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Research paper

English Alphabet Tutorial Using Kinect for Person with ASD

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Abstract

People diagnose with Autism Spectrum Disorder (ASD) is under the group called Pervasive Developmental Disorder (PDD). Students with ASD tend to have problems with familiarization of alphabets for the reason that they tend to lose focus in a short span of time. Thus, the proponents developed an interactive tutorial in alphabet familiarization. The tutorial is a program developed in software called Visual Studio. A device called Kinect enables the user to interact with the program using hand gestures. Several processes is executed in the program which are capturing of hand gestures, segmentation of the hand from the body, isolation of the finger tip from the hand, recognition of the finger gesture, and lastly comparison of the input gesture to the plotted points. The extensive experiments and testing demonstrates that our tutorial program can recognize the gestured letters with 95.24% accuracy for capital letters and 98.56% for small letters. Also, it can interpret the input gestures with an average execution time of 15.62 milliseconds for both capital and small letters.

Keywords: *Autism Spectrum Disorder, Attention span, Kinect, Pervasive Developmental Disorder, Interactive*.

1. Introduction

Autism Spectrum Disorder (ASD) refers to a group of developmental disorders. A person diagnose with ASD includes having a difficulty to socialize with others, to communicate and to use their imagination; they also have trouble with routine change and suffers repetitive movements and behaviors. The condition usually identified around the developmental age of child usually at first two years of age because it is the stage where a child develops motor skills and communication skills [1].

ASD is under the group of condition called Pervasive Developmental Disorder (PDD). PDD are group of condition where there is a delay in motor skills. PDD have five types [2], the difference of ASD from any other type of PDD is that they are capable to undertake special education programs [3]. They are capable of going to school like any other kid except that they were on different class, a class with the same conditions with them.

The first basic lesson teach in class is Alphabets. Learning alphabets gives students the access to learn words, to spell and to read. A child with automatic, accurate recognition of letters will have easier time learning about letter sounds and word spelling than a child who does not know the letters of the alphabets. So for students to level up their learning they must learn to write and read the letters of the alphabets. However, kids diagnosed with ASD can find it difficult to fully familiarized with each letter since it involves different strokes and some of the letters look similar [4]. Another factor that affects the familiarization of student with Alphabets, they tend to lost focus on [5].

With the downside of students having a difficulty to familiarize the alphabets, the researchers are developing an interactive tutorial in alphabet familiarization for a child with ASD.

It is a challenge in teaching alphabet for the students to be fully familiarized with each letter. This is because all the letters in the alphabet have different shapes and despite these differences, some letters have similarities in how they look like which causes confusion to the young learners [4]. A further discussion is about the difficulty of teaching lesson to students with ASD, they tend to have a short attention span which is the reason for the loss of interest in the activities. One of the activities that causes this lack of interest are activities that involve shared attention [5]. The use of computer-based technologies into the classroom for typically functioning students is known to many but fewer individuals recognize the benefit that computer-based technologies may afford to students with special needs specifically to those who are enrolled in Special Education. Integrating technologies in educating students with special learning needs help in preparing them to participate in a rapidly-changing world where work and leisure activities are increasingly transformed by technology [6]. Therefore, computer technology in a form of full utilization and appropriate use can assist students with special needs in overcoming the limitations that hinder classroom participation [7]. Kinect relies on the interaction that exists between the user and the computer. Engaging in the process of learning with the use of Kinect ensures a longer attention span which students often lack in special needs education [8].

1.1. Conceptual Framework

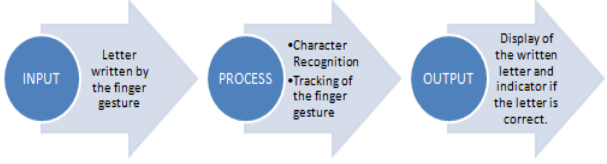

Fig. 1: Conceptual Framework of the design project

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The input of the project is the finger gesture. The user will have to stand within the visual range of the camera and write a letter through finger gestures. The letters that can be written are alphabet letters from A to Z. The system will recognize the finger gesture and will compare the input to the given instruction. An indicator will be used for the user to know if the letter written in front of the camera is correct based on the instruction given by the system. In addition to that, the user will be able to see a displayed image of the written letter in the computer screen

