

A Profile Recognition System Based on Emotions for Children with ASD in an Interactive Museum Visit

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Abstract: Children with Autism Spectrum Disorder (ASD) may experience difficulties in doing some activities on their own as they are likely to be more sensitive to visual or auditory stimuli. This may limit their selection of activities, and these must be adapted for them and their companions. One of the most important issues for this group is to be able to manage and recognise their emotions, which leads to a better understanding of themselves and their surroundings.

In recent years, information technology has helped to develop assistance tools for education and daily habits. However, research in emotional management in children with ASD has not been fully explored for leisure and cultural activities.

In this paper we present a proposal for a user model and a mobile application intended to assist children with ASD when visiting a leisure space and assess the emotional impact as they go through the different attractions. Users will respond to a questionnaire based on the basic emotions in an itinerary suitable for their general behaviour.

The methodology is validated by a non-profit organisation, who helped to create a case study, intended to provide guidance for recommendations on leisure activities for these children and their caregivers.

1 INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder, characterised by deficits of social communication and social interaction, along with restricted and repetitive patterns in behaviours, activities and interests (First, 2013). It is an umbrella term that refers to multiple manifestations ranging from very mild to severe, though certain symptomatology is shared along these individuals (Lord et al., 2018).

The DSM-5 (First, 2013) describes some common signs and symptoms of ASD, which may come more mild or severe depending on the diagnosis and treatment depends on this, though most people require a lifelong support (Lord et al., 2018).

Some of them include deficits in social emotional reciprocity and non-verbal communicative behaviours, low comprehension of general social stimuli (Bandrés et al., 2021), hyperreactivity or hyporeactivity to sensory input and unusual interests in sensory

aspects of the environment (First, 2013; Grzadzinski et al., 2013; Lord et al., 2018).

For instance, a child diagnosed with ASD may feel overwhelmed by lights or loud noises, which may affect how they feel in certain situations. Because of this, children need the company of a tutor for their daily activities, and this could affect their participation and choice for cultural or playful activities (Huang and Kang, 2021).

Given the quick and simple access to technology, a wide range of mobile applications has been developed to improve accessibility of people with special sociability needs and their families (Gallardo-Montes et al., 2021). Generally, they provide assistance in the fields of education, communication skills, and therapy (Cibrian et al., 2022; Krause and Neto, 2021; Fletcher-Watson, 2014).

Information and Communication Technologies (ICTs) have therefore become a useful tool for children with ASD in their education process meant for lifetime use (Dratsiou et al., 2021). These users are keen to visual and sensory stimuli, therefore, new technologies of digital transformation such as Augmented Reality, Computer Vision and gamification

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across different contexts have made a trend in recent years (Krause and Neto, 2021; Lian and Sunar, 2021; Mubin et al., 2020; Torrado et al., 2019; Grossard et al., 2017).

Some of the main problems covered by these applications include ASD diagnosis, adaptive learning and emotional recognition (Krause and Neto, 2021). This study will focus on the latter.

According to psychologist Robert Plutchik, there are 8 basic emotions defined by joy, trust, fear, surprise, sadness, anticipation, anger, and disgust. The rest are defined as a combination of these primary emotions and, similarly to the colour palette, a wheel of emotions is proposed, referred as Plutchik's Emotion Wheel (Plutchik, 2001).

Children and adolescents with ASD have more difficulties than typically developing group pairs for emotion recognition and management (Papoutsis et al., 2018). Hence, therapy for people with ASD involves a process of emotion identification and recognition, and in recent years this has been mediated with the use of technology (Rashidan et al., 2021).

On the other hand, interactive museums may offer an interesting option for participation in leisure yet ordered activities, as they can be ordered in different itineraries or attractive points depending on the visitors' interests (Yates et al., 2022). If a child with ASD gets affected by any stimuli, it is relevant to communicate their emotions well to their caregiver.

All in all, there is room for investigation within the context of emotional perception by children with ASD as an interactive experience. We propose an adaptation of a user model for profile assignment based on the user perception when visiting interactive attractions, the idea is to compare this information to a pre-evaluation made from experts, to see if they fit.

2 RELATED WORK AND MOTIVATION

Some notable applications involving the use of smartphones as assistance tools in museum visits or emotional recognition for children with ASD are summarised as follows.

ARTis (Vita et al., 2021) is a mobile application that facilitates the accessibility and visit of museums for children with ASD and their tutors by overlapping virtual content with the surrounding reality. Through the smartphone camera, it creates a path inside a museum to help the user orientate and "experience" an appealing and interactive visit. It is guided by a friendly 3D avatar that follows a path guided with GPS tracking, it allows users to interact with different

points of interest of the museum.

