CSAAT - Culturally Sensitive Autism Assessment Tool

Autism is neurodevelopmental disorder, which may cause impairments in social behaviors such as lack of eye contact, facial expressions, poor communication abilities that may result both verbal and non-verbality and repetitive and stereotype behaviors. Early diagnosis of symptoms within first 3 months to 18months in life may help the children to direct for therapeutic sessions and improve their social skills. However, it is critical to identify these symptoms in infants as this is the developmental age of children. In this research, the main goal is to develop a screening tool for autism for Sri Lankan environment that will help to diagnose children by parents and general medical officers.

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Project Title

CSAAT - Culturally Sensitive Autism Assessment Tool

Project brief

Autism is a neurodevelopmental disorder with few characteristic symptoms. Those symptoms include abnormalities in eye contact (eye gaze) and body language, lack of facial expressions, poorly integrated verbal and nonverbal communication, abnormal social approach and failure of normal back-and-forth conversation (reciprocity), deficits in understanding and use of gestures, stereotyped or repetitive motor movements, ritualized patterns of verbal and nonverbal behavior, excessive smelling or touching of objects. Availability of few or more symptoms and severity (vary by context and fluctuate over time) of those symptoms create "spectrum" of disorders, hence called Autism Spectrum Disorder (ASD) [1]. The Centers for Disease Control and Prevention (CDC)'s Autism and Developmental Disabilities Monitoring Network (ADDM) report that approximately one in 68 children can be identified with the above symptoms in USA [2]. Systematic reviews have published varying rates in prevalence due to lack of organized screening and survey [3]. In Asia, the South Asia region represents more than 20% of the world's population, yet the prevalence of ASD in this part of the world is still largely unknown [4]. In a study done in Sri Lanka it was revealed that by the age of 24 months, only 14.3% of children with autism have sought treatment [5], which was a low figure compared to Western countries. In Sri Lanka at present, there are few facilities available, but, for majority of families, these remain inaccessible because of high cost. Autism interventions require multidisciplinary resources (speech therapists, occupational therapists, and psychologists). These resources are not available in many parts of the country [6]. In one study it was reported that majority of General Medical Officers (GMOs) in Sri Lanka, who are often the first point of contact for families, are unaware of the characteristics of ASD. A study done in a tertiary children hospital revealed that 34% of the doctors were unaware of the main presenting symptoms as speech delay and a further 39% failed to recognize the co-morbidities in ASD [6].The screening methods for ASD have not been systematic in our country over the past years. Many tools have been used, but up to now there are no standards set for screening of this vulnerable group of children. Signs of ASD appears as early as 6 months of age and early diagnosis is vital as early intensive behavioral interventions improve adaptive behavior, language and intelligence in autism and diagnostic delays can worsen prognosis. On early diagnosis, symptoms involving eye gaze, reciprocity, motor skills, gait and speech play major roles.

Project Team

Project Investigators

Name	Role of the Project
Dr. Pradeepa Samarasinghe	Principal Investigator, Project Coordinator
Prof. Koliya Pulasinghe	Co-investigator, Deputy Project Coordinator
Prof. Chandimal Jayawardene	Co-investigator
Dr. Nuwan Kodagoda	Co-investigator
Dr. Lasantha Seneviratne	Co-investigator
Dr. Dharshana Kasthurirathna	Co-investigator
Dr. Anuradha Karunasena	Co-investigator
Dr. Shyam Reyal	Co-investigator
Ms. Chathurangika Kahandawaarachchi	Co-investigator

External Collaborators

Name	Designation	Institute
Dr. Swarna Wijetunge	Consultant child and adolescent psychiatrist	Lady Ridgeway Hospital for Children, Colombo
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Dr. Chitraka Wickramarachchi	Senior Lecturer in Statistics	Department of Statistics, Faculty of Applied Sciences, University of Sri Jayewardenepura
Prof. Thushara Abhayapala	Deputy Dean	College of Engineering and Computer Science, The Australian National University, Australia
Dr. Pratheepan Yogarajah	Lecturer	School of Computing and Intelligent Systems, Ulster University, UK
Dr. Michela Papandrea	Lecturer-Researcher	University of Applied Sciences and Arts of Southern Switzerland
Dr. Bryan Gardiner	Associate Head of School	School of Computing and Intelligent Systems, Ulster University, UK
Charith Abhayaratne	Lecturer	Department of Electronic and Electrical Engineering, The University of Sheffield, UK

