

Yalu: Computer Game Based Solution to Screen Learning Disabilities in Kids

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Abstract – This paper presents the extracted computational techniques and outcomes of software solution developed for learning disability evaluation in young children. Learning disabilities are neurological disorders which affects brain functions. It is efficient to diagnose them in early stages. The developed application screens the learning disabilities by using gamefication module. This game module contains tasks which are based on symptoms of these disabilities. By evaluating children interactions to the tasks, this game module evaluates the child condition and provides the results to respective parties. Background problem of these disabilities, clinical diagnosing methods and criteria and methodology used for development of this solution is explicated by this paper. Ultimately, the proof testimonies of concepts are set forth by summarizing the outcomes obtained from standard statistical concepts.

Keywords – Learning disability evaluation, Dyslexia, Dyspraxia, Dysgraphia, Dyscalculia

I. INTRODUCTION

Learning disabilities are neurological disorders that affect the brain's ability to receive, process, store, respond to and communicate information. Learning disabilities (LD) are a combination of disorders, not a single disorder. These are not the same as intellectual disabilities which are formerly known as mental retardation, sensory impairments or autism spectrum disorders. People with learning disabilities are of average or above-average intelligence but still struggle to acquire skills that impact their performance in school, at home, in the community and in the workplace. Learning disabilities are lifelong disabilities and does not have medical cure. Learning disabilities are four types. Each type is involve with different ability of brain [1]. The main types of learning disabilities are Dyslexia, Dysgraphia, Dyscalculia, and Dyspraxia.

Most common type is Dyslexia. Dyslexia is difficulty in the use and processing of linguistic and symbolic codes, alphabetic letters representing speech sounds or numeric representing numbers or quantities. It can affect spoken language, written language and language comprehension [2]. Dyslexia can simply describe as disability with reading. Writing is a skill highly valued in our society, even in a time of computers and technology. In the past, handwriting was prized because it was a primary form of communication; people needed to get notes to others that were legible. Second type of learning disabilities involve with writing which is Dysgraphia. Children are not able to keep up with written assignments, cannot put coherent thoughts together on paper, or write legibly in correct format [3]. Third type is Dyscalculia. It refers to a persistent difficulty in the learning or understanding of number concepts, counting principles, cardinality or arithmetic. These difficulties are often called a mathematical disability [4]. Last type is dyspraxia. Dyspraxia manifests itself in problems in adequately registering, interpreting, organizing and integrating sensory information to produce an efficient response. As children dyspraxics are often referred to as having “clumsy child

syndrome” because of their tendency to bump into things and they frequently have trouble with sports, e.g. catching balls. Dyspraxia is also known as Developmental Co-ordination Disorder (DCD) [5].

People with LD face different kind of problems in every stage of life. Bullying in school is the difficult for children. Because effect of bullying is haunt them through the life. Difficulties in several areas listed in following table 1.

TABLE I
COMMON PROBLEMS OF LEARNING DISABILITIES

Area	Difficulties
Social	Lack of ability to comprehend nonverbal communication Significant deficiencies in social judgment and social interaction
Academic	Problems in math, reading comprehension, handwriting Problems with organization, problem-solving, higher reasoning Strengths include strong verbal and auditory attention and memory
Visual-Spatial	Lack of image, poor visual recall Faulty spatial perception and spatial relations
Motor	Lack of coordination Severe balance problems Difficulties with fine motor skills
Emotional	Frequent tantrums, difficulties soothing, easily overwhelmed Fears of new places and changes in routines Prone to depression and anxiety as they get older

Source: <http://www.waisman.wisc.edu/>

Experts aren't exactly sure what causes learning disabilities. Some possible causes are like heredity. Often, learning disabilities run in the family, therefore it's not uncommon to find that people with learning disabilities have parents or other relatives with similar difficulties. Problems during pregnancy

and birth. Learning disabilities may be caused by illness or injury during or before birth. It may also be caused by low birth weight, lack of oxygen, drug and alcohol use during pregnancy, and premature or prolonged labour. Also incidents after birth, Head injuries, nutritional deprivation, and exposure to toxic substances (i.e. lead) can contribute to learning disabilities. Learning disabilities are not caused by economic disadvantage, environmental factors, or cultural differences. In fact, there is frequently no apparent cause for learning disabilities.