The main goal of ARTis is to provide an experience centred on the end-user for a tailored cultural experience that can help to increase and improve social skills, through a greater sense of self-efficacy and autonomy (Lorenzo et al., 2019). With the use of Augmented Reality (AR) and Internet of Things (IoT) applied in the use of games, pop-up videos and visual content, it makes the cultural tour more enjoyable and motivating, although certain research protocols for usability testing have to be worked on as well as extension to other contexts (Vita et al., 2021).

Tobias in the Zoo (Carvalho et al., 2015) presents an AR application in the form of a GameBook to assist children with ASD to recognise and acquire emotions by engaging their attention and motivation. It shows the story of Tobias, a virtual character who has adventures during a zoo park visit along 5 scenarios. Each stage interacts with virtual animals and real-world situations which will conduct the children to become involved on fictional contents associated with emotions.

In each GameBook chapter, Tobias identifies five emotions (happiness, anger, sadness, fear and disgust) and narrates examples of it as a part of the story. At the end of each chapter, a mini game for emotion association is prompted to the user in the form of a questionnaire based on a situation description and an image of Tobias expressing the emotion. At the end of the book it has an evaluation of all presented emotions in a memory game (Carvalho et al., 2015).

Guess What? (Kalantarian et al., 2019) is a mobile charade-style game available in iOS and Android platforms, made for emotion association training to children with ASD.

With the use of image pattern recognition, it has been designed to be a shared experience between the child, who attempts to enact the prompt shown on the screen through gestures and facial expressions, and the parent, who is tasked with guessing the word associated with the prompt during a 90s game session (Kalantarian et al., 2020).

All in all, these projects show how the use of games intended for assistance and emotional learning can be suited for children with ASD, presenting good results in terms of their behaviour. However, these tools work with a learning mechanism where emotions are taught by repetition or common face patterns but are not necessarily experienced by the users themselves.

We propose a tool where users associate their feelings to a given emotion as they go through an interactive experience, so that recognition comes first hand rather than given by a storybook or character.

As for visual learners such as them, it is key to maintain innovative and yet simple interfaces in order to draw their attention. Also, applications should provide an enhanced experience for the child and their family. To this matter, these tools should not only be thought of as playful activities, it is also important to understand the outcomes of their opinions in order to improve future recommendations and decisions based on their motivations.

The value of deciding which activity is appropriate is key for therapists and caregivers when they have to propose them for children with restricted interests, so our proposal aims to establish common patterns that may improve that decision.

3 METHODOLOGY

In this section, we describe the proposed user model and evaluation strategy for a leisure visit tailored for children with ASD. The main goal is to monitor their perceptions and recommend future activities based on previous patterns defined by experts from a local organisation that plans leisure visits for families with children diagnosed with ASD.

3.1 User Profiles

In order to prepare for the visit, therapists have described common behaviour patterns that children follow as they participate in leisure activities. These have been reduced to four major profile characterizations.

Adventurous. Children with this profile prefer activities that dare them to be stimulated and hyped. They show interest in dynamic attractions that require active participation, involving movement, lights or sound. Usually, they tend to have an autonomous yet impulsive behaviour and don't pay attention to instructions carefully, so may need reinforcement of them.

Viewer. Children with this profile tend to more calmed activities that do not require major movement or active participation, they prefer to watch or have a demonstration of an action. They are also keener to learn and ask questions about the context, as they keep their concentration for longer periods, as well as comment on what they perceive with their companions.

Participative. Children with this profile represent an intermediate point as they enjoy dynamic and more calm activities equally. In principle, it is hard to determine what plans they could enjoy

most, depending on what entertains them at any given moment. They like to be accompanied by their tutors as they feel supported if they feel insecure.

Little Interested. Children with this profile don't feel highly motivated and rather scared by the activities, as it triggers them to have a higher reactivity to sensory stimuli, insecurities or don't show interest at all. Perhaps their time or concentration span may be lower and generally depend on their tutor for most of their communication. Familiar activities may be repeated rather than exploring something new.

Even though, as we defined, ASD covers a wide range of manifestations, these profiles serve as an approach for organising future activities. Some other things should be considered.

For instance, proper and clear itineraries should be defined and presented in advance, as they need to feel secure in their space. Also, the environment should be nice and comfortable, lights and noises must be controlled and any other possible distractions. Finally, a help system should be provided as well as a protocol if they don't feel comfortable enough to keep up with the activity.

3.2 AVI Model for Emotion Recognition

As for the division of the previous profiles, a selected criteria is defined according to an adaptation of the motivational dimension model by Zhang in (Zhang et al., 2020) and the emotional mapping proposed by Park in (Park et al., 2019). These models were chosen as they allow to quantify some common emotions so it can be parameterized according to valence and arousal levels.

