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Natalia I. Vargas-Cuentas[1], Daniela Hidalgo[1], Avid Roman-Gonzalez[1], Michael Power[2], Robert H. Gilman[3], Mirko Zimic[1*]

[1]*Laboratorio de Bioinformática y Biología Molecular, Universidad Peruana Cayetano Heredia – UPCH*

[2]*Center for Children with Special Needs -CCSN*

[3]*Department of International Health, School of Public Health, Johns Hopkins University - JHU*

* mirko.zimic@upch.pe

Abstract—**Autism Spectrum Disorders (ASD) are characterized by a deficit in social integration, language development, and restricted interests. ASD is defined as a prevalence development life disability. However, children who are early diagnosed and intervention improve long-term prognosis. This project proposes to detect autism in children at a first level (preclinical stage) using a tool "eye tracking" highly cost-effective and embedded in a tablet. The results obtained with this system have been compared with the outcomes of the Modified Autism in Children M-CHAT questionnaire.**

Keywords— Autism spectrum disorders, eye tracking, diagnosis, M-CHAT.

I. INTRODUCTIÓN

ACCORDING to some data presented in [1], the prevalence of autism is 1 in every 88 people. In this sense, ASD is a permanent problem that affects a high percentage of the population. In the aftermath, the families of children with autism have some difficulties about the diagnosis because they are the ones who identify the first signs or suspicions in delaying the development of your child. The potential impact of this situation not only for the individual but also for the family and the government points to a significant need to identify tools for early diagnosis.

There are some aspects considered to refer to the difficulties of early detection of autismμ. The logical and likely problem of parents to detect subtle symptoms like those that characterize autism in their early stages (especially if it is the first child); lack of information from most pediatricians and other professionals to detect autism early, and the inadequacy of development assessment tools currently in use by specialists [2]

Currently, the diagnosis must be based on at least two levels of performance; at a first level is to looking within the healthy population for a child with series of signs of a high probability of ASD. These people go into a second phase where they held a series of diagnostic tests to rule out other diseases, and finally, register the case to have a clinical diagnosis [3].

Currently, in Peru, there are not detection instruments of autism spectrum disorders adapted to the context of primary health care services. According to Diez-Cuervo, et al. (2005) [4], specialized diagnosis is a complicated and costly procedure, under a clinical trial, reported. However, early detection of cases in which the diagnosis is indicated is a simple and inexpensive process, which will streamline performance.

For all above reasons, the present project aims to propose a method for early diagnosis of autism, noninvasive, efficient and the majority of Peruvians. This proposal will ensure screening in health systems and, therefore, increase the likelihood of early diagnosis and intervention in each case.

The project introduces an innovative tool, which generates a significant impact from its simplicity, allowing use in poor remote communities where there is a lack of specialists to diagnose autism in younger children, in which clinical symptoms are not evident. Furthermore, it is intended that this tool is accessible nationwide, seeking to be a resource for mass use and can be used by doctors not specialized in any pediatric unit or health center. The idea also is to develop a database of patients diagnosed with the aim to review each case and maintain adequate control.

The previous diagnosis will develop a particular model of intervention and a better outlook. For example, giving an early intervention for children with autism, 86% can develop a verbal communication skill, in contrast to 50% who do not receive any intervention [5]. The interest in the early identification is due to the evidence accumulated over the last ten years; that establish that a particular, personalized early intervention for children and their families leads to an improvement in the prognosis for most children with ASD [4]

II. BACKGROUND

The diagnosis of ASD is made from deficits in social and communicative behavior; besides the presence of repetitive and restricted behaviors. In the diagnostic assessments with standardized instruments such as ADOS, where direct

observation of the child and ADI-R, where the child's parents are interviewed, it is required medical experts on the subject. Studies conducted in the US by the Centers for Disease Control indicate that the ADI-R and ADOS are used in less than 0.1% and 2.1% respectively for the diagnosis of autism made in the community. Other instruments and parent questionnaires and checklists are used in only 30% of these assessments while 67% use non-standardized or validated tools [6].

As noted, one of the deficits that come with autism diagnosis is the social gap. Within this situation, the development of mutual look and preferential attention to the social interaction; in a study presented in [7], where participated 66 children, of which 14 had a diagnosis of the autism spectrum, 36 children with normal development and 15 children with developmental delay but not autism. One shows ten videos to the children, in these videos an actress looking directly at the camera and developing a caregiving role. It found that children with ASD did not have a preferential binding in the eyes of adults who approach and prefer to see the region of the mouth. Setting the relationship between the eyes and the level of social deficit is also presented suggesting that could be useful for quantifying the social phenotype in early autism early within the development. The results indicate that the skills present in typical children were not found in children with autism at age two; notes atypical development that generates failures in social commitment. A child with ASD is learning in a world dominated by a particular world instead of social events [8].

