International Journal of Information & Computation Technology.
ISSN 0974-2239 Volume 4, Number 1 (2014), pp. 47-54
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Integrating and Classification of Facial Expressions to Children with Autism Spectrum Disorders

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Abstract

Autism Spectrum Disorders (ASDs), a neuero-developmental disability in children is a cause of major concern. The children with ASDs find it difficult to express and recognize emotions which makes it hard for them to interact socially. Conventional methods use medicinal means, special education and behavioral analysis. They are not always successful and are usually expensive. There is a significant need to develop technology based methods for effective intervention and cure. We propose an interactive game design which uses modern computer vision and computer graphics techniques. This game tracks facial features and uses tracked features to: 1) recognize the facial expressions of the player, and 2) animate an avatar, which mimics the player's facial expressions. The ultimate goal of the game is to influence the emotional behavior of the player.

Index Terms: Autism Spectrum Disorders, Serious Games, Facial Expression Analysis, Facial Puppetry.

1. Introduction

Autism may be viewed as a neurodevelopmental disability that can affect social, language or behavioral skills of a per-son. Most autistic persons show symptoms of withdrawal from social interactions and a lack of emotional empathy to-wards others. This behavior is usually attributed to their in-ability in understanding or expressing emotions.

The underlying causes of Autism Spectrum Disorders (ASDs) are still not well understood but an alarming num-ber of persons are diagnosed with this disorder. The last two decades have seen an explosive growth in the number of people diagnosed with ASDs. Recent studies suggest the number of people suffering from ASDs to be at-least 6 per 1000 in developed countries [1] (1 in 110 children in the U.S. [2]). This is significantly higher than about 1 per 1000 during 1980s. These statistics suggest that techniques for cure and treatment of ASDs need immediate attention from scientific community.

The signs of autism are often observed in the early years of a child's life. The children with this disorder usually show impaired conversational abilities, lack of eye contact, repetitive and restricted behavior [3]. Early intervention through psychiatric medications, therapies and behavioral analysis or both is employed for treatment. It has been seen that these conventional methods are not effective in many cases [4] and are usually very expensive [5]. There is a significant need to develop technology enabled ways of early intervention that can help autistic children in learning how to express them-selves and understand others emotionally.

In the following sections we review some of the con-ventional ways and some recent technology based ways em-ployed in treatment of ASDs. We then present the details of our game design followed by a discussion about some of the preliminary results.

2. Related Work

This section discusses some the traditional methods used for treating ASDs and their shortcomings, followed by an overview of some of the recent technology based methods that are being explored:

2.1. Conventional Methods

ASDs are usually considered to be not completely curable. Most children with ASDs remain affected even as adults and face similar problems related to social interaction, mental health throughout their life [6]. Therefore, management and intervention are needed very early in order to alleviate certain aspects of ASDs. Psychiatric medication is one way which pediatricians use to treat children suffering from ASDs. Most of the times these medicines are employed to treat specific symptoms of ASDs like anxiety, depression etc. Several re-searchers argue that there is a lack of research justifying the use of such psychoactive medicines for treating ASDs and can cause adverse effects on the health of patients [7].

Another way which has been effective in treatment of ASDs is through educational/behavioral intervention. Ap-plied Behavioral Analysis (ABA) has proven to be very use-ful in some of the cases [8]. In this approach therapists work with a child individually for 20-40 hours a week, teaching the child several skills in a simple step-by-step manner. These programs should be started at a very young age in order for them to be most effective. Designing such programs in a manner which keeps the child engaged is very important.

Delay/lack of speech development is a commonly ob-served symptom in children suffering from ASDs. Speech therapies which use sign language to teach children spoken language have been applied successfully. Another common method which is used for developing speech and social skills in autistic children is known as Picture

Exchange Communi-cation Systen (PECS) [9] [10]. In this method, children learn to communicate through exchange of pictures and symbols to their communication partners. This technique has shown exceptional results over the last few years and is shown to be easily learnt by most students.

2.2. Technology based Methods

There is a lot of evidence that children with ASDs learn bet-ter through interactive visual means [11]. Ramdoss et. al. [12] provide a systematic analysis for the use of Computer based Intervention (CBI) in enhancing communication skills in autistic children. Recently there has been significant effort in the direction of using modern technology to develop computer based systems which can be used to teach children with ASDs various social and communication skills.

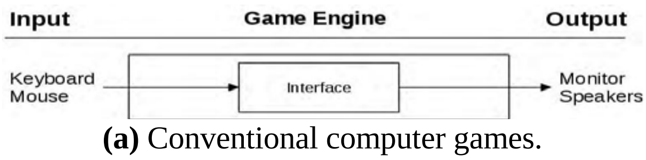
Tanaka et. al [13] have designed a program known as Let's Face It—which uses computerized games in order to teach face processing skills to children suffering from ASDs. Their program engages the child through various interactive game modules designed to teach basic face processing skills. One component of their system use facial expressions of the children as an input to the game which involves solving a maze [14]. The robot, named Kaspar, [15] is an interactive robot which can make several facial expressions like smile, frown, laugh etc. This robot interacts with children suffering from ASDs and it has been observed that interaction with the robot helps in improving the social skills in those children.

