in the dense layer; a 0.5 dropout rate; the Adam optimiser with a 0.001 learning rate; and the categorical crossentropy loss function. The model is trained with a batch size of 32 for epochs 15-20, and 20% of the training data is used for validation. To improve model performance and prevent overfitting, early stopping is used. After training the CNN model, the model uses MediaPipe and OpenCV to capture the children's fingers in real time. 21 finger points were extracted from the live video input using MediaPipe. For gesture classification, a bounding box covers the hand. OpenCV is used to capture real-time video input from a webcam. MediaPipe is then used to extract the child's hand and convert the frames to RGB format. The hand's cropped region is then expanded and sent into the CNN model for classification. Based on the movement of the identified hand, the system performs the 0 to 9 or unknown classification during real time. After each practice, save their progress in MongoDB by Node.js server to track their progress. The kids are treated to entertaining music and animations when their classification results display on the screen. A history of their results is recorded, helping in giving the kid opportunities for training in the future and telling the parents about areas that need attention

D. Improve Writing Skills

The writing instruction system of Improve Writing Skills provides children with Sinhala letter education through an AI-powered multisensory platform. The research dataset consists of 108,933 images divided into 454 classes where training receives 87,141 images and validation and testing each obtain 10,896 images. Random rotations between plus and minus ten degrees together with controlled distortions prepare the dataset to handle the handwriting variations found in Down syndrome children. The normalizing process converts the images to grayscale then reduces their size to 80×80 pixels before applying noise reduction technology. The CNN model achieves 95.97% test accuracy which satisfies real-world application needs for deployment purposes. A three-block CNN architecture contains the first block with two layers of 32 filters followed by the second block with two layers of 64 filters and a final layer of 128 filters (all implemented using 7×7 kernels and ReLU activation with same padding) and max-pooling layers at strategic points (8×8 and 2×2).

Flattening output is transmitted to a dense layer consisting of 1000 units that leads to the classification layer. The training utilized 50 Epochs together with Adam optimizer at 0.00001 learning rate and achieved 90.8% accuracy at epoch 5 along with 99.5% accuracy at epoch 20 through its initial fast progress. The softmax output layer produces a confidence rating (0-100%) equivalent to the certainty level of the child's letter copying success. The web-based interface, built with React.js and HTML5 Canvas, displays Sinhala letters with sound and animated stroke-order guidance. Children interact with the interface using touchscreens to trace letters, which are stored as PNG files. A Flask backend API uses the CNN model to interpret these images, storing results in a Firebase database for monitoring progress.

These four components continuously track and record a child's performance, which is then analyzed individually. Then they bring the child's performance data to one component called progress tracking. The system provides parents with a complete progress dashboard with analysis, guidance, and recommendations for future education based on the child's development. This comprehensive and engaging educational experience is tailored to children with Down syndrome through this integrated approach. Each component has separate deep-learning models and works individually but uses only one database

IV. Results and Discussion

A. Word pronunciation development

The vocabulary training step targets children with Down syndrome by helping them develop their vocabulary to enhance their pronunciation, focusing on three-stage improvement in word pronunciation. Stage one involves teaching children proper mouth movements, which is essential for developing accurate sound production. It begins with low-intensity sounds and gradually transitions to higher sound ranges while also teaching correct breathing techniques to optimise word pronunciation. The second stage emphasises learning correct word pronunciation. Children improve their efficiency in producing words by continuing to develop their sound production skills until they can speak words with increasing precision.As illustrated in Figure 2, the diagram, it shows four clusters. The first three clusters detect sounds with low pronunciation, but cluster four analyses sound production from moderate to high levels.

The cluster examines pronunciation levels to award children points according to their achievement.The third step in developing vocabulary knowledge while improving its quality. This level compares tasks learnt before and day-to-day to day seeing objects. learnt word set food in learning stages one and two , vocabulary development provided before the never-seeded food list reaches this. At this stage, every word provides a maximum of 10 seconds. Using this much time, one can easily identify thinking style improvement.

B. Improve Writing Skills

The enhanced CNN for Sinhala letter identification achieved 95.97% test accuracy across 454 character classifications. The model showed rapid improvement, reaching 90.8% accuracy by epoch 5 and 99.5% by epoch 20, with final training accuracy of 99.94% and validation accuracy of 95.81%. The model effectively learned intrinsic features of Sinhala characters with excellent generalization.Testing with 18 children with Down syndrome in Colombo district revealed significant improvements. Initially, 12 children showed character recognition below 40%, while 6 demonstrated moderate skills (40-60%). After four weeks, 85% of children improved their recognition rates by an average of 55%, with

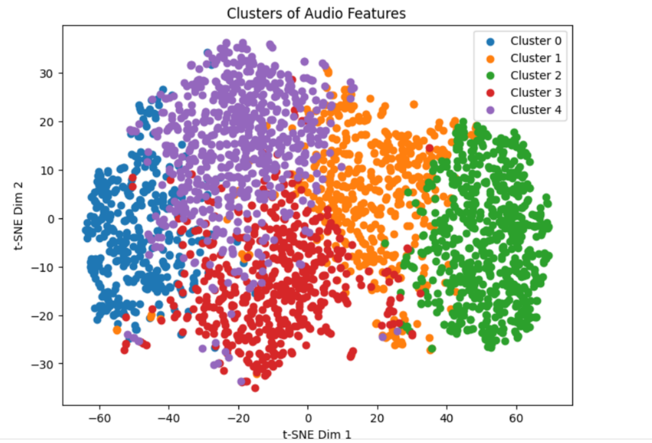

Fig. 2. Audio features

72% better stroke order adherence and 48% less character size irregularity.