III. Autism Diagnosis Tool

A) Cost-Effective Portable System
Pierce, K., et al. (2011) tried to determine, in children with ASD from 14 to 42 months, the existence of a tendency towards geometric repetitions (for example, fixing the wheels of the car). The study provided strong evidence of some babies at risk for ASDs begin with an unusual preference for geometric repetition [9].

The tool used in this research is based on "eye tracking" system that seeks to identify early changes in the visual preference of the child. The video that we use is divided into two scenes where a scene was composed of children participating in different games and social activities, and the second scene was composed by abstract in motion forms and curves with attractive colors.
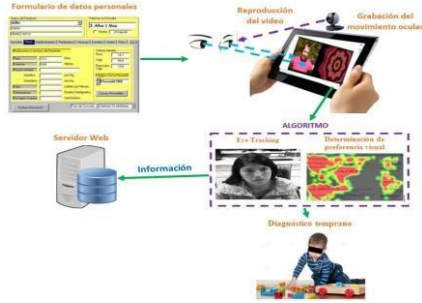

Fig. 1 Block diagram of the ASD diagnosis tool

Finally, the idea is to have a Web server that automatically centralize information allowing store text files containing the personal data of each child, diagnostic data and other material that may be important to create an electronic health record. This record will allow monitoring and control of each child.

The block diagram of the "eye tracking" algorithm is given as shown in Figure 2. In Figure 2, one can observe the workflow step that the algorithm will follow to reach a final result, for this reason, three primary processes will be described below:
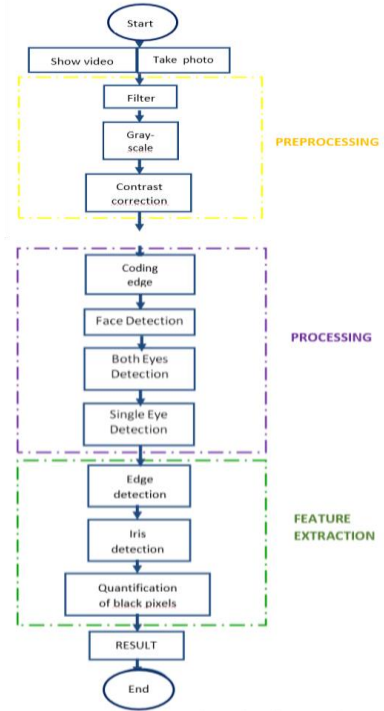

Fig. 2 Workflow of the diagnosis algorithm

a) Pre-processing: In this stage, one use techniques to improve the quality of the obtained image, a filter is performed to smooth, enhance edges and remove noise from the image. One converts images to grayscale values; finally, a contrast correction is performed.

b) Processing: At this stage one make an extensive enhancement of the features of the image. Also, one performs a face coding of a child to adequately recognize that photography provided a face as input to the algorithm. On the other hand, a cascade algorithm was implemented with the primary objective of face detection, detection of both eyes, and eye detection for each of the child's eyes.

c) Feature extraction: In this stage, one makes an ocular edge detection for correctly identifying the eye iris and eventually quantifying or counting the black pixels of the identified iris to discriminate what is the direction of gaze.

B) Modified Childhood Autism Questionnaire (MCHAT)
Considering the need to compare and validate the results obtained in this research, one will use a tool applied internationally to detect autism spectrum disorders in children aged between 18 and 60.

Fig. 3 Graphical User Interface (GUI)

M-CHAT is a tool that was created with the intention of improving the sensitivity of CHAT. It consists of 23 questions dichotomous yes-no answers, of which 9 correspond to the original CHAT and has an aggregate of 14 questions related to the core symptoms present in very young children with autism.

Robins et al. (2001) designed MCHAT in the United States, and direct observation of the CHAT was omitted. It has been validated with a sample of 2,500 children aged 2 years and has a sensitivity of 87%, specificity 99%, positive predictive value 80% and negative predictive value of 99% [10].

IV. TEST PROTOCOL

A) Procedures
After validation of judges screening survey, they settled and formed the different participating groups, contacted them and finally carried out the necessary psychological evaluations and confirmation procedures or diagnosis according to the results of the M-CHAT test.

B) Constitution of groups for evaluation:
As a result of preliminary tests that were conducted, it was identified that the sample size of this project should be 8 case children and 24 control children. So, it may reach 84% of statistics power to detect a difference of 55% between the null hypothesis of both ratios. Group 1, control children is 10% and the alternative hypothesis of proportion in Group 2, case children, is 65% using a one-sided chi-squared test with continuity correction, and a significance level of 5%.

The characteristics of the control children are male and female children between 18 months and 7 years old. No previous diagnosis of mental or neurological disease.