3. Our Approach

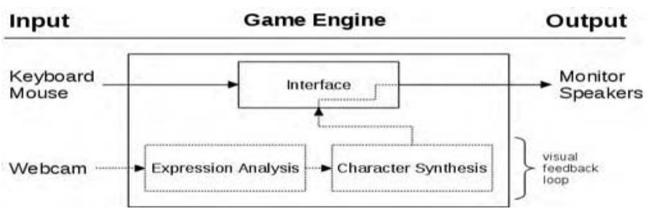
3.1. Overview

Conventional computer games consist of a simple feedback loop: input is usually obtained from a mouse and a keyboard, whereas the output (feedback) is provided through a moni-tor and audio speakers (see Figure 1(a)). Even though there is a large spectrum of computer games in terms of complex-ity, from games merely having basic interfaces to games with advanced 3D graphics, the input/output media rarely change.

The serious game presented in this paper introduces a sec-ond feedback loop, which in turn provides additional capabil-ities to the game (see Figure 1(b)). In this second loop, visual



(a) Conventional computer games.



(b) Our game.

Fig. 1. Conventional computer games vs. our game input from the player is continuously and automatically ob-tained by the use of a typical webcam. This additional input: 1) brings the human-computer interaction to a level, which conventional games cannot achieve, and 2) allows the design of sophisticated game modes.

Based on the existing literature on the characteristics of autistic children, and the interviews conducted with the psy-chologists, therapists, and parents, four initial game modes are designed for the proposed game:

- Recognize the expression, where the player is pre-sented with a sequence of random facial expressions and required to identify a specific (pre-selected) ex-pression from the set.
- Build a face, where the player is asked to construct a facial expression on a 3D avatar to match a defined emotion.
- Become your avatar, which has three levels. Level one is a free-play mode, where an avatar simply mimics the player's facial expressions. In level two, the player attempts to achieve a target facial expression. Finally, level three is a follow-up mode, where the player must follow an avatar's expressions.
- Live a story, where the player is presented with a story and asked to perform the appropriate expressions to the situations depicted in the story.

Note that, the last two game modes are made possible by the "visual feedback loop", and the associated expression analy-sis and character synthesis modules. These modules are ex-plained in more detail in Section 3.2.

3.2. Technology

As illustrated in Figure 1(b), input to the "visual feedback loop" is the real-time streaming video of the player. First, fa-cial features are located and tracked without using any mark-ers on the face. These tracked features are then used for both animating a virtual character and recognizing the expressions of the player.

3.2.1. Tracking Facial Features

Facial feature tracking is the process of consistently locating a set of landmark points in a face image. These landmark points usually correspond to distinctive facial features (such as the eye/lip corners), so that they may easily be manually localized during the training process.

Various approaches have been proposed for this purpose in the literature. A very popular class of methods model the face using a deformable, linear, shape model. Locating the landmark points on the face is then simply fitting this model to the given image.

Two of the most common fitting strategies are: holistic fitting, and patch-based fitting. Active Appearance Models (AAMs) by Matthews and Baker [16] is an example of holis-tic fitting, where the authors use the whole face image to com-pute an error image, and then adjust the model parameters according to this error image.

Patch-based fitting, in contrary, is accomplished by the use of "local experts". In these methods, such as the one by Saragih et al. [17], "local experts" are used to detect the land-marks, and then a joint motion prior (the deformable, linear, shape model), is enforced over all individual expert responses.

In our work, we are trying to address the limitations of these two approaches, such as the cumbersome, manual, person-specific training in [16], and not so accurate fitting accuracy due to generic training in [17].

3.2.2. Facial Puppetry

The goal of facial puppetry is to transfer the expressions of the player to a virtual character. This is achieved by learning a linear mapping between the facial deformations of the player and the facial deformations of the character.

Given a large number of labeled expression pairs (one for the player and one for the character) this mapping can easily be learned. However, such labeled expression pairs rarely ex-ists. Saragih et al. [18] proposed an approach to overcome this problem. In their work, the authors synthesize the ex-pression pairs by first learning expression-specific mapping functions from a large dataset and then applying these func-tions to the player and the character.

3.2.3. Facial Expression Recognition

Automated Facial Expression Analysis forms an important component in the overall design of our game modes. It forms the medium of interaction with the system and gameplay. A robust facial expression recognition system is needed to accu-rately give a feedback to the children playing the game.

We have developed an approach to recognize six basic fa-cial expressions namely: anger, disgust, fear, joy, sadness and surprise. Our approach [19] uses the facial features tracked over the children's face as discussed above. These facial fea-tures gives us the precise information about the face shape based on the location of fiducial points (e.g. contours of eyes, eyebrows, mouth etc.) which are important for recognizing facial expressions. We apