

Autistic Verbal Behavior Parameters

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Abstract.

The main goal of this paper is to present a method that allows the automatic detection of communication patterns of patients with a severe state of ASD (Autism Spectrum Disorder), through audio and video processing. Patients with ASD have social and communicative disorders that make it difficult to analyze their expression. Their natural language presents different degrees of alteration, from a slight difficulty of expression to the total impossibility of speaking. The processing of the routines to be able to extract video and sound patterns is based on the work "ASD: ML perspective for Individual Performance Evaluation". Taking the basis that stereotyped responses can be detected in a systematic way, similar to those that specialized therapists usually describe: gaze fixation, nodding, leg movements, clapping, among others; In this work, a model for the parameterization of said movements and sounds is proposed, through routines specially oriented to detect automatic patterns by audio and video processing. In this work there are the development and first results obtained from audio analysis of a use case, and main findings in relation to how the patient tends to interact with the environment. They allow to suppose that autistic verbal behavior might be interpreted by its physically manifested sounds.

Keywords

Autistic Spectrum Disorder, Linguistics, Sound Processing

I. Introduction

Autism is a neuro-developmental disorder characterized by a triad of symptoms observable in the first three years of life, consisting of impaired language development, stereotyped behaviors associated with restricted interests, and social interaction disorder [01]. According to statistics published by the Centers for Disease Control and Prevention, it is estimated that 1 in 68 children, born after 2002, are diagnosed with Autism Spectrum Disorder (ASD). Children with ASD can have significant social, communication, and behavioral problems. The Diagnostic and Statistical Manual of Mental Disorders (DSM), which is the diagnostic classification system with the most international relevance, as the World Health Organization (WHO) considers Autism Spectrum Disorders (ASD) as pervasive developmental disorders. These are characterized by a wide variety of clinical and behavioral expressions that are the result of multifactorial developmental dysfunctions of the central nervous system [02].

On the other hand, children with autism show significant cognitive deficits in different areas [03]. Many of the characteristics of children with Generalized Developmental Disorder (PDD) and autism could be explained by defects in their attentional processes [04]. Autistic people act inappropriately with the stimuli they see, and seem to have particular difficulties in interpreting socially relevant information, since socially significant stimuli are physically complex, and this fact is fundamental to behavior adaptive [05] [06]. People with ASD have certain similar symptoms such as problems with social interaction. But there are differences in the timing of symptoms, their severity, and their nature [07].

In guide [08] the cases of altered verbal language are explained, in some cases reaching the complete impossibility of speech. Both hearing loss or hyperacusis can be general or focused on a certain sound, there are studies that allow us to process sounds to determine whether a patient has ASD or not, although not conclusively.

In [09] five different musical notes are composed which are described by: pitch, intensity and timbre: frequency, amplitude, harmonic composition or waveform. Different sound tests were carried out with autism spectrum patients, they were filmed and the reactions they had to each note (movements of hands, arms, head, feet, sounds, etc.) or the absence of reaction were noted. A protocol was followed for the filming, noting on sheets. It should be noted that this type of evaluation contrasts with the proposal, where the patient's sound production is analyzed. In the study carried out [10] a new method for automatic detection of stereotyped behavior patterns is presented using data from an accelerometer. Orthogonal subspaces are extracted from the sensor data, which are used to generate a clustering of the dictionary and in turn for the representation of signals.

The algorithm was improved for the detection of new events that were unknown. In [11] a study carried out at the University of Southern California (USA) of the design of an emotionally directed interactive agent for boys with autism, called Rachel, is presented. In it, an incorporated conversation agent (RCT) was developed to achieve the interaction of patients, previously diagnosed with autism, who participated together with their parents, interacting with the RCT. The agent produces different scenarios that represent emotions such as angry,

sad, happy and scared; with the aim of allowing a controlled evaluation of the communication skills of children with ASD.

The ECA asks children and sometimes children and parents to relate and interact with the system, while they are being recorded. It should be noted that the Wizard of Oz method was used, which indicates that there is a person -therapist- interacting from behind with the system, without being perceived by the children. The problem with this work is the lack of statistics and validations of the evaluations made by the authors about the tests carried out.

The rest of this paper organizes as follows: Section II presents some of the state of the art, section III introduces the proposal, materials and methods, section IV describes a testing protocol, section V is a detailed analysis of sound recordings of a use case, and section VI has conclusions and future work.

II. State of the Art

Degrees of autism

The DSM-V [12] of the American Psychiatric Association, establishes a classification guide, a coding used by much of the scientific community to diagnose different mental disorders. According to the authors [13] those who suffer from ASD experience a series of symptoms based on Wing's triad, these disorders refer to social interaction, communication and lack of flexibility in reasoning and behavior. In turn, there are classifications of different degrees in the guides and manuals, which leads specialists [13] to affirm that despite Wing's classification, no person suffering from ASD is similar to another in terms of their observable characteristics.

People who are diagnosed with Autism Spectrum Disorder ASD have deficiencies in communication and social interaction. The DSM-V guide determines the level of ASD on a three-grade scale, detailed below.

Grade 1. Need Help

Social communication. Without on-site help, deficiencies in social communication cause major problems. Difficulty initiating social interactions and clear examples of atypical or unsatisfactory responses to the social openness of other people. May appear to have little interest in social interactions. For example, a person who is able to speak in complete sentences and who establishes communication but whose extensive conversation with other people fails and whose attempts to make friends are eccentric and usually unsuccessful.

Restricted and repetitive behaviors. Behavioral inflexibility causes significant interference with performance in one or more contexts. Difficulty alternating activities. Organizational and planning problems make autonomy difficult.

Grade 2. Needs Notable Help

Social communication. Notable deficiencies in verbal and non-verbal social communication skills; apparent social problems even with on-site help; limited initiation of social interactions; and reduced response or abnormal responses to the social openness of other people. For example, a person who emits simple sentences, whose interaction is limited to very specific special interests, and who has very eccentric non-verbal communication.

Restricted and repetitive behaviors. Behavioral inflexibility, difficulty coping with changes, or other restricted / repetitive behaviors often appear clearly to the casual observer and interfere with functioning in various contexts. Anxiety and / or difficulty in changing the focus of action.

Grade 3. Needs Very Notable Help

Social communication. Severe deficits in verbal and nonverbal social communication skills cause severe functional impairment, very limited initiation of social interactions, and minimal response to other people's social openness. For example, a person with few intelligible words who rarely initiates interaction and who, when he does, performs unusual strategies only to meet needs and only responds to very direct social approaches. Restricted and repetitive behaviors. Behavioral inflexibility, extreme difficulty coping with changes, or other restricted / repetitive behaviors significantly interfere with functioning across the board. Intense anxiety / difficulty in changing focus of action.

Verbal behavior

In DSM-V they make a mention of verbal and non-verbal social communication, when indicating one of the problems that patients with ASD present. B.F. Skinner [14] carried out studies on verbal behavior, indicating that vocal language is only a part or subset, arguing that the emission of sounds or certain actions such as gestures are verbal even though they are not part of an organized language, since they provoke a reaction in the listener or observer similar to the emission of vocal language and therefore must be part of the verbal behavior.

Detectable movements

Repetitive and stereotyped behaviors are considered an important symptom of autism spectrum disorders (ASD). Jumping, turning, and other rhythmic body movements were described in the first patients originally described in Kanner's series [15] [16].

Leo Kanner conducted an evaluation in the case study with 8 boys and 3 girls, describing various repetitive movements such as: rhythmic jumping, clapping, sucking sounds, walking on tiptoe, not looking directly at the face, continuous repetition of words and / or phrases. Later, in 1979, Lorna Wing and Judith Gould [16] determined that people with Autism Spectrum Disorder have problems in three areas: a) They cannot develop skills in reciprocal social interaction. b) they have difficulties in their verbal and non-verbal communication and c) they

have restricted patterns of behavior and interests. These symptoms are known as the Wing Triad.

III. Proposal, materials and methods

The Use case

A video that was filmed in a session of the work of a therapist with a patient diagnosed with severe ASD is analyzed while they carried out tasks of identification, concentration, pointing, etc. The video has a total duration of 22:00 minutes, in order to identify sounds and movements, the different actions of the patient were recorded in an online Google spreadsheet called *videos.xls*.

The first sheet of the worksheet was divided into the following columns: Time, Action, Characteristics, Comments. Figure 1 shows an example of the original spreadsheet, considered for data collection.

	Inicio	Acción	Características	Comentarios	Otros	Movimientos detectables
1	0:00:00	Festejo	Le levanta mano derecha repetidas veces	Terapeuta le baja la mano mientras anota algo		2
2	0:00:06	Murmura	Murmullo con letra "a"	Mientras mira el objeto en la mesa		6
3	0:00:09	Aprieta juguete sonoro	Con mano izquierda y luego ambas	Luego da incentivo y repetición de acción de la terapeuta		
4	0:00:16	"Investiga" presión del juguete	Lo presiona con ambas manos	Terapeuta celebra la acción con un "que bueno"		
5	0:00:28	Coloca codo y antebrazo sobre el escritorio				
6	0:00:32	Movimiento de cara y boca	Mueve la cara hacia su derecha varias veces	La terapeuta le "acomoda" la cara para que mire al frente		5
7	0:00:35	Busca con la mirada	Mueve ojos y cara hacia su derecha buscando	La terapeuta dice "se fue papá" y "saludón"		
8	0:00:37	Movimiento de brazo derecho	Parece saludar a su papá de esta forma			