Parents reported 90% increased engagement compared to traditional methods, with attention spans 65% longer during system use. Teachers noted a 45% improvement in classroom character formation accuracy, and 80% of parents observed better transfer of writing skills to school settings. The adaptive difficulty adjustment enabled 75% of children to progress through at least three levels during testing. Satisfaction rates reached 88% among parents and 92% among children, confirming the system's effectiveness for Sinhala writing skill development in children with Down syndrome.

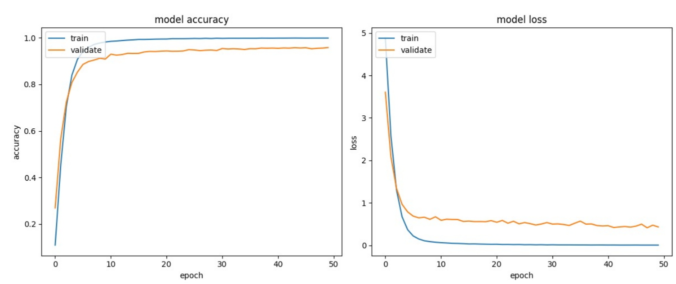

Fig. 3. Handwriting prediction

C. gross motor skills development

The created gross motor skill development system shared with group of children with Down Syndrome and their parents. Choose some random 15 DS children and follow up period them to do this gross motor skill system. 10 children were classified under the Easy level, 3 children were classified under medium level and other rest of the children classified 70% of children in easy level improved into medium level and some children in medium level improved into hard level. There are some obstacles when doing this thing with the children. Some sessions were held in noisy environments affected children's engagement, selected children has varied physical abilities.

Their parents gave good comments for that system. Because they don't need to hire a physical trainer to develop their children's gross motor skills. The selected skills in the system are simple, so if the child wants more demonstration about that parents can also do it for them. The trained model accuracy is 90%. From this model will analyze the child very closely and provide the accurate result both child and parent.Figure 4 show accuracy of module

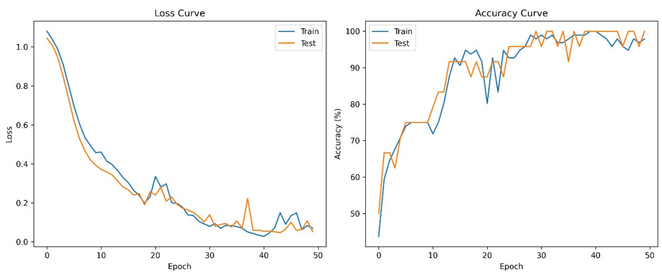

Fig. 4. Gross motor skills

D. *Teaching basic mathematics by finger maths*

The developed CNN model achieved 88% accuracy and 0.35 loss, with a real-time response time under 5s. In a preliminary test with 20 children with Down syndrome in Anuradhapura district Sri Lanka, 75% improved number recognition (0–10) by 40%, and 70% could perform basic addition. The platform's overall success rate was 85%. Additionally, 90% of parents reported a 60% increase in engagement, and the feedback system enabled 80% accurate progress tracking, raising parent satisfaction by 70%. Social inclusion also improved, with 60% of children participating in school math activities and peer interaction increasing by 50%. This research shows strong potential to benefit over 10,000 children in Sri Lanka and beyond.

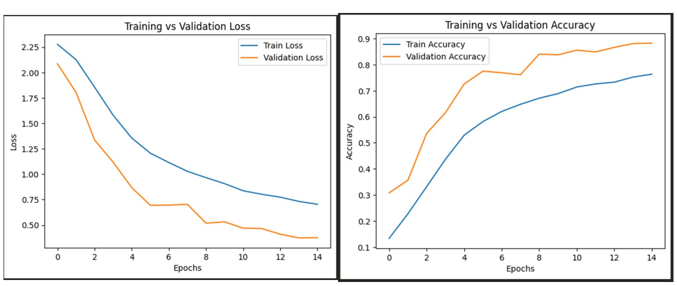

Fig. 5. hand recognition

V. Ethical Considerations

Special attention has been paid to ensuring the privacy, informed consent, and data protection of children with Down syndrome in this research. To protect the privacy of children, their images or identifying information (e.g., name, address) will not be used. Written informed consent, explained in plain English and Sinhala, will be obtained from parents, and children will be given the freedom to withdraw from participation. The data collected will be encrypted and stored on a server with 100% security and will be permanently deleted at the end of the research.