Researchers

Name	Role of the Project
Ms. Veerandi Kulasekara	Researcher – Speech Recognition
Ms. Vijani Piyawardana	Researcher – Dialog Management
Ms. Manuri Senarathna	Researcher – Speech Synthesis
Mr. Nushara Wedasingha	Researcher – Restricted and Repetitive behavior analysis
Mr. Gagana Hashentha	Researcher – Gesture and Gait Analysis
Ms. Amali Gunasinghe	Researcher – Gaze Analysis
Ms. Vidushani Dhanawansa	Researcher – Gaze and Attention Analysis
Ms. Malithi Mithsara	Researcher – Criteria based video analysis
Ms. Madhuka Nadeeshani	Researcher – Emotion Analysis
Ms. Lumini Wickramasinghe	Researcher – Emotion Analysis
Ms. Kusheni Tharushika	Researcher – Emotion Analysis
Ms. Thilini Jayasekara	Researcher – Data Store
Mr. Nadun Ranasinghe	Researcher – SAR Implementation
Ms. Shashipraba Perera	Researcher – Mobile Application

Photos of Project Members

Supervisors

Dr. Pradeepa Samarasinghe

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Prof. Chandimal Jayawardena

Dr. Nuwan Kodagoda

Dr. Lasantha Seneviratne

Dr. Dharshsana Kasthurirathna

Dr. Anuradha Karunasena

Dr. Shyam Reyal

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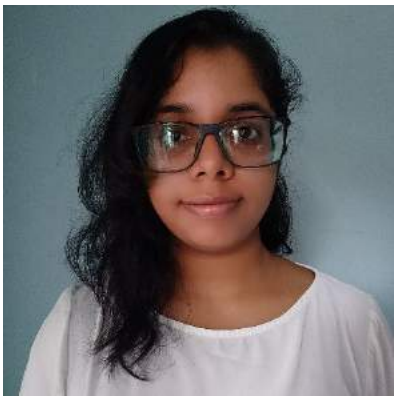
Mr. Nushara Wedasinghe

Mr. Gagan Hashentha

Ms. Amali Gunasinghe



Ms. Vidushani Dhanawansa

Ms. Thilini Jayasekara

Ms. Madhuka Nadeeshani

Ms. Kusheni Tharushika

Ms. Lumini Wickramasinghe

Mr. Nadun Ranasinghe

Ms. Shashipraba Perera

Main objective

To Research and identify the pattern variations of emotions, eye gaze, gestures and speech of young children with Autism which will lead to develop a Culturally Sensitive Autism Assessment Tool. This tool will enable early screening of infants which would result in early interventions of those children with Autism.

Detailed Objectives of the study

To date, no study has been performed on the early autism indicators in Sri Lanka and no attempt has been taken to implement an automated early screening tool. This will be the first research on how eye gaze, emotion recognition, speech, gait and motor skills of young children could be integrated into a single screening tool for ASD.

1. Automated gaze and emotion analysis - Children use gaze and emotions as early as being two months old. The automated analysis of eye gaze, smile, imitation of facial expressions, responsiveness would give an early indication of autistic symptoms. These social cues that we measure, can be recorded in greater detail and at an early age which would give more opportunities for diagnosis of ASD and early intervention. Though there has been few researches in developed countries using gaze patterns for autistic screening, the devices and the technologies they have used are not affordable by Sri Lanka.
2. Automated speech and language analysis - Delay and regression in speech are the most common symptoms of autistic screening. Young children start babbling as early as 5 months and use around 300 words when they reach 3 years of age. To date in Sri Lanka there has not been an attempt to develop an automated speech screening tool which would help to identify speech deficiencies and speech patterns of children in this age group. This research will be totally dedicated to analyzing Sinhala and Tamil speech and language, which are not attempted by other countries.
3. Automated gait and motion analysis - Only a limited research has been done worldwide and none in Sri Lanka on analyzing the gait, motion patterns and motor skills of autistic children and existing research has rarely used quantitative methods in their analysis. Most of those researches also involves children older than 3 years of age indicating the need for longitudinal research with infants starting within the first year of life. In a recent study [8], it is shown that disruption in early motor development could have cascading effects that contribute to disruption even in language development. This elevates the critical level of the need of the research of automated motor skills analysis.