According to experts, four major emotions tend to be the most frequent: fear, happiness, sadness and tiredness. These emotions were ordered according to both mentioned models, representing one in each quadrant in the Cartesian plane, with axis of arousal and valence, as it shows in figure 1. Therefore, we propose the AVI (acronym for Arousal, Valence and Interest) model that connects these three parameters with the four emotions raised by the opinion of experts. As for the arousal and valence factors, possible values are given by -1 and 1, in order to maintain the bidimensional plane.

Additionally, a third parameter that represents the interest of the activity is added to have a model dependent of three parameters as that should broaden the scope of action. This parameter represents how an activity can be appealing in three levels, low, medium

and high, respectively represented by the values -1, 0 and 1.

The idea is that therapists give a punctuation for each profile, which is stored in a number vector. This vector will be used to determine the shortest distance between the points represented by the vectors, using the Euclidean distance.

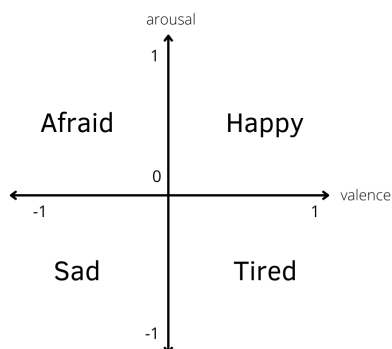


Figure 1: AVI Model of Emotions.

3.3 Before the Visit

Due to their behaviour, as a general rule, people with ASD and their companions need to be informed of visit details in advance. For this, experts prepare useful information guides with the use of adequate and visual content, to provide details such as the address, working hours of the visiting space and other relevant suggestions, as well as contact information if additional assistance is needed.

In this phase, itineraries for the visit are defined in accordance with the available options. Each itinerary is tailored for each user profile and it is added in the preparation guides.

All of this material is included in the mobile application so it can be consulted in advance by the families. Important information such as the address, working hours of the museum and a map of the itineraries is provided for maintaining a correct pattern of visit, as well as contact information if additional assistance is needed.

Firstly, we conduct a session along with the therapists to describe eight user personas, two for each user profile, giving them a name, age, and descriptions of their diagnosis, interests and general behaviour. Later, the discussion moves to estimating the corresponding values for the AVI vectors of each user persona for the itinerary corresponding to their profile.

3.4 During the Visit

The leisure place is selected depending on the availability, attractions and adaptation for people with spe-

cial needs, some common places tend to be art galleries, museums or interactive spaces.

In a general visit, a main protocol and data protection consent must be defined to secure the information and assure that all information collected is for academic use only. Small groups are preferred in order to maintain a calm environment as well as selecting a time period where the space is not crowded, and if possible, to book a time just for this evaluation.

Prior to the visit, experts will discuss the suggested profile for every child, depending on their behaviour on previous leisure activities, and will assign a corresponding itinerary to each.

As for the day of the visit, a member of the accompanying family group will be responsible for providing the information for this evaluation, in the name of its child. This person will be instructed on how to use the application and respond to the questionnaires as they move along the proposed itinerary, according to their profile. For this, mobile phones with the applications will be provided and with their consent, the data of the questions will be registered anonymously, as shown in table 1.

Finally, each user will represent a given profile that will be contrasted to the AVI vectors provided by the experts in the user persona evaluation. Metrics for accuracy and consistency are proposed in order to determine the comparison overall.

4 MOBILE APPLICATION FOR THE VISIT

We propose an application for registration of the user evaluation of the AVI model as they pass through different attractions defined in an itinerary of attractions. The main sections of the app include: Guides (maps and important information about the visit location), Surveys (questionnaires for storing information of the AVI model) and a Profile (detailing a description of the proposed profiles and recommendations).

Guides. As people with ASD tend to follow structured routines, the preparation guides give them an anticipation of what to expect in their visit. Contains maps, pictures and any other important information about the visit location, also the protocols that will be used.

Surveys. Contains questionnaires for registration of the AVI model, meant to be answered by the caregivers or family members in charge of the child after they visit an attraction. See figures 2 and 3.

Profile. Contains a description of the proposed profile according to experts evaluation, its corre-

sponding itinerary and associated recommendations. See figure 4 .

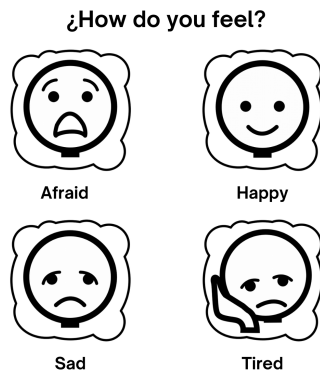


Figure 2: Emotions questionnaire.