Fig 1. Working Spreadsheet

Afterwards, the worksheet is corrected to add to the time column, two new columns where the time before the start of the movement / listening and the time after it are recorded. In the Action column, the detectable movements according to the list prepared are recorded; A brief description of these movements is recorded in the Characteristics column and finally, in the Comments column, the actions and expressions that the therapist performs at each opportunity are recorded. Later this sheet is corrected again taking each column with the exact time of occurrence (see Table 1).

Table 1. Time-sheet of Stimulus upon every sound slice detected

Reference	time ₁	time ₂	time ₃	time ₄	time ₅	time ₆	time ₇
Time Slice 1	0:00:00	2:31:00	3:58:00	4:18:00	5:17:00	6:52:00	7:25:00
Label: iuuu		He moved or was	The book is given	The therapist stood up	Most of the time she is	A vehicle is heard in the	He got bored

Reference	time ₁	time ₂	time ₃	time ₄	time ₅	time ₆	time ₇
		someone in the room, before he had lost focus on the therapist			standing behind him hace uuuuu	background while passing the pages of his book	reading the book a second time and turning the pages seemed
Time Slice 2	1:57:00	2:07:00	2:19:00	2:52:00	3:18:00	7:03:00	8:20:00
Label: aaaa	You won the token (Buenísimo oooooo) + timer beep + eye contact to therapist + gives him yellow toy	Token arrangement	Points to card and the therapist congratulates him + gives him red toy	Buenísimoooooo o (good)	He gives him yellow ball, (Biennnnn Excellentee)	Wait for the stimulation of the therapist to turn the page	Look at the floor, he gets bored of waiting
Time Slice 4	3:40:00	10:30:00	16:25:00	16:30:00	18:10	19:09:00	
Clapping Sound 4	Given the lack of attention to him, the therapist takes a long time in his notes	He asks for silence, takes him a glass and plate and touches his mouth. Seems eager to play and win the lollipop	Sneezing and health	Sneezing and health	They clean his nose	He's bored now, he makes many new movements, he stretches, he wants to finish now	

The registration has been traditionally performed manually according to the actions of the patient and the indications of the therapist. The actions are those that are described in the introduction section and that are added to the capture protocol. The list of detectable movements (see an excerpt in Table 2) was taken from the work of Ángel Riviere [17] and modified according to the description of each of the movements by the author and the therapists.

Table 2. ASD typical behavior

Movimiento detectable	Descripción
Rhythmic jumps	The body sitting / standing, the patient facing the front, performs vertical stentorian movements with / without arm movements.
Clapping	It is the action of clapping the palms of the hands together repeatedly as a sign of both approval (joy) and, sometimes, rejection
Sucking sounds	It is the effect of producing a sound similar to the sucking of the bottle or the mother's breast when drinking milk

Walk on tiptoe	It is the action of walking on the balls of the feet without contact between the heels and the ground. It hits both feet at the same time
Do not look to the face directly	The patient, seen from the front, does not direct his gaze towards us but appears skewed, to the right (more frequently) or to the left
<i>The list continues...</i>	

IV. Testing protocol

For this activity, the audio of the video used previously in this work was taken; In this way, it is possible to identify only the moments when vocal sounds or clapping of the patient are heard.

After exhaustive manual work, 88 opportunities were recorded in which a sound and / or movement can be identified by the patient. Each of these sounds was identified in order and then divided by similarity. In this way, the sounds where the expression “iuuu” was recorded was identified as Sound 1; the expression "aaaa" was identified as Sound 2; the expression “brrrr” was identified as Sound 3 and the “Clapping” were identified as Sound 4. It should be clarified that in addition to the identifications such as: Sound 1, Sound 2, Sound 3 and Sound 4 (Clapping) there was some other sound such as example the expression of joy and others with very complex identification and not all the same.

On several occasions, each background sound is accompanied by a sound or movement of the patient, for example in the order number 4, 5, 14, 21, 28, 29, 33, 36, 43, 46, 47, 57, 58, 59, 74, 77, 79, 80, 81. On other occasions, the patient performs the clapping movement accompanied by one of the sounds registered, for example in the order number 1, 2, 22, 24, 44, 75, 78, 82. In addition, slice of sound 1 is associated with a movement and expression as if it were angry as recorded in the order 15, 61, 69, 83.