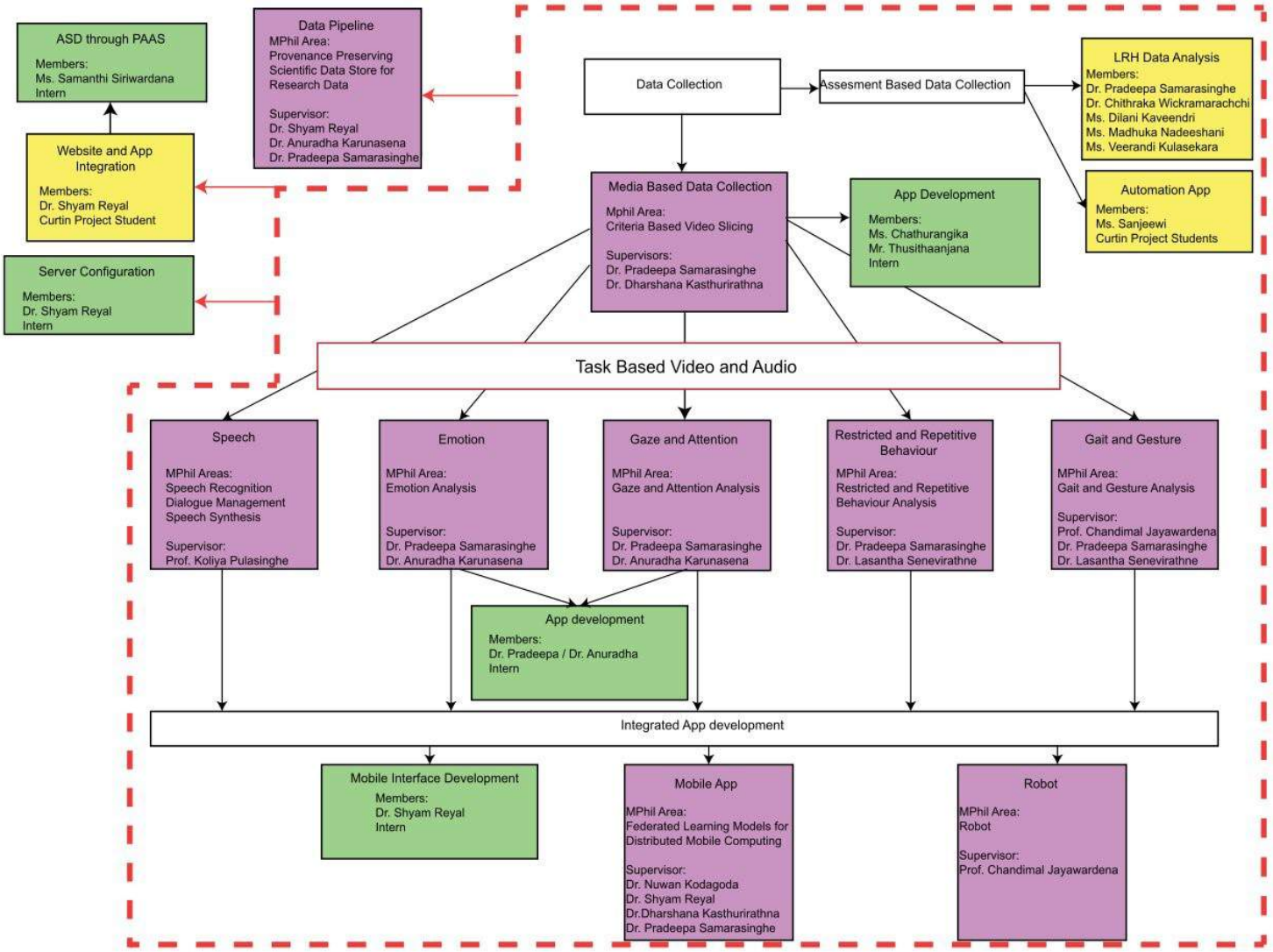
Based on the above problem analysis and justifications, key objectives of our research are to

1. Study in depth and develop novel models to use the following as ASD screening indicators of infants and young children in order to start early screening from 4 months of age,
    - Eye gaze and emotions
    - Speech and language

- Gait and gesture patterns

2. Develop an automated smart device-based application with the above indicators.
3. Use a Socially Assistive Robot (SAR) in performing advanced ASD screening with the above indicators to improve the accuracy, to screen often and to link the screening results to individuals across their age.

Overall Project Design



Methodology

System Overview

This research is carried out to develop an automated culturally sensitive tool capable of screening young children for evidence of ASD. The proposed tool collects gaze, gait, emotion and speech information of children and analyses them for evidence of ASD. The system overview of the proposed system during the training phase is shown in figure 1.