2. Methods and Procedure

2.1. Functional Design

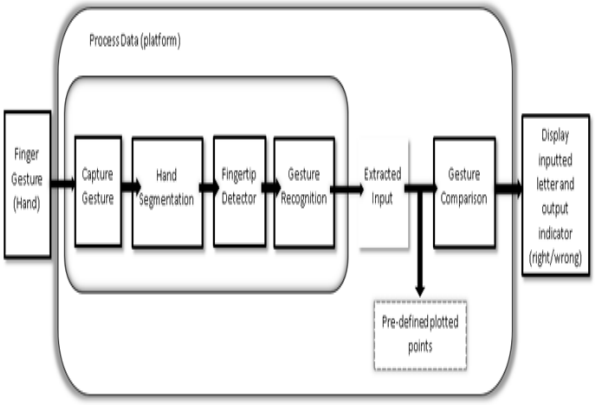

Fig. 2: Glass Box

Interrelation of the input, process, and output of the proposed design project which is the form of glass box. The finger gesture of the hand will serve as the input of the system. The first process is capturing the gestures using the Kinect camera [9]. The utilization of Kinect makes it possible for the system to conduct marker-less detection [10]. In addition to that, Kinect is capable of obtaining the depth details of an image which is necessary for the succeeding functions [11]. The hand will then be segmented from the body using K-Curvature Algorithm [12]. K-curvature algorithm is specifically designed for marker-less detection [13]. Then, the fingertips of the segmented hand will be detected using Dual Mode Switching Algorithm [14]. Next is recognizing the gestured letters done by the hand using Support Vector Machine [15]. The recognized gesture will be compared to the pre-defined plotted points assigned by the proponents. Finally, a display indicating whether it's right or wrong will serve as the output of the system. The group used different numbers of stars as means in evaluating the writing performance of the user.

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2.3. System Flow

This program has two modes; Tutorial and Assessment mode. The user will select if he/she would want to take tutorial or assessment. If the user selects the tutorial mode, there were two options; capital letters and small letters. The tutorial is just basically a tutoring platform where it shows how letters can be written and the user can also write in the paint board part of GUI. However, if the user select Assessment mode in the homepage the user will be given two options if he/she wants to take assessment for Capital letters or Small letters. If the user selects any of these two, the user will select the level of difficulty which are Easy, Normal, and Hard with a duration of 30 seconds, 20 seconds, and 10 seconds respectively. If the user failed to finish it within the time duration for each level it will be considered as wrong. After that, the program will display the rating of each letters if it is correct or not. Lastly, if the user would want to continue to use the program it will go back to the homepage. Otherwise the user can select the exit button in the homepage.

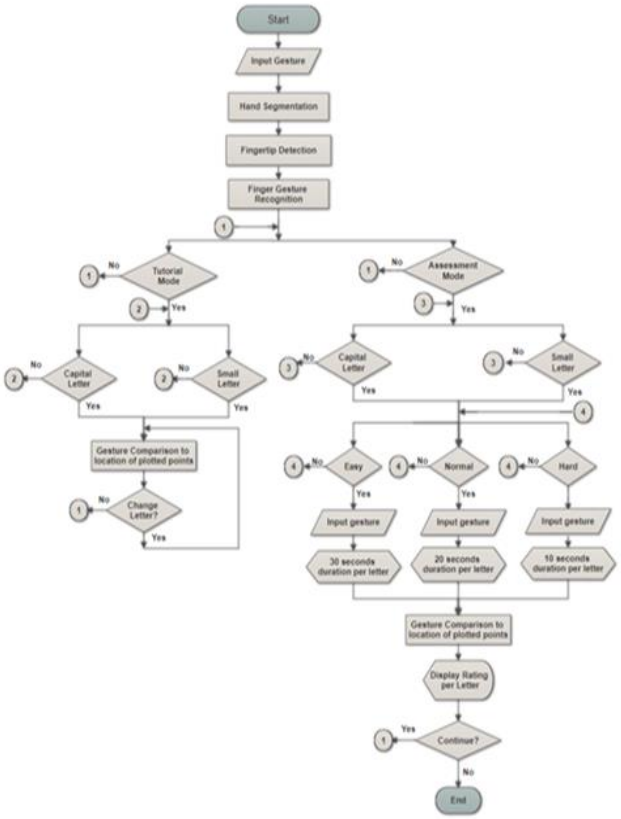

Fig. 3: System Flowchart

2.4. System Setup

The system setup is the assembly and arrangement of the tools and apparatus required for the performance of an operation.

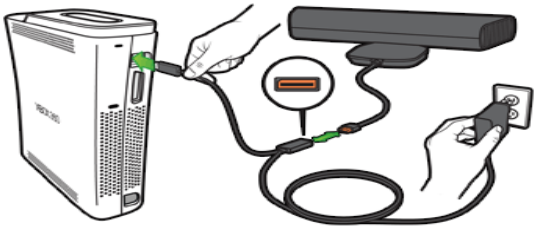

Fig. 4: Interfacing Kinect to PC

Fig. 4 shows on how to interface Kinect to PC. Since it has a different port, it cannot be connected directly to the PC. It requires, Kinect adapter for Windows. It basically connects the Kinect to the computer. Also, the Kinect SDK v1.7 should be installed in the computer unit so that the computer can support the device.