Modeling the problem with metadata

For this, we use the sliding windows method, this method is a widely used concept for the development of specific algorithms. When using a sliding windows, the system is asked to logically consider all possible windows of a given length. In other words, we have events at those points in time when the content of the window actually changes, in other words, when an event enters or leaves the window.

Furthermore, as its name suggests, an essential characteristic is that its ends move or “slide”, but always in the same direction.

For the case object of this project, five versions were written in Python, one of them fulfilling what was proposed in each version, and five versions in Octave, with four of them fulfilling what was proposed.

In the final version, you see a 39-line code function. For this, the library implemented is LTFAT. It provides signal processing algorithms for use with Octave software. The functions provided by the signal package include the creation of waveforms, design of FIR and IIR filters, spectral analysis, Fourier transforms -among others-, window functions and re-sampling and frequency shift. Some wavelet functions are also included, since there is no specific wavelet packet.

Four main variables were used, A and B, which would be the variables to store the sound file used; AA and AB whose function is to store the number of seconds that each loaded sound consists of.

Also, it uses two for loops from 1 to AA / AB whose main objective is to divide and compare both sounds for every second (The graph will vary based on this). An if conditional where it is stated that, if both sounds are equal in a given second, they are stored in a variable C. The pseudocode of the mentioned algorithm is in Figure 2.

```
function retval = SlidingWindows4 ()
B = "TherapyVideo.wav"
A = "Slice.wav"
N = 1e3;
AA = size(A); #Matrix size to make the for in the comparison
AB = size(B);
#Sliding Windows comparison
for i = 1 : AA,
    for j = 1 : AB,
        if metaDataComparison (A(i), B(j)) #meta data are similar
            C(i) = A(i)
        endif
    endfor
endfor
endfunction
x = SlidingWindows4()
save salidasw.csv x(1:100)
```

Fig 2. Sliding Windows for matching the pattern slice

Regarding the graphical part, it consists of LTFAT functions, where it is plotted from the scale on the X and Y axes, and the variation of sound with the previously mentioned variable C is displayed (Figure 3 and a zoom-in in Figure 4).

Every sound has 4 sub-slices labeled SS1 to SS4, in order from the first second to the last. Figures have the following color code:

- **Blue** - SS1
- **Red dot** - SS2.
- **Yellow** - SS3.
- **Violet** - SS4.
- **Black** – Σ_i SS_i.

The plot shows the metadata corresponding to each Sub Slice of a pattern

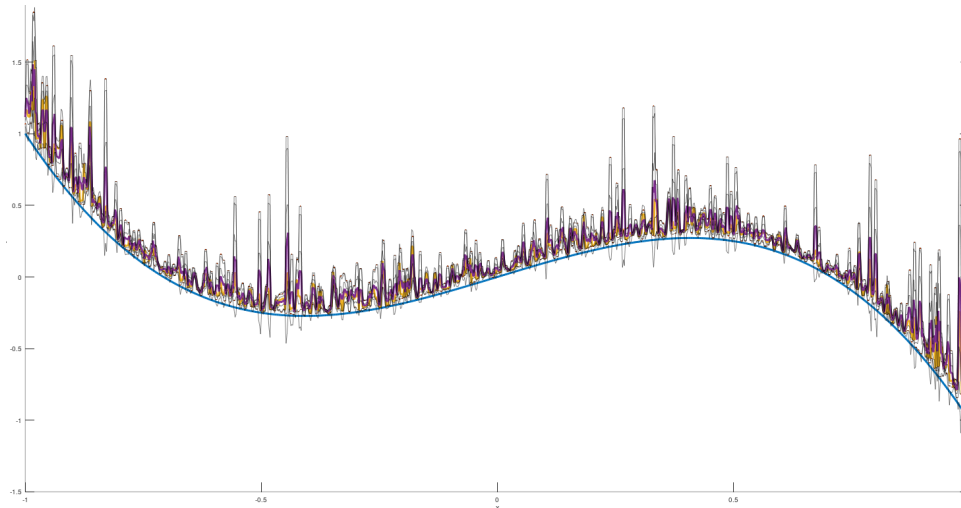


Fig 3. Sliding Windows graphical output

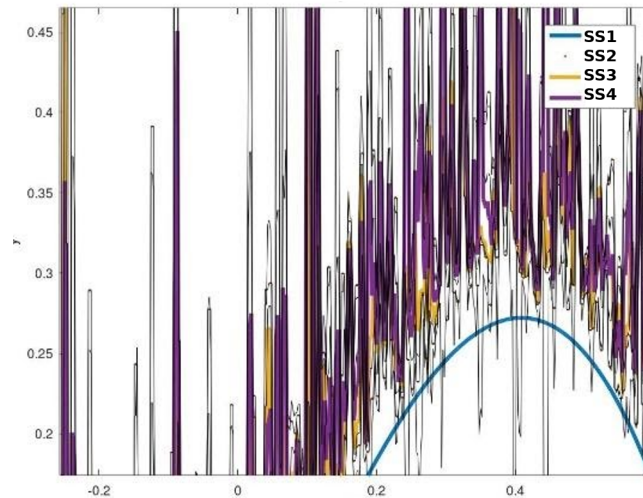


Fig 4. Sliding Windows graphical output with zoom in

The plot shows the differences between metadata values for the video sub parts, as being processed for sound pattern. Running the algorithm using the Sliding Windows with two cut pointers algorithm [23] on sounds results in Figure 5.

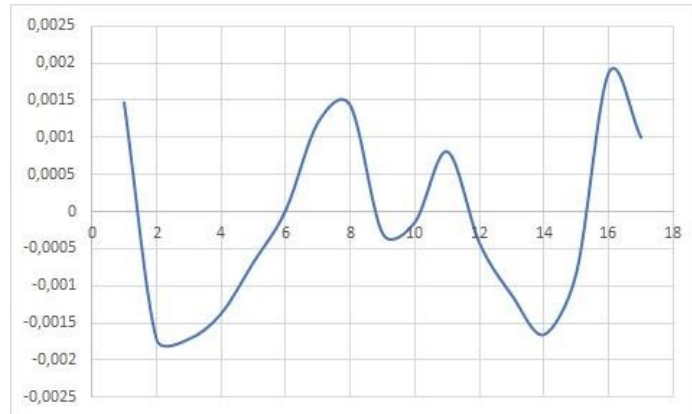


Fig 5. Sliding Windows with 2 cut-points

The plot represents the main curve representing the variations between the current slice and slice 1 is now bi-modal. This is because the comparison is second by second and not the entire slice. Since the sensibility is bigger, the plot shows that behind the global behavior shown in Fig. 3, there are moments where metadata representing the sound matches better in some parts.

Advantages and disadvantages of using the proposed approach

To use the Sliding Windows technique, several versions of the program were made, which contain different points in favor and others against. The first version was created in Python to use an appropriate and leading programming language at the time, after an investigation of the case, the frequency, duration and comparison of similarities were obtained. The biggest downside is that it requires different libraries for it to work.

Then the first version was made in Octave, the result of investigating the operation of the software thoroughly, it is possible to pass an audio strip and that it reflects a graph detailing the different sounds that were detected. The disadvantage is that it is not possible to load more than one audio strip at a time and it is also very impractical to compare different graphics.

For the second version made in Octave, currently the last version made, it is possible to pass two different audio strips, obtaining a graph in which it is analyzed in which points there are coincidences.

Wavelets

The use of the Fourier transform does not solve the problem of a better localization of a signal. In addition, we will have problems if the events are presented very close to each other since it will be very difficult to differentiate behaviors within the same window width.

The mathematical tool that helps solve these problems is the Wavelet Transform. This transform can detect high frequency phenomena. Once we choose the window size, the fre-

quencies are analyzed with the same time and frequency resolutions, different from what happens in the Wavelet Transform which has a window size adapted to the frequencies.

This work is based on the BIOTECH project. This is a proposal to apply morphosyntactic linguistic wavelets (MLW) as an intelligent system capable of providing in-depth information on the reasoning process related to linguistic expressions [18]. It has been applied to interpret WEB content, automatic summarization, dialogue profiles, texts and author profiles, bilingualism effects in young children, etc. [19] [20].

To be able to process with MLW it is mandatory to have linguistic expressions made by the patients. To overcome the lack of language articulations, the project is based on the concept of verbal behavior [21], detecting verbal activities with specific audio and video devices.

Verbal behavior is becoming widely accepted as a crucial perspective for autism spectrum disorder in therapies; Greer [22] expresses that there is more and more evidence on onto-genetics, the sources of language and its development that leads to a renewed interest in the theory that verbal ability in humans is the result of evolution and onto-genetics of development.

Another important aspect to consider is the particularity of each individual. Experts claim [07] that skills training should be intensive, but also personalized for best results.