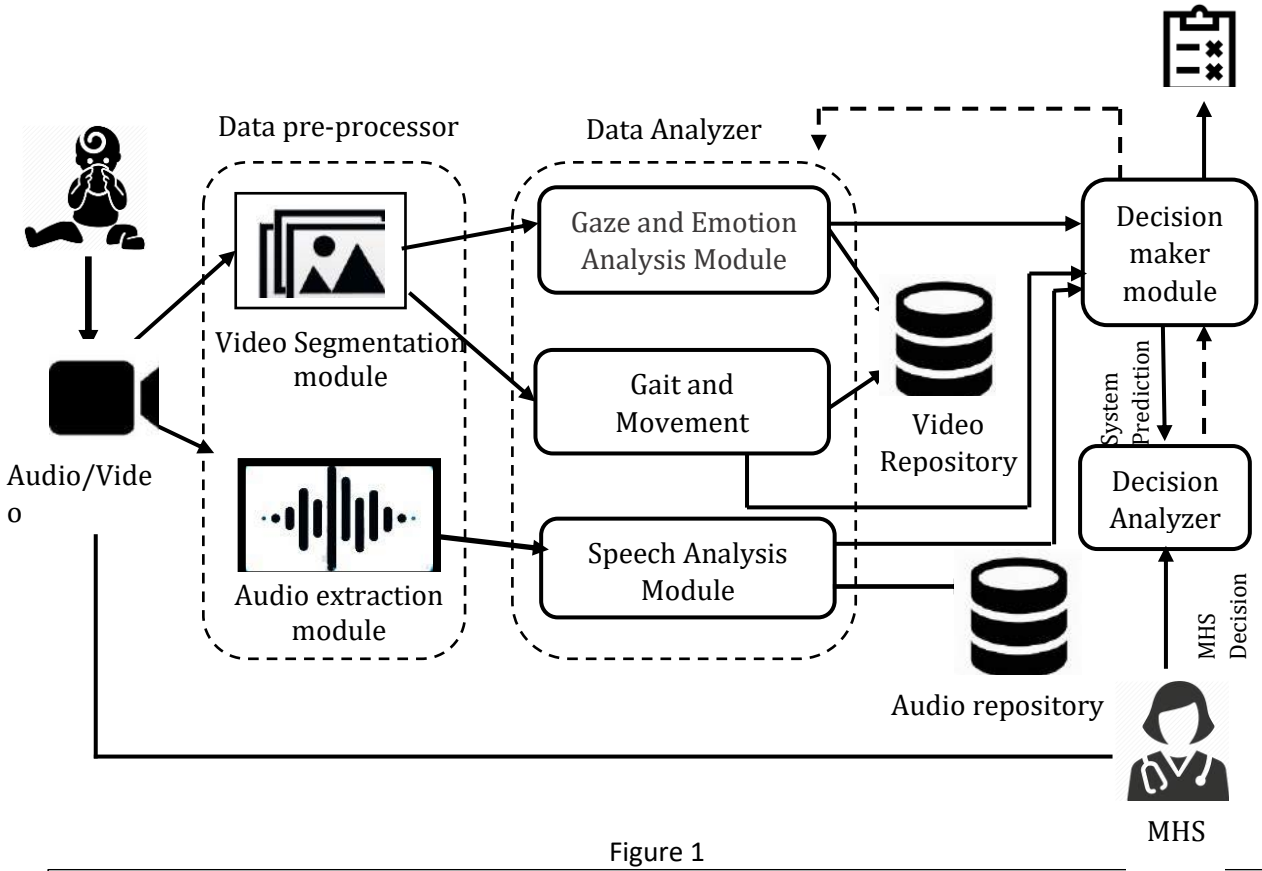


Figure 1

Direct Path	———	
Training Path	- - - - - - - - -	(This will continue until the MHS decision is same as the system prediction)

As shown in the figure, the system collects video and audio of children, in particular, related to gait, gaze, emotion and speech, which are processed by two modules in the data pre-processor, namely, audio extraction module and video segmentation module. The purpose of the above two modules is to refine and prepare collected data to be processed by the modules in the data analyzer. The data analyzer module consists of three modules namely gaze and emotion analysis module, gait and movement analysis module and speech analysis module which analyzes gaze and emotion, gait and movement and speech respectively for signs of ASD. The decisions made by those three modules independently are, next, sent to the decision maker module which makes a prediction based on the inputs. Once the decision marker module makes a prediction, the prediction made is compared with the decision made by a MHS who analyses the same inputs. If the prediction made by the system is different from the decision made by the Medical Health Specialists (MHS), the feedback is fed to the decision maker module and the data analyzer module would be further refined. Once the prediction made by the system is equal to the MHS decision, the decision maker module is considered ready for implementation.

Use of socially assistive robots in screening, diagnosis, and therapeutic settings of ASD affected children have been reported in various literature. It is interesting to note that autistic children do like to interact with small humanoid robot compared to human. Therefore, in this research, it is intended to use a humanoid robot in a simulation environment to engage with children screened positive by initial assessments. A humanoid robot with required audio and video sensors to capture both verbal and non-verbal cues of communication, facial expressions, gestures and postures, and gait and movement of children with required sensitivity will be utilized in this research. This robot will be equipped with aforesaid algorithms to generate a screening report with an assessment score that indicates how apparent the deficiency of behavior is affected by ASD. A report of this nature will be used as a precursor for diagnosis as well as effectiveness of treatment plans. Some children who are normal until 12 months to 18 months of age “Regress” to ASD as a type of ASD. The CSSAR can be employed to assess the “Progress” or the “Regress” of children identified by tier-1 or getting treatments as shown in Figure 2.

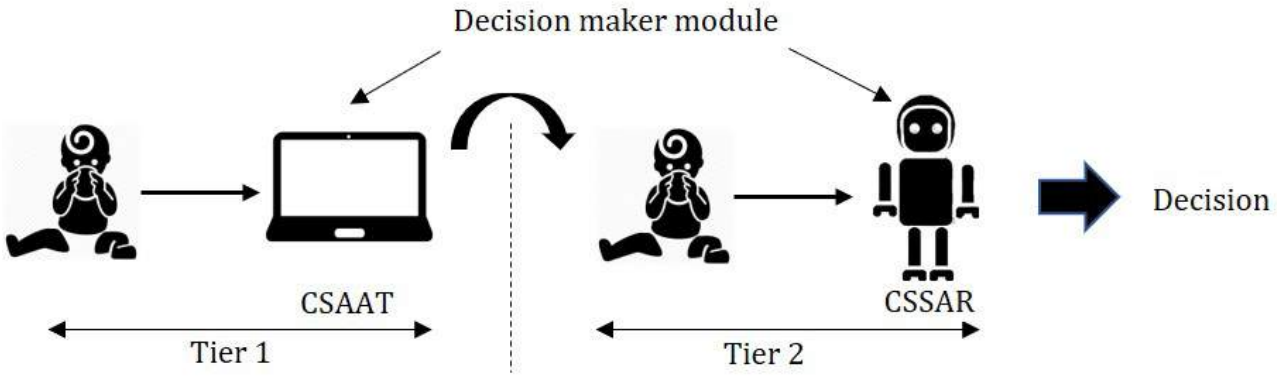


Figure 2

There is a variation of appearing the array of autistic symptoms in children with ASD. Sometimes these symptoms are highly apparent or are subtle and difficult to identify. Fuzziness of the level of significance of apparent ASD

symptoms will be captured with the aid of an expert panel which consists of a child psychiatrist, a pediatric neurologist, and a speech therapist to train the SAR to improve its accuracy. In this simulation environment, we can capture data from children who are susceptible as ASD affected children. Necessary modifications will be implemented to this robot to capture the audio and video signals of these children for future research to improve the quality of assessments.

Grant Details

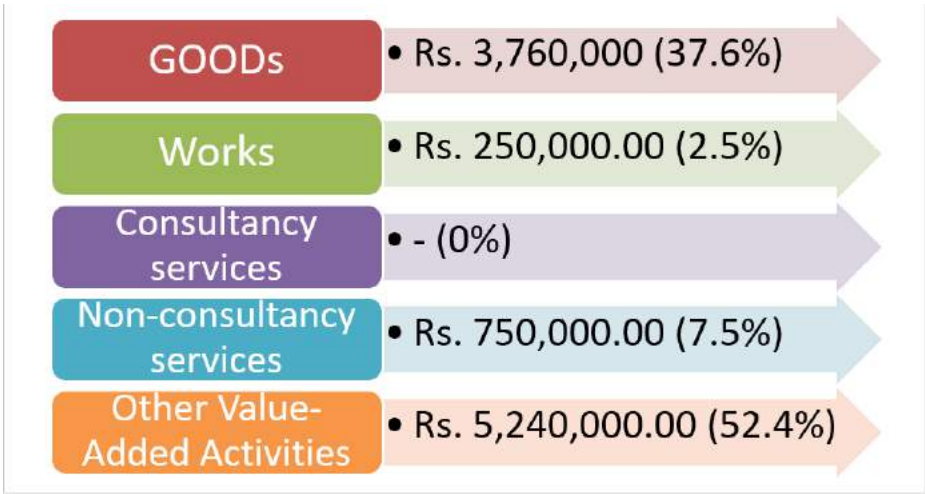
Type

Accelerating Higher Education Expansion and Development (AHEAD) – World bank funded Development Oriented Research (DOR) Grant

Grant amount

Grant amount is Rs. 10 Million.