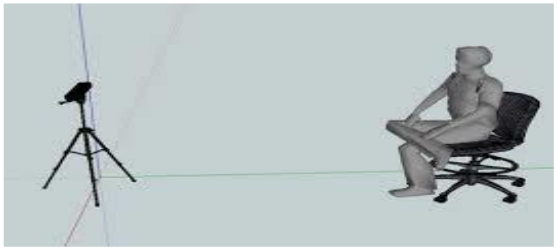

Fig. 5: Kinect to User Interface

For the fig. 5, it shows the position of the Kinect camera must be 1 meter to 1.5 meter away from the user, it should be 90 degrees facing the user.

2.5. Graphical User Interface

Upon opening the program, the user can see the homepage on the left side shown in Figure VI. The homepage contains the assessment mode, tutorial mode, and the exit button. The right side shows the working area of the user. Here a dot pattern of a specific letter will be shown that the user will follow. The interface also contains a back button that will take you back to the homepage, an erase button that will clear all written in the screen, and list button that will show the list of all the letters from a to z.

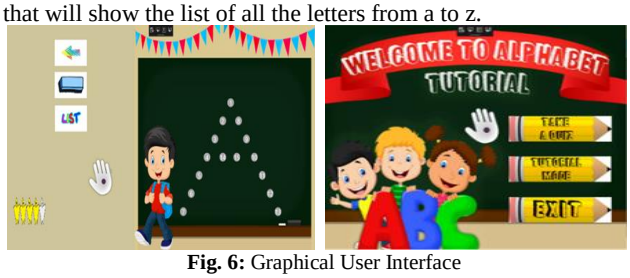

Fig. 6: Graphical User Interface

3. Results and Discussion

3.1. Testing and Result

3.1.1 Accuracy

Table 1: Accuracy Testing

Capital Letter	Average	Small Letter	Average
A	100	a	100
B	96.33	b	100
C	86.67	c	90
D	100	d	100
E	93.33	e	100
F	93.33	f	100
G	80	g	83.33
H	100	h	100
I	100	i	100
J	93.33	j	100
K	100	k	90
L	93.33	l	100
M	100	m	100
N	86.67	n	100
O	86.67	o	100
P	93.33	p	100
Q	93.33	q	100
R	100	r	100
S	100	s	100
T	100	t	100
U	86.67	u	100
V	100	v	100
X	100	x	100
Y	100	y	100
Z	93.33	z	100
Total	**95.2 %**	**Total**	**98.6 %**

Table 1 shows the result of accuracy testing in the program. Thirty trials of each letter for both upper case and lower case were taken into consideration. For the upper case letters, a total average of 95.2% is obtained which falls under very satisfactory in the metrics. For the lower case letters, a total average of 98.6% is obtained which falls under excellent in the metrics. Looking at table 1, it can be observed that letters having a combination of curves (e.g. G and g) have the lowest accuracy due to variations of directions and positions. Overall, results show that the system has great accuracy.

3.1.2 Effectiveness

Table 2: Superior Intellect ASD Student

Student No.	Effectiveness	Student No.	Effectiveness
1	0.17	9	0.31
2	0.24	10	0.37
3	0.20	20	0.19
4	0.30	21	0.20
5	0.26	28	0.19
6	0.38	29	0.19
7	0.36	30	0.20
8	**0.25**	**Total**	**0.25**

Table 2, the samples that fall under the category of students with relatively superior class performance showed significant gains from pre-assessment to post-assessment. The effectiveness of the system for the said group of students also significantly high. Thus, indicating improvement in the performance of the students while using the system.

Based on table III, three out of four samples under the category of students with intellectual disability achieved a positive gain in score although the values are relatively low compared to the other students from different categories. Despite that, the three samples showed improvement from the pre-assessment to post-assessment. On the other hand, one student got a significant decrease in score which resulted to a negative average of effectiveness of the system for students under the said category. Despite that, the average falls under the scale of satisfactory

Table 3: Students with Intellectual Disability

Student No.	Effectiveness
11	0.02
22	0.04
23	-0.12
26	0.03
Total	**-0.01**

Table 4 shows the comparison between the pre-assessment and post-assessment scores of students with EBD/ADHD. The gains in terms of score shown in the figure above are relatively average compared to those from superior students and students with intellectual disability. In addition to that, the figure shows the improvement of the students while using the system.