Evaluating these disabilities are different from country to country. With the amount of knowledge parents have on these disabilities; time to evaluate these conditions vary. In country like Sri Lanka, many parents are not aware of this medical condition and children with LD are labelled as idiots or lazy children. Also in the school with the amount of children in the class teachers may not able to keep eye on each child and these children are lagged behind due to learning difficulties.

If a parent or teacher suspects about child having these disabilities, they can take child to trained consultant and get tested. Consultant diagnose the child using DSM V criteria [6]. In Sri Lanka; they use some paper base mechanism which is very time consuming and unattractive method. Unawareness of this condition leads to the undiagnosed of this condition and it mostly became major problem in life of Learning disability people.

II. EXISTING SYSTEMS

In Sri Lanka there is no software based method available to evaluate these disabilities even though internationally, Yalu kind of game based applications are difficult to find. There are several applications designed to test this issue, but most of them are based on questionnaires to be followed by parents, guardian or child. For that they must be very keen in computer literacy and also fluent in English because most of applications are in English. Although this applications give results based on answers provide to questions, not by the interactions of user or by observing the actions of user. And these applications are basically address to more mature children in age above six. Basically those existing solutions does not address four types of learning disabilities and they are not interesting for children at all.

- **Dore dyslexia symptom check** [7] – Questionnaire based testing application. Child or parent can answer the questions and take the test results. User must have good computer literacy in order to perform this test. This is a free test, but to have the results user have to give an email and results will be sending to that email. This application test only one category of only.
- **Adult Self-Assessment Tool by IDA** [8] – Questionnaire based testing method, only for adults. Adult can answer the question given in test and according to answers user given scores. Site says if user have high score, user have high possibility of LDs. User have to have good computer literacy. Child cannot interact with this application.
- **Lexion** [9] – Complex system used to test only Dyslexia. At least child should be 6 years old to be interacting with

this system. And this system contains applications for train dyslexic students.

- **Dyslexia Screener** [10] – Age must be above 6 to do testing using this system and it's costly. This site contains different type of screening applications, but parents have to buy them to test each disability.
- **Lexercise** [11] – Complex dyslexia screening application. Child must have a good computer literacy to test with this application.

Problem with all these systems are they mainly focused on one kind of learning disability, but most of the time there is two or more learning disability in children. And these all online or desktop mode applications can be played by a person who has more computer literacy only.

TABLE II
SUMMARY OF BACKGROUND CONTEXT

Name	Lang	Age	Disability	User	Attractive ss
Lexercise	En	6+	Dyslexia	Parent	No
Dore	En	Adult	Dyslexia	Parent/Child	No
IDA	En	Adult	Dyslexia	Parent	No
Screener	En	6 -14+	Dyscalculia	Child	No
Checklist	En	Adult	Dyspraxia	Parent/Child	No
Yalu	En/Sin	4-6	All LDs	Child/Parents	Yes

Summary of the survey

As in the survey, all screening applications address only one type of LD. There couldn't find any application which will identify Dysgraphia. To overcome those problems YALU Learning Disability Evaluation Kit is introduce. Yalu system is designed to identify all four type of learning disabilities including Dysgraphia. This product is designed in very interactive way so that child can be interact with games very easily.

III. YALU INTRODUCTION

For the purpose of screening learning disabilities in early stages, a computer based software solution has been developed for children aged between 4 to 6 years old, which will be known as 'Yalu' Learning disability Evaluation Kit. Yalu was designed in such a way that, to detect symptoms of learning disabilities in children and provide a report about child condition to responsible parties. When a software application functions in collaboration with children, there are lot of aspects that should be considered, such as child knowledge, abilities and child psychology of respective age groups. Therefore the Yalu has been designed under the consultation of psychiatric specialists and a child psychologist, as a story based game series which includes attractive graphics and interesting stories which give instructions to go through the games. Ultimately Yalu comes to children in a tablet computer which requires only ability to touch and a display screen with a Kinect device to detect body gestures. Finally, the evaluation procedure should be accurate

and must not to be limited to the ultimate phase, should be a continuous procedure from the beginning to the end of the session. Therefore Yalu use several techniques to fulfil above aspects by game changing mechanism, parent/guardian questionnaires and effective condition analyzing mechanism. Few of the psychological and technical aspects which we have embedded in Yalu learning disability evaluation kit are elaborated below.