Proposed Budget



Research Areas

1. Speech

Children with ASD often have challenges in speech and language usage. In CSAAT project, it is aimed at programming/training a robot to maintain a dialogue with children with the intention of recognizing ASD landmarks in the conversation. Robot's communication interface has speech recognition, dialogue management, and speech synthesis to maintain a back-and-forth conversation with children. In this research a Sinhala speech synthesizing algorithm must be developed to complete the communication interface.

i. Speech Recognition

Autism Spectrum Disorder (ASD) is a neuro-developmental disorder characterized by social impairments, communication difficulties and repetitive behaviors. Lack of speech is the main symptom that 82.4% of children were directed to clinics at the average age of 35.8 months and finally get diagnosed for ASD. Children can be directed for early intervention by identifying the symptoms appears in speech and language such as difficulties in prosody, abstract use of language, echolalia, delay in response and limited amount of functional words that appears as early as first 6 -18 months of life. Kaldi based novel Automatic Speech Recognition (ASR) system in Sinhala for children is to be developed that can recognize speech impairments in autistic children in early childhood utterances and help the speech therapists to carryout therapeutic activities to overcome ASD. Moreover, this research develops a speech data corpus in Sinhala Language of both typical and atypical children for future research.

Area of research – Sinhala Speech Recognition, Natural Language Processing

Supervisor – Prof. Koliya Pulasinghe

Co-supervisor – Dr. Shyam Reyal

Research Assistant – Veerandi Kulasekara

ii. Dialogue Management

According to recent statistics, one among 95 kids in Sri Lanka is diagnosed with Autism Spectrum Disorder (ASD), a neuro-developmental disorder. In Sri Lanka, they are identified at average of 35.6 months of age where symptoms can be diagnosed as early as 6 months. Early diagnosis and clinical intervention improve them to co-exist with typical students when they enter schools. ASD consists of pool of social interaction impairments including speech and language impairments such as echolalia, poor reciprocity in conversations, self-talk, delay in response, respond in a few words or no talk at all. A Novel Sinhala Dialogue Management System based on RASA framework is proposed to engage with atypical kids to instigate above hallmarks in language impairments to assess the level of impairment and conduct therapeutic conversations to help recovery. Culturally inherited role-plays and conversational games will be used to sustain interest and engagement of the kids.

Area of research – Sinhala Speech Analysis, Dialogue Management, Natural Language Processing

Supervisor – Prof. Koliya Pulasinghe

Co-supervisor – Dr. Shyam Reyal

Research Assistant – Vijani Piyawardana

iii. Speech Synthesis

The limited speaking skills and communication problems faced by children suffering from Autism Spectrum Disorder (ASD) suggests the need for a back-and-forth conversation to be maintained with the children. Upon the successful recognition of Sinhala speech and the development of a system to maintain a dialogue with the children, there arises a necessity for the conversion of Sinhala text to an audio output. In this study, a novel approach of conversion of text-to-speech (TTS) is proposed for the artificial production of human speech in Sinhala language.

Area of research – Sinhala Speech Synthesis, Text-to-Speech synthesizers

Supervisor – Prof. Koliya Pulasinghe

Co-supervisor – Dr. Shyam Reyal

Research Assistant – Manuri Senarathna

2. Gesture and Gait Analysis

A variety of movement disturbances including atypical gait, upper limb movements and postural control are also important as early signs of autism. Atypical gait is defined as an unusual style of walking from the normal pattern of walking and researchers have tried many different variables to test the abnormal gait patterns of children with ASD. Most studies have either used basic gait measurements, kinematic, kinetic or a combination of these. A limited research has been conducted on the link between infant motor skills and autism and much of the literature tend to provide a qualitative description of gait and motion based on the observation of clinicians. Thus, it is imperative to quantify these descriptions with measuring tools real time, specially starting as early as 6 months of age. Therefore, automated tools for quantitative gait and motion analysis have become vital for assessing pathologies manifested by atypical motor behaviors. This research is to analyze the gesture and gait patterns of children with Autism.

Area of research – Computer Vision, Sensors, Deep Learning

Supervisor – Prof. Chandimal Jayawardene (primary), Dr. Pradeepa Samarasinghe, Dr. Lasantha Senevirathne

External Supervisor -

Research Assistant – Gagan Hashentha

3. Socially Assistive Robot for Detecting Autistic Behaviour

About 1 in every 160 children globally has autism spectrum disorder (ASD). ASD is a developmental disability, which is characterized by social, emotional, and communication challenges. Recent advancements in the research domain of socially-assistive robots have shown a promising direction to use robots to help children with ASD. A socially-assistive robot can be built with capabilities such as games to engage children, collect data and to identify the risk of developing ASD; thus, enabling early interventions to improve their conditions. Further, recent research has shown that socially-assistive robots can be successfully used for enhancing social skills of children with ASD as well. In this particular MPhil project an already available programmable robot will be developed as a social-assistive robot to perform the above mentioned functions. The primary focus will be on early detection of ASD related behavior, although the same robot may be extended as a therapeutic agent as well.