Table 4: Students with EBD/ADH

Student No.	Effectiveness
12	0.13
17	0.12
18	0.16
24	0.08
Total	**0.12**

Table 5: Student with Multiple Disorder

Student No.	Effectiveness
15	**0.11**

Table 5 shows the gain from the score of one student with multiple disorder. Similar with the data from students with EBD/ADHD,

the said student obtained a relatively average gain in score and has displayed an improvement while using the system.

Table 6: Students with Speech Deficiency

Student No.	Effectiveness
13	0.13
14	0.13
16	0.09
19	0.16
25	0.14
27	0.09
Total	**0.12**

In table 6, effectiveness of the system for students with speech deficiency are relatively average. In addition to that, all samples under this category has displayed improvement while using the system based on their scores from pre-assessment to post-assessment.

Table 7: Students effectiveness based on age and gender

Age	Class Intervals	Male	Female	Total	Percentage
5 to 6	-0.12 to 0.15	5	3	8	26.67%
	0.16 to 0.39	1	2	3	10.00%
7 to 8	-0.12 to 0.15	3	1	4	13.33%
	0.16 to 0.39	10	6	16	53.33%
	Total	19	11	30	100%

As shown in table VII, there is a high effectiveness for ages 7 to 8 as shown on data. However, for ages 5 to 6 the results obtained a low effectiveness for the system. For the female there's 54.55% of the female population under ages 7 to 8 with an effectiveness rating between 0.16 to 0.39, for the male, there were 10 out of 19 males or 52.63% under this category. For the whole class, 26.67% are from ages 5 to 6 with an effectiveness rating ranging from -0.12 to 0.15. Under same age bracket 10% of the population having with an effectiveness rating ranging from 0.16 to 0.39. For 7 to 8 age bracket, 13.33% of the population has an effectiveness rating ranging from -0.12 to 0.15. Also, on the same age bracket 53.33% of the population has an effectiveness rating ranging from 0.16 to 0.39.

3.1.3 Response Time

In table 8, the total average response time is 15.63ms. The recording of the response time for each trial happened the same time as the testing of the accuracy. This means that the average response time for each letter shown in Table 8 corresponds to the average accuracy for each letter in Table 1 for capital letters. The function that contributes to the recorded response time is the hand segmentation.

Table 8: Response Time of Upper Case Letters

Letter	Average Response Time	Letter	Average Response Time	Letter	Average Response Time
A	15.63	J	15.62	S	15.62
B	15.62	K	15.63	T	15.61
C	15.62	L	15.63	U	15.63
D	15.63	M	15.63	V	15.62
E	15.63	N	15.62	W	15.63
F	15.62	O	15.63	X	15.62
G	15.66	P	15.63	Y	15.62
H	15.63	Q	15.63	Z	15.63
I	15.62	R	15.62	**Total**	**15.63**

In Table 9, the average response time is the same with Table 8 which is 15.63ms. As explained above, the setup in testing the response time is the same with the testing of accuracy. The average response time for each letter shown in Table 9 corresponds to the average accuracy for each letter in Table 1 for small letters. The function that contributes to the recorded response time is the hand segmentation.

Table 9: Response Time of Lower Case Letters

Letter	Average Response Time	Letter	Average Response Time	Letter	Average Response Time
a	15.63	j	15.62	s	15.62
b	15.621	k	15.63	T	15.61
c	15.62	l	15.63	U	15.63
d	15.63	m	15.63	v	15.62
e	15.63	n	15.62	w	15.63
f	15.62	o	15.63	x	15.62
g	15.66	p	15.63	y	15.63
h	15.63	q	15.63	z	15.63
i	15.62	r	15.62	**Total**	**15.63**

4. Conclusion and Recommendation

4.1. Conclusion

There were 30 trials for each letter in accuracy and response time test the result were evaluated while there were 30 students used in testing the effectiveness of this program. The conclusion was made based on the data gathered and its evaluation by the researchers:

- The proponents obtained an average accuracy of 96.86% which falls under the scale of "very satisfactory" as stated in the metrics using the standard setup.
- The system has an average response time of 15.62ms which falls under the scale of 16.12ms-15.54ms with "Very satisfactory" remarks.
- The system obtained an average effectiveness of 0.17067which falls under the scale of -0.21-0.20 with a remarks of "Satisfactory".

4.2. Recommendation

During the developmental stage, the researchers were able to see some aspects that the project might improve on. The following items below are some of the things that the researchers took note of:

- Include more data points (pre-defined plotted points) to obtain a higher accuracy. More data sample, higher accuracy.
- Increase the time frame in assessment mode from 30 seconds per letter to 1 minute per letter for students who have intellectual disability.
- Lessen the complexity of the mechanics of the assessment mode for ages 5 to 6 (both male and female).

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