VI. Conclusion

The research project aims to using deep learning and image processing to improve needs of Down Syndrome children in gross motor skills, speaking skills, basic mathematics and writing skills. By using deep learning models such as LSTM for speech and action recognition, CNN for gesture and handwriting classification and OpenCv and MediaPipe for real time hand and skeleton tracking. The system provides unique, personalized and interactive interface that children prefer. Gross motor skills Development Use LSTM to action recognition to analyze gross motor skills and classify the levels (easy,medium,hard). Based on the these three levels system provides personalized feedback and skills to enhance their gross motor ability.

Word Pronunciation Development System anallyzes and categorizes the pronunciation skills of children with Down Syndrome (low,medium, moderate, high) using LSTM and audio preprocessing models. In this section children offer interactive and gamified learning experiences to enhance their word pronunciation. Teaching basic mathematics By finger mathematics using a skeleton-based model to recognize the hand, the system teaches number concepts and arithmetic operations for children with Down Syndrome. Real-time feedback, animations, and progress tracking optimize engagement and learning. Writing Ability Development Use CNN model trained on a Sinhala letter dataset is employed to identify and analyze handwriting. The system offers multisensory feedback to enhance the writing ability of children with Down Syndrome. Overall, the system presents technology based approach that effectively track individual difficulties and provide better solutions for the children with Down Syndrome in meaningful, effective and interesting way. The system mainly talks about Real time feedback, game-based learning activities to help children to enhance their skills in order to build their personal life.

References

[1] D. Logan, V. De Silva, S. M. Clancy, R. J. Proeschold-Bell, C. Wijesinghe, L. Hart, and T. Østbye, "School-aged children with Down Syndrome in Galle, Sri Lanka: Relationship between level of disability, resource use, and caregiver burden," Disability, CBR & Inclusive Development, vol. 34, no. 3, 2023.

[2] A. Bourazeri et al., "EnCity: A serious game for empowering young people with Down's syndrome," in Proc. IEEE SeGAH, 2017.

[3] S. A. S. T. Sampath et al., "E-Learning education system for children with Down Syndrome," Sri Lanka Institute of Information Technology (SLIIT), Malabe, Sri Lanka.

[4] G. Vaudano et al., "The mathematical development of children with Down Syndrome: The adapted Cuisenaire material as a learning facilitator," Research Center of ISCE, Instituto Superior de Lisboa e Vale do Tejo, Portugal, 2022.

[5] S. Dhamodaran et al., "Implementation of hand gesture recognition using OpenCV," NIET, NIMS University, Jaipur, India, 2024.

[6] Y. Alnasser, "Perceptions of Saudi elementary school special education teachers regarding mathematics content and instructional practices for students with intellectual disabilities," Int. J. Dev. Disabil., Nov. 2024.

[7] K. V. Prasad et al., “Convolutional long short-term memory hybrid networks for skeletal based human action recognition,” Int. J. Innov. Technol. Explor. Eng. (IJITEE)

[8] UNESCO, “Finger counting as a key tool for the development of children’s numerical skills,” United Nations Educational, Scientific and Cultural Organization, 2021.

[9] D. Escudero-Mancebo et al., “Evaluating the impact of an autonomous playing mode in a learning game to train oral skills of users with Down syndrome,” IEEE Access, July 2021.

[10] H. M. C. H. Herath et al., “EduPlanner – Best teaching method for students with Down Syndrome,” in Proc. 5th Int. Conf. Adv. Comput. (ICAC), Malabe, Sri Lanka, 2023, pp. 304–309.

[11] Y. Amemiya et al., “A support system for gross motor assessment of preschool children,” Japan Women’s College of Physical Education and Tokyo Denki University, Tokyo, Japan.

[12] S. Wellala et al., “Assistive learning platform for children with Down Syndrome,” Sri Lanka Institute of Information Technology (SLIIT), Malabe, Sri Lanka.

[13] S. Silva et al., “Effectiveness of deep learning technologies to assist educational inclusion for children with Down Syndrome,” Sri Lanka Institute of Information Technology (SLIIT), Malabe, Sri Lanka.

[14] S. Suzuki et al., “Enhancement of gross-motor action recognition for children by CNN with OpenPose,” Graduate School of Advanced Science and Technology, Tokyo Denki University, Tokyo, Japan.

[15] I. Escobar et al., “Mobile application for vowel learning in children with Down Syndrome,” in Proc. IEEE CHILECON, 2017.

[16] W. M. Shalash et al., “No Limit: A Down Syndrome children educational game,” in Proc. IEEE GEM, 2018.

[17] R. Cui et al., “Multisource learning for skeleton-based action recognition,” J. Electron. Imaging, 2018.

[18] N. binti Mohamad, “Number skills conceptual framework for Down Syndrome children,” B.Tech. dissertation, Faculty of Information and Communication Technology, 2020.