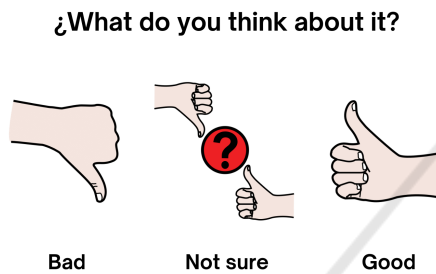


Figure 3: Emotions questionnaire.

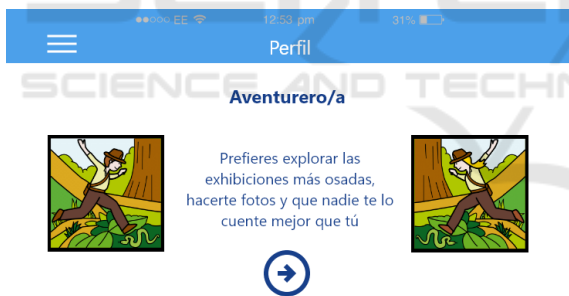


Figure 4: Adventurous profile description example.

5 A CASE STUDY

The user model and strategy are meant for any interactive museum visit, though an example case study is provided for better understanding and generating consequent results.

With the help of a local organisation, we managed to plan the visit for the Illusions Museum of Madrid. This space provides optical illusions, rooms with mirrors and entertaining attractions meant for children to learn by playing and learning science through an artistic environment. It is a space that induces different emotions to visitors, and the organisation has teamed

up for a special visit for people with autism and their families.

5.1 Preparation Phase

According to the methodology, experts work in the preparation guides for the visit, and elaborate the corresponding itineraries for each of the four user profiles. This visual material is included in the Guides section of the mobile application.

In the session with experts, we elaborate a description for the eight user personas and ask them to complete the questionnaires as if they were in the child's position. These answers were later discussed as a group to give a final score for each user persona, that will serve to contrast it with the information given by the final users.

We have recruited a group of 6 children with their families that wish to participate in exchange for a free visit to the museum. The organisation has helped to book the visit and review all corresponding material, including protocols and user consents. Experts of the organisation also assign a user profile and itinerary for each child, corresponding to their diagnosis background and perceived interests.

5.2 Museum Visit

In the visit itself, instructions will be given to all participant groups regarding the overall experience, use of the application and main museum guidelines. A mobile phone with the tool will be handed to a family member of each group, provided their agreement to participate in the evaluation. This person will be in charge of answering the questionnaires as they move along the proposed itinerary, according to their profile. An example of some response answers is shown in table 1.

Table 1: Example of user evaluation.

| Profile | Attraction | Emotion | Interest |
|---------|----------------|---------|----------|
| Viewer | Optical room | Happy | 1 |
| | Kaleidoscope | Happy | 1 |
| | Mirrors room | Bored | 0 |
| | Holograms room | Sad | -1 |

6 CONCLUSIONS

People diagnosed with ASD have difficulties in social communication and interaction contexts, which is rooted in different symptoms such as hyperreactivity or hyporeactivity to sensory stimuli, repetitive pat-

terms in restricted activities and interests. Therefore, the presence of a tutor is essential, and, in leisure activities which are not always adapted for these end users.

As people with ASD usually have challenges to identify the emotions of their own and from their peers, many research applications have been made for emotional recognition but only few of them have been targeted for leisure or cultural activities.

This paper proposes an innovative application for museum visits suited for children with ASD, with a focus on emotional recognition about their artistic experience. The goal is to assess how they feel when moving along the different attractions of a leisure place, based on the completion of questionnaires that measure four basic emotions.

To this extent, a correct user model would help caregivers to decide on what activities are best suited for their children and also to have better planning with the help of an assistance mobile application, which is portable and more attractive for visual learners.

This paper presents the corresponding tool, that provides the preparation guidelines for a visit and the data collect system that provides feedback for experts that work with planning leisure activities for children with ASD.

7 FUTURE WORK

The proposed case study will be applied in accordance to the proposed work plan, the current stage is pending to find an available time according to the schedule of the local non-profit organisation and the participant museum.

All information will be protected according to ethical guidelines and accessed only for research purposes. It will be used for a user model based on their answers and to assign an emotional profile which may help for future museum visits and help to guide other activities of the organisation.

Future work will test the usability of mobile applications like these and define a framework for extending the emotional impact in other leisure contexts such as restaurants, theatres or cinemas. This way, a correct adaptation should provide a better user model and help them to enjoy the activities based on how they feel, which contributes to a more pleasant user experience.

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