A. Yalu Overview

“Yalu” Learning Disability Evaluation Kit has main functionalities such as LD symptom detecting game series, game changing algorithm according to confirm user condition and analyzing algorithm to generate final conclusion report. Above functionalities was developed upon a technical structure which includes tablet computer game series, Kinect based game series and a website.



Fig. 1. High-level architecture diagram of Yalu system

1) *Tablet computer game series*: Android game series can be played in android tab devices. It identify Dyslexia, Dysgraphia and Dyscalculia. These games can play by children in age group four to six. We developed five different android games according to age group (age four, age four and half, etc.) based on stories known to children. Child needs to listen to instruction in games and follow them to complete the game, no marks are given and game don't indicate that the child response is right or wrong. There are more than eighteen tasks to complete the game with two game levels.

2) *Kinect based game series*: Kinect PC game series used to identify Dyspraxia. These games played by children in age six. Child has to move hand, body according to interact with game and each motion identified using Kinect device. There are minimum two games. All games are attractive, colourful and easily to understand. Each user will be given separate login so we ensure that child is not playing these games with previous practice. It might lead to false indications.

3) *Website*: Main web application is used to register and download the game and to view games results. Final result will be given to parent or guardian. And also it's impossible to 100%

correctly say whether child is having or not these disabilities, what we can do is give indications to parents, so that they can meet up with a specialist and confirm the situation. And for more accurate results we include some questionnaires to fill by parents about child and child background. And take those details in our final conclusion.

B. Implementation

Tablet game series

These games are designed as story base games which have background story for each game and child has to go through the game to know the whole story. There are instructions playing in background and child need to interact according to them. For each age group there is one main game and it contains two levels. Each level includes three sub games for identify dyscalculia, dysgraphia and dyslexia with twelve symptoms.

For dyscalculia,

- Can count, but difficult to count objects.
- Trouble recognizing printed numbers
- Trouble organizing things in logical way
- Difficulty discriminating large or smaller number.

For dysgraphia,

- Mix upper and lower case letters
- Inability to write or draw in line or margin
- Trouble forming letter shapes
- Trouble in writing given pace

For dyslexia,

- Recognize letters
- Difficult in matching letters/words to sounds
- Difficulty in learning the alphabet, numbers, days of week like similar common word sequence.
- Reading wrong order.

Each sub game contains six to eight tasks with three subtasks for each. First level is static and second level of game is dynamic. According to answers provide in first level, second level changes to confirm the results.

There are several type of tasks which need different types of interactions. First type of tasks are selections. In these tasks users have to select respective answer from other answers. Second type of tasks are drag and drops. In those tasks user have to drag the respective answers for respective fields and if user feels it is wrong then user can drag another answer for the respective place. Second type of tasks are draw in lines. User has to draw on given lines and application will check if the user draw on the given coordinates. Next type of tasks are draw in given pace. Application checks if user draw in the given pace. Third type of tasks are match the objects using lines. User need to draw a line to the matching answer. Last type of tasks are draw a given letter with a correct shape. It will be evaluate by using image processing process.

Before play the game user needs to login to the system. If it is the first login application calls the web server and loads the registered children names under that user name. After that user needs to select child name from the list and according to the age of selected child respective game will be load automatically. While child play the game the interaction for each task is save in local database in tablet. After finish each level application

will check if internet is available or not. If available, application sends the child progress to the database server.