In this work, an Octave function was used (See algorithm in Fig. 5) to generate an algorithm that reads a selected audio strip, a number of coefficients, the type of wavelet to apply and a type of channel, and shows an application graph and an output file in csv format.

```
function retval = AplicoWvlet (input1, input2, input3, canal)
f = input1;
% original [y, fs] = audioread (filename, samples, datatype)
[f,fs] = audioread (input1);
J = input2; % number of coefficients
wvNom = input3; % The wavelet to apply
%reduce input to one channel
[c,info] = fwt(f(:,canal),wvNom,J,1); %apply the wavelet and return c
coefficients
plotwavelets(c,info,fs,'dynrange',90);
## Frequency bands of the transform with x-axis in a log scale and band
## peaks normalized to 1. Only positive frequency band is shown.
[g,a] = wfbt2filterbank({wvNom,J,'dwt'});
filterbankfreqz(g,a,20*1024,'linabs','posfreq','plot','inf','flog');
% show the information structure of the signal
info
%return coefficients
retval=c;
endfunction
```

Fig 6. Wavelets algorithm

V. Analysis of sounds

The analysis of every slice provides information on how often certain pattern is being repeated during the interaction with the patient. This type of information intends to make it rel-

evant how every slice acts as a vocabulary for the individual. Following this conception Table 2 becomes a reference of that to expect when there is a stimulus, to confirm where is the focus at any moment.

All the selected sound patterns were made to compare each one of them and draw more precise conclusions about the behavior of the data. The comparison of the sound clippings, despite being different in their specific content, apparently have a very similar result between them.

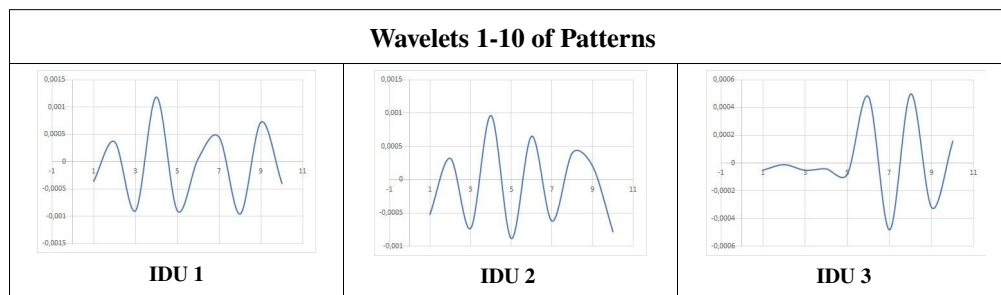
Table 3 show the most relevant clippings, the echoic sound (Label), the internal ID (IDU), the order of first instance (FI), the timestamp of the first instance (Time), the threshold defined to determine is the cumulative distances between a metadata in the pattern is similar to metadata in some part of the video (MetaDtThreshold), the threshold defined to determine is the distance between certain metadata in the pattern is similar to metadata in some part of the video (PatternThreshold) and the number of sub-slices of the pattern (NumSubSlices).

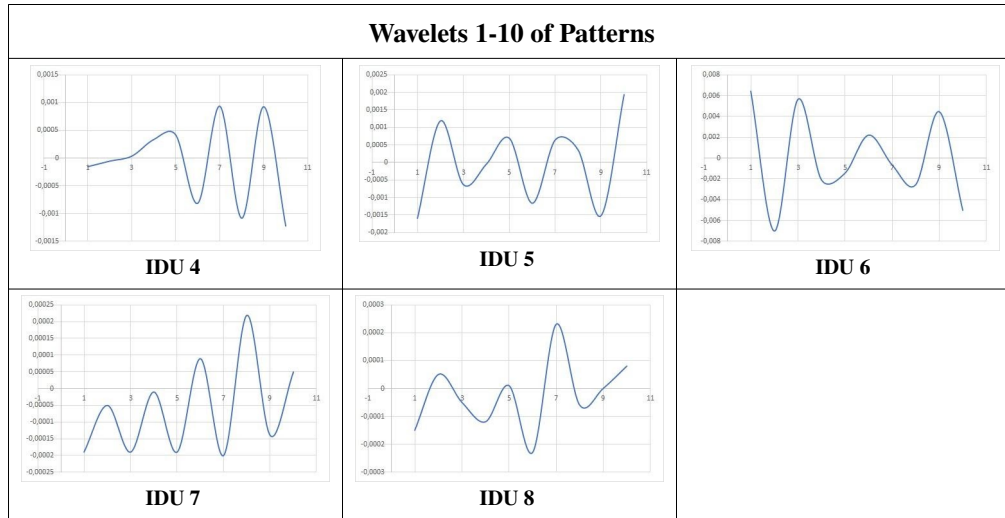
Table 3. Summary of patterns detected in the interaction

Label	IDU	FI	Time	MetaDtThreshold	PatternThreshold	NumSubSlices
iuuiuiui.wav	1	1	10:10	0.5	0.4	4
iuuiuiuu.wav	2	2	14:22	0.5	0.4	4
iuuiuiuu.wav	3	3	13:30	0.5	0.4	4
iuuiuiuu.wav	4	3	13:30	0.5	0.4	4
iuuiuiui.wav	5	1	7:23	0.5	0.4	4
iuuiuu.wav	6	0	0:00	0.5	0.4	4
iuuu.wav	7	4	2:53	0.5	0.4	4
iuuiuu.wav	8	0	10:17	0.5	0.4	4

Table 4 summarizes a selection of the first eight selected clippings considered to be the most repetitive in the recording. The plots show the wavelet description in every case. They are so frequent in the original interaction with the patient that are used as patterns of reactions.