Area of research – Socially Assistive Robotics

Supervisors – Prof. Koliya Pulasinghe (primary), Prof. Chandimal Jayawardena

External Supervisor -

Research Assistant - Nadun Ranasinghe

4. Restricted and Repetitive Behavior Analysis

The presence of restrictive and repetitive behaviors (RRBs), interests, and activities is one of the key indicators of Autism. Individuals may engage in stereotyped and repetitive motor movements (e.g., hand flapping, rocking, punching, drumming or lining up items) or speech. They may have an insistence on sameness. RRBs can be problematic when others interfere with the child's way of behavior leading to anxiety and aggression. This research focuses on identifying the RRBs of the children and finding ways to automate the behavior analysis and prediction.

Area of research – Computer Vision, Deep Learning

Supervisor – Dr. Pradeepa Samarasinghe (primary), Dr. Lasantha Senevirathne

External Supervisor - Michela Papandrea, Researcher of University of Applied Sciences and Arts of Southern Switzerland

Research Assistant – Nushara Wedasinghe

5. Emotion Analysis

It has been found that there are significant differences in social interaction of children with ASD. Emotion expression and emotion recognition play key roles in social interaction. Children with Autism has shown poor emotion expression as well as recognition of others' emotions. This research is aimed at developing an automated tool to identify the deficits in both emotion expression and recognition of children with Autism. The automated analysis of smile, imitation of facial expressions, responsiveness would signal an early indication of autistic symptoms.

Area of research – Computer Vision, Deep Learning

Supervisor – Dr. Pradeepa Samarasinghe(primary), Dr. Anuradha Karunasena

External Supervisor -

Research Assistants – Madhuka Nadeeshani, Lumini Wickramasinghe, Kusheni Tharushika, Dakheela Madanayake

6. Gaze and Attention Analysis

Children with ASD have shown variant behaviors in eye contact, disengagement of visual attention, visual tracking and social interest and affect in comparison to typically developing (TD) children. These social cues that we measure, gaze and attention in particular, can be recorded in greater detail and at an early age which would give more opportunities for diagnosis of ASD and early intervention. Though there has been few research studies in developed countries using gaze patterns for autistic screening, the devices and technologies they have used are not affordable in Sri Lanka. This research area attempts to find affordable techniques for evaluating gaze and attention of children with Autism.

Area of research – Computer Vision, Deep Learning

Supervisors – Dr. Pradeepa Samarasinghe(primary), Dr. Anuradha Karunasena

External Supervisor – Dr. Bryan Gardiner

Research Assistant – Ms. Vidushani Dhanawansa

7. Provenance Preserving Scientific Data Store for Research Data

The CSAAT project aims to early-detect Autism in young children using anomalies in emotion, gaze, movement, and speech by application of machine learning / deep learning techniques. This requires collection and storage of large volumes of video, speech and image data, along with corresponding meta-data. Meta-data could be automatically extracted features from the data, or annotations made by researchers. Further, it is required to perform custom queries to retrieve certain subsets of this data on-demand, using the above meta-data as search parameters. This section addresses the research questions such as what meta-data could (and should) be extracted from the source data, how best to design the interface to make annotations, and how the meta-data could be stored and indexed.

Area of research – Computer Vision, Deep Learning

Supervisors – Dr. Shyam Reyal (primary), Dr. Pradeepa Samarasinghe, Dr. Anuradha Karunasena

Research Assistant – Ms. Thilini Jayasekara

8. Federated Learning Models for Distributed Mobile Computing

The CSAAT project aims to early-detect Autism in young children using anomalies in emotion, gaze, movement, and speech by application of machine learning / deep learning techniques. One objective is to provide a mobile-app to the general public which concerned parties (parents, carers, etc.) could use to upload a video, voice-clip, or image of a child onto the cloud for preliminary screening for Autism by the CSAAT system and this section focuses on the mobile application endpoint of the CSAAT project.