Tablet game changing

There are two game levels available for evaluation process, first static level and second dynamic level. In first level this application stores the interactions child give to game tasks. Then after finish the level one, internal analyze is take place. Then it evaluate the tasks which child has failed and which are passed. Then to the next level tasks are filled automatically to ensure the disabilities. First child is given the level one game according to the age. Assume the age is five. Then child plays the android game and finish it all three sub games. In each sub game child has to finish eight sub tasks and there given four symptoms to catch. With two tasks for each symptom it carries six marks for each symptom. After level one finishes application calculate the marks for each symptom. If child scores more than four in one symptom, for level two of game application will give the above age that symptom tasks means age five and half game tasks. If child fail to score more than four, application will give below level game tasks to do.

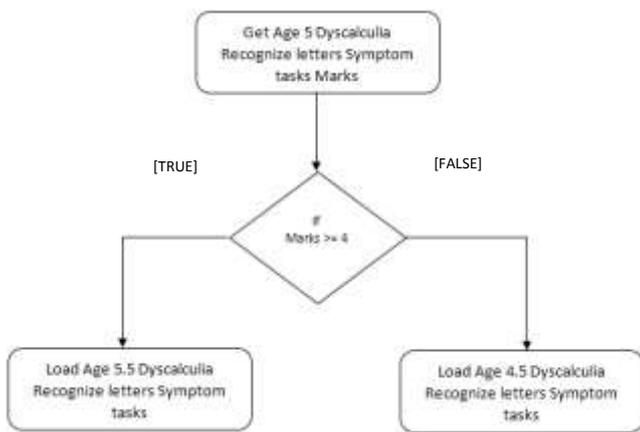


Fig. 2. Game changing algorithm

Condition analyzing mechanism

After all the games are played by a child server database would update from the child's interactions, by processing those interactions and the parents feedback on child the system provide a final conclusion as report to parents through the web site. This report generation process include an analyzing algorithm which is introduced to diagnosis learning disability out of user interaction with the games and questionnaires. Those questionnaires are for parent in web application. These questions based on child behavior and other symptoms of learning disabilities which are unable to check with a software such as child's attitude and behavior. The tablet game result is providing response of child's on dyslexia, dysgraphia and dyscalculia symptoms while the Kinect games provide the dyspraxia symptoms' responses. Once the child done with those games, result will automatically update in the database server.

The algorithm is developed to process each and every interaction of user's along with a symptom and judge that the user affected with the symptom and then give a final conclusion

out of all symptoms that the child is suffering from learning disabilities or not. The algorithm check's user condition step by step.

- Get symptoms one by one of the tablet and Kinect games and give a mark to user interaction.
- For the first level of the game is weighted by 2 and the next game level will be weighted by 4 or 1 according to average marks of first level.
- If the child pass the level 1 he will going into next level which has the weight by 4 or else if the child fail level 1 next game will be weight 1 category game.
- Such as finally get the addition of marks out of all levels of a one symptom.
- After getting the final mark of all the symptoms it will give a red, yellow and green warning of the condition of child of having that symptom.
- Altogether warnings and marks of the questionnaires would going into a final conclusion of the child.
- Finally system would generate a report out of the result, conclusion and child's details.

The final conclusion can be access only by the parent or guardian of the child. There for they have to login to the website to access. The report can view on the webpage or can be downloaded in PDF format or get a print out or it also able to email to own email address which is provided when user registered.