Table 4. Plots of the pattern's wavelet encoding





The table makes it clear that every pattern has its own set of values. Something interesting arises when the numeric values of the ten first wavelets are compared. They have exact the same value for half of the code values, for all the patterns (see Table 5).

Table 5. Shared Wv-Coefficient in Patterns

MetaData<x>SubSlice<y>	Pattern IDU	Coefficient
MtDt1SS1	[1 .. 8]	0.0010946527865457112
MtDt3SS1	[1 .. 8]	1321.678276643991
MtDt1SS2	[1 .. 8]	5.6848702944657583e-05
MtDt3SS2	[1 .. 8]	1320.678276643991
MtDt1SS3	[1 .. 8]	-0.00099214605055142672
MtDt3SS3	[1 .. 8]	1319.678276643991
MtSt1SS4	[1 .. 8]	-0.00034117011565242596
MtDt2SS4	[1 .. 8]	1318.678276643991

In the first column **MetaData<x>SubSlice<y>**, represents the meta-data number x of the sub-slice y. For instance MtDr1SS1 is the first meta-data of the first sub-slice. Being the meta-data, the slice selected. Table 6 shows the differences between wavelets.

Table 6. Peculiar Wv-Coefficient in Patterns

IDU	MtDt2SS1	MtDt2SS2	MtDt2SS3	MtDt2SS4
1	-0.0020528575776790816	0.0002588129000799545	-0.000245072739345066	-0.0015204748838714478
2	0.0021977747536751817	-0.0034819255348520128	0.0022764760814601996	0.00069383337150009678
3	-0.00097355336163544397	-0.0001024680700039816	0.0001136690832276187	-0.0013034488259488612
4	0.003132295832909505	-0.0049550723423626994	-0.000232883456961878	0.0031827103193633227
5	-0.00016357432850720686	-0.0021609758627610296	0.0011700772129727612	0.00092281295499667968
6	0.00077712413649748283	-0.00063347949123720429	0.0017681726388932544	-0.0011592643588369624
7	0.001260975846586664	0.0040332202143579304	-0.0018817369033875039	0.0048301140722170344
8	0.0027855119145471512	0.00059980364665990769	0.0031983855195914408	4.3684541036182338e-05

Finally, Table 7 has the wavelet decomposition of the eight patterns as a whole (without Sub-slicing and metadata).

Table 6. Wv-Coefficient in Patterns

IDU1	IDU2	IDU3	IDU4	IDU5	IDU6	IDU7	IDU8
-0.00036	-0.00052	-0.00005	-0.00015	-0.00159	0.00645	-0.00019	-0.00015
0.00037	0.00032	-0.00001	-0.00005	0.00118	-0.00702	-0.00005	-0.00005
-0.0009	-0.00073	-0.00005	0.00004	-0.00063	0.00566	-0.00019	-0.00005
0.00119	0.00096	-0.00004	0.00034	-0.00005	-0.00209	-0.00001	-0.00012
-0.0009	-0.00088	-0.00008	0.00042	0.00069	-0.00144	-0.00019	0.00001
0.00006	0.00065	0.00048	-0.00081	-0.00116	0.00222	0.00009	-0.00023
0.00045	-0.00062	-0.00048	0.00094	0.00064	-0.00065	-0.0002	0.00023
-0.00096	0.0004	0.0005	-0.00108	0.00035	-0.00256	0.00022	-0.00006
0.99973	0.0002	-0.00032	0.00093	-0.00151	0.00447	-0.00014	0
-0.0004	-0.00078	0.00016	-0.00122	0.00193	-0.00502	0.00005	0.00008

VI. Conclusions and future work

This paper presents an introduction of main characteristics of patients suffering Autistic spectrum Disorder. Those that has not preserved verbal behavior has severe problems to communicate since they can't articulate any language in the sense that has been traditionally defined. After analyzing the recording of a patient's interaction it is possible to determine several repetitive movements and sounds, that are present upon certain stimuli. The sounds can be considered of a pattern to evaluate when it is re-used during the interaction. All the patterns have certain basic similarity. The findings in this paper might be considered as a first step to evaluate other patient's interactions and their characteristics. Other pending activities are: implement a prototype that makes it simpler to evaluate sounds automatically, apply similar considerations to video recordings, track the evolution in time of the communication of the individual.