The case children were derived from the Instituto Nacional de Ciencias Neurologicas (National Institute of Neurological Sciences), they have a previous diagnosis of ASD and are receiving therapy within the Institute.

C) Evaluation:
Evaluations were performed in the "Instituto Medico del Lenguaje y Aprendizaje" – IMLA (Medical Institute of Language and Learning). The first provided information was the ethical considerations; at this stage, it was stressed that participation is voluntary, that there is complete confidentiality of personal data of the child, and the objectives of the research were explained. All it summarized in an informed consent that parents authorize the participation of their youngest child.

As a next step, we proceeded to the implementation of MCHAT/ES, which was developed by parents. It was necessary to gather additional information summarized in a sociodemographic poll. For example: environment where the child grows, sex, age, weight, height, district of origin, people living at home, marital status of the parents, level of education of father and mother, place for medical care, rooms in the home, materials floors, and a family history with a diagnosis ASD.

Finally, we proceeded to the assessment using the algorithm tool where the first visual stimulus presented to the child was a video. This video has a duration of one minute, which contains two scenes on the same screen: the left side is a social scene, and the right side is colorful moving objects. Webcam device made a video recording of the child watching two scenes. This video is the material that the software must process to quantify the percentage of time of child watching a scene or another.

V. RESULT ANALYSIS

A) Results of the analysis of the discriminative ability obtained by our diagnostic tool
The participating children had to watch five Videos of one minute. Each video contains a 10-second introduction, consisting of a lively current attractive and sound design.

On the other hand, the principal part of the video is 50 seconds long, composed of a divided screen into two without sound scenes, one social scene, and an abstract object scene.

Regarding the observation of the videos, one obtains the following results:

Children number	Number of watched videos	Control Childs	Case Childs
14	5 Videos	11	3
4	4 Videos	4	0
5	3 Videos	4	1
7	2 Videos	4	3
1	0 videos	0	1

Table 1: Number of children per number of watched videos

As shown in Table 1, a higher rate of clinical controls and clinical cases could observe the five videos displayed by the software.

Fig. 4 Number of watched videos vs. number of children vs. controls and cases

As shown in Figure 4, only one could not see any video, this child belonged to the group of clinical cases.

On the other hand, during the tests, one can identify the existence of different reasons that could cause disruption in the child as shown in Table 2:

Reasons for distraction	Number of children
Boredom	4
Tiredness of the child	2
Child sitting alone	3
Testing child without his mother	3
A disturbance in the environment (object or mom sitting incorrectly)	3
Misbehavior	2

Table 2: Reasons for distraction and number of children

As shown in Table 2, the reason causing the disturbance in a greater number of children was boredom, as children had a tendency to get bored after seeing, at least, three videos. As we can see, other reasons for distraction with a high percentage of occurrence among children participating in the test occurred because the child was alone or a different person to her/his mother at the time of testing front video diagnostic tool.

Finally, doing a statistical analysis of the obtained results, it was possible to get the following P values for each diagnosis video:

Video	P Valium
1	0.046
2	0.015
3	0.923
4	0.223
5	0.070

Table 3: Diagnosis video vs. P valium

As shown in Table 3, diagnosis video 2 has a P value of 0.015. The P value should normally be in the range of 0.01 to 0.05 to be significant. For this reason, we can say that the Video 2 is one that contributes to achieving better discrimination of clinical case and control children.

B) Results of the analysis of the discriminative ability obtained by the MCHAT

For the evaluation process, the participating children were divided into two categories as seen in Table 3.

Category Diagnostic	No suspect	Suspect
	M-CHAT (-)	M-CHAT(+)
TGD AUTISM	1 (12.5%)	7 (87.5%)
Normal Development	20 (83.3%)	4 (16.6%)
TOTAL	21	11

Table 4: Distribution of participants according to diagnostic categories

In Table 4, we can see that 87.5% of cases children were confirmed with the MCHAT diagnosis.

Table 4 also shows the existence of a 16.6% (4 children) of control children who result as positive (+) in the M-CHAT test. One of them, within their sociodemographic record, recorded family history of ASD within the family (older sister).

VI. DISCUSSION

- On the MCHAT results, the negative subject (-) with a previous diagnosis, could be explained by the continuous therapy following since its first diagnosis, this probably is improving their prognosis and consequently result in an overlap in the outcome of the test M-CHAT.

- Between the five videos used in the tests, according to the statistical analysis, it was observed that the Video 2 is the best for contributing to discrimination between autistic and non-autistic children.

- The visual preference of the child, regarding social or abstract scenes, helps to determine the risk of autism in children. However, one need to determine the contribution percentage of distractions in the result.

- For future tests, we will take into account the fact that children can always be in the company of his parents because, in this way, they feel safer to see the videos.

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