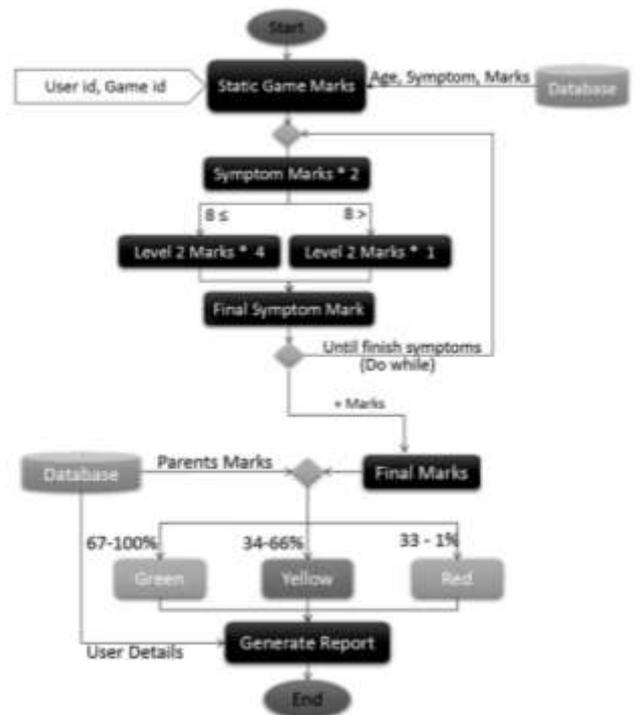


Fig. 3. Diagram of game analyzing algorithm

The system only guaranty that the final report is accurate up to 70% if the parents are not attend to questioners or it will accurate up to 80%. Parents are able to meet a consultant doctor

with the report we provide since it will be accepted by any psychiatric doctor.

IV. FINDINGS/RESULTS AND EVIDENCE

YALU screening application has to test in two types. First one to ensure its functional ability and second test to ensure the medical accuracy of the application. In the development phase the unit testing and integrating testing done and final system testing was performed after the final integration. There used predefined test cases to test fully functional and non-functional requirements of the system. Android application, Kinect game and web application has passed the system testing.

For ensure the medically correctness in the application, the system design and tasks were designed with the advice from the expert of this area Prof. Hemamali Perera. According to expertise idea it was more efficient to use five age groups in games and develop tasks to each age group with the increasing of difficulty. That concept is the basic system structure of this application. To perform UAT testing this application is given to two per schools in Kaduwela. There 25 students has play the game and obtain the final conclusion.

For each preschool teacher given a document with criteria and the symptoms which are testing in each age game. Teachers are asked to go through the criteria and mark each child for having these symptoms or not. Then those marked children play the YALU games and their parents are asked to answer the questioner in the web application. Using both answers, final conclusion for each child is given.

Preschool 1	
Tested children count	: 10
Criteria matched children	: 3
Evaluated as positive (criteria matched)	: 3
Evaluated as positive (criteria not matched)	: 1
Preschool 2	
Tested children count	: 15
Criteria matched children	: 4
Evaluated as positive (criteria matched)	: 3
Evaluated as positive (criteria not matched)	: 2
Total No of students	
Tested children count	: 25
Criteria matched children	: 7
Evaluated as positive (criteria matched)	: 6
Evaluated as positive (criteria not matched)	: 3

VI. DISSCUSSION

YALU team has tested the application using 50 students in age four to five in three different preschools. From those students 14 students has been marked as having learning disability symptoms by their teachers. And from our system 12 of them were identified as positive for having probability of being learning disability. Therefore it can conclude that e 85% of accuracy can guarantee from our system.

V. CONCLUSION

There are several applications designed to test this issue. But most of these applications are based on questionnaires to be followed by parents, guardian or child. But as children, to do so they must be very keen in computer literacy and also in English, because most of applications are in English. Therefore parents, guardian or children who have no good English knowledge can do this. Although these applications give results based on answers provide to questions, they do not give results by the interactions of user or by observing the actions of user. Getting user's interaction is the most important fact when detecting these Learning disabilities. Using user's interaction it's easy to detect/say what kind of learning disability someone has. And also most of these applications are web-based applications not standalone applications. Therefore the Availability of these applications is less. And these applications are basically address to more adult children (above 6 years old). If we can detect these Learning Disabilities in early ages (less than age 8) we can get quick actions to these children.

VI. FUTURE WORKS

After completely develop, the product will deliver for the Lady Ridgway hospital for free of charge. The final product will deliver for private hospitals and kindergartens with a license. And for parents, they have to download the product through our web site. After developing the Sinhala version of the product next target is to develop the English version of the product and deliver it to the international market.

In future development team will develop this application and release it as a new version. In the new version it plans to change game structure for more interesting way. Also upgrade the age range from four to ten. Apply new techniques to catch more symptoms and increase the accuracy of the application results. And also in future team plans to develop Learning disability training application to give training to children with learning disability.

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