References

- [01] Filipek, P. A., Accardo, P. J., y Ashwal, S. (2000) Parameter practice: Detection and autistic diagnose. *Neurology*, 55, 468479. DOI: 10.1212
- [02] Contreras, V., Fernández, D., Ruíz Rodríguez, J. J., & Pons, C. (2016). Natural interfaces as an educational complement, cognitive and social performance for ASD. In VII Congreso Argentino de Informática en Salud (CAIS 2016)-JAIIO 45.
- [03] Greer, R. D. (1997) The wide application of behavior analysis to schooling behavior (CABAS®). *Behavior and Social matter*.
- [04] Krams, B. (2013) Small humanoid robot helps children with ASD. *Healthline News*. Obtained from <http://www.healthline.com/healthnews>
- [05] Palau, M., Valls Santasusana, A., Y Salvadó, B. (2010). Neurolinguistic disorders of ASD. *Neuro anatomical functional basis*. V 50, N 6976.
- [06] Señor C., Shulman C, y Di Lavore P. (2004) Regression and loss of speech in ASD TruM specification. *Magazine of children's Psycol. & Psychiatry*. 45 (5), 93655
- [07] Greer RD (1997) The comprehensive application of behavior analysis to schooling. (CABAS®). *Behavior and Social Issues*, 7(1)
- [08] Bustamante P., Lafalla A, Coria N, Agüero M, López de Luise, D.; Parra C, Azor R, Moya J, Cuesta J. Protocol for evaluation of somatic and oral behavior to sound

stimuli in patients with autism spectrum. CI2S Lab. Pringles 10- P2. University of Burgos.

[09] López de Luise, D., Jesús Azor, R. & Párraga, C. (2015) Autistic verbal behavior. Automated model of the patient profile - audio. Edit. Académica Española. ISBN 978-3-659-07183-6

[10] Cheol-Hong, N., Ahmed H. (2010) Novel pattern detection in children with autism spectrum disorder using iterative subspace identification. Department of electrical and computer engineering university of Minnesota, USA. 978-1-4244-4296-6/10 ©2010 IEEE ICASSP 2010. PPS 2266/2269

[11] Mower, E., Black, M.P., Flores, E., Williams, M., Narayanan, S. (2011) Design of an emotionally targeted interactive agent for children with autism. University of Southern California (USC), 2011 IEEE, 978-1-61284-350-6 / 11

[12] DSM-V Encoding update®. Supplement to the Diagnostic and Statistical Manual of Mental Disorders. Fifth edition. American Psychiatric Association. 2014

[13] Ministry of Science and Innovation Spain. Clinical practice guide for the management of patients with autism spectrum disorders in primary care. Nipo: 477-09-052-8 isbn: 978-84-451-3244-9: Estilo Estugraf Impresores, S.L. Pol. Ind. Los Huertecillos, Nave 13 - 28350 Ciempozuelos (Madrid). 2009.

[14] Skinner B.F. (1981) Verbal Conduct, Translation by Rubén Ardilla, Edit. Trillas Mexico, ISBN 968-24-0987-X.

[15] Kanner, Leo. (Artículo original) (1943). Autistic disturbances of affective contact. Nervous Child. N2, (217250). Translated by Teresa Sanz Vicario. Published in the Spanish Journal of Intellectual Disability Siglo Cero www.feaps.org

[16] Wing L. (1993) The definition and prevalence of autism: a review. European Child and Adolescent Psychiatry. Vol 2:61-74.

[17] Riviere, A. & Martos. The little boy with autism, Year 2000. ISBN: 9788460702610

[18] López De Luise, D., Hisgen, D., Cabrera, A., y Morales Rins, M. (2012) Modeling dialogs with linguistic Wavelets. Theory and Practice in Modern Computing, 1, 11 - 13.

[19] López De Luise D (2012) Morphosyntactic linguistic wavelets for knowledge management. InTechOpen 8:167–189. doi:10.5772/35438

[20] López De Luise D, Hisgen D (2013) MLW and bilingualism: case study and definition of basic techniques. IGI global: Advanced Research and Trends in New Technologies, Software, Human-Computer Interaction, and Communicability, 568–600

[21] Sundberg ML (2007) A brief overview of a behavioral approach to language assessment and intervention for children with autism association for behavior analysis newsletter, 30(3)

[22] Douglas Greer D (2008) The ontogenetic selection of verbal capabilities: contributions of skinner's verbal behavior theory to a more comprehensive understanding of language. Int J Psychol Psychol Ther 8(3):363–386

[23] Two Pointer with Sliding Window Algorithm to Compute the Longest Substring with At Most K Distinct Characters (2020) Taken from <https://helloacm.com/>