Area of research – Mobile Computing, Distributed Computing, Machine Learning, Federated Learning

Supervisors – Dr Nuwan Kodagoda (primary), Dr Dharshana Kasthurirathna, Dr Shyam Reyal, Dr Pradeepa Samarasinghe

Research Assistant – Ms. Shashipraba Perera

Publications Details

Type	Title	Author/s	year	Conference/ journal name	Status
Abstract	Novel Automated Sinhala Speech Recognition System to Screen Young Children with Autism Spectrum Disorder (ASD) in Sri Lanka	Veerandi Kulasekara, Vijani Piyawardana, Shyam Reyal, Koliya Pulasinghe	2020	Symposium in Natural Language Processing (SNLP2020)	Abstract Presentation is done.

Abstract	Novel Automated Sinhala Speech and Dialogue Management System to Screen Young Children with Autism Spectrum Disorder (ASD) in Sri Lanka	Vijani Piyawardana, Veerandi Kulasekara, Shyam Reyal, Koliya Pulasinghe	2020	Symposium in Natural Language Processing (SNLP2020)	Abstract Presentation is done.
Conference article	Facial Emotion Prediction through action units and deep learning	Madhuka Nadeeshani, Akash Jayaweera, Pradeepa Samarasinghe	2020	International Conference in Advancement in Computing (ICAC2020)	Paper published
Journal Article	Review of Technology on Facial Emotion Expression Analysis of Young Children with Autism	Pradeepa Samarasinghe, Dulangi Dahanayake, Swarna Wijethunga, Madhuka Nadeeshani	2021	Sri Lanka Journal of NSF	Preparing for submission
Journal Article	Diagnosing Autism in low-income countries:clinical record-based analysis in Sri Lanka	K.G.H.S Peiris, Chitraka Wickramarachchi, Veerandi Kulasekara, Madhuka Nadeeshani, Pradeepa Samarasinghe, and Dulangi Dahanayake	2021	Autism Research	Preparing for submission

Internship Areas

Intern Members

Name of the Intern	Assigned Project	Supervisor
Ms. Thilini Jayasekara	CSAAT Web	Dr. Shyam Reyal
Ms. Shanika Dilrukshi	LRH Website, Data Collection and Automation	Ms. Sanjeevi Chandrasiri
Ms. Vidusha Nasome	Video Analysis	Dr. Pradeepa Samarasinghe/ Ms. Madhuka Nadeeshani
Mr. Sachin Muthumala Athukorala	Data Collection/ full stack	Mr. Thusithanjana Thilakarathne
Ms. Nethmini Aloka Kaluarachchi	Data Pipeline	Dr. Anuradha Karunasena
Mr. Thisura Hettiarachchi	DevOps	Dr. Shyam Reyal
Mr. Sutharshan Shanmugarajah	Mobile-client full stack development	Dr. Nuwan Kodagoda
Ms.Sawandi Naotunna	Automating PAAS	Ms.Lumini Wickramasinghe
Ms. Tharushi Ranruwini	Development Milestones Assessment Tool (DMAT)	Ms.Samanthi Siriwardana
Ms.Keshari Jayakody	Automating PASS	Dr.Shyam Reyal
Ms.Shashini Hewadewa	Psychological Area	Mr.Thusithanjana Thilakarathna
Ms.Aparna Jayawardana	Pubudu Mobile App	Ms.Madhuka Nadeeshani

Objectives and Responsibilities

CSAAT Web

- Design a full stack web-application for the given requirements
- Implement the agreed design using software engineering best practices to a high standard
- Implement automated testing, deployment and maintenance mechanisms
- Manage content and information architecture of the web application
- Document the technical aspects and development process

LRH Website, Data collection and Automation

- Integrate development environments for writing and editing coded
- Recommend and execute improvement to automated data collection and automation.
- Create technical documentation for reference and reporting
- Develop a hibernate framework to work with multiple data sources
- Consult to evaluate software-hardware interfaces and develop specifications and performance requirements

Video Analysis

- Develop a mechanism to choose the best stream out of multiple views
- Design and develop an application to classify main categorized of behaviors
- Develop incorporating annotations for the videos

- Design and implement data pipelines to the behavior categorizations and generate reports

DevOps

- Design full-stack mobile application for the given requirements
- Develop a full-stack mobile application based on the approved design
- Use best practices from software engineering to a high production standard
- Implement automated testing, deployment and maintenance mechanism

Data collection/ full stack

- Develop and application to setup and configure data collection devices
- Through the application, synchronize the collected data
- Design and develop an application to categorize collected data
- Design data storage and retrieval mechanism related to the collected data

Data pipeline

- Develop a conceptual data model to represent the data required to the problem
- Design and develop a relational database using MySQL to store and retrieve meta data
- Fine-tune the database for efficient retrieval of stored data
- Develop a full-stack application to query the database and visualize the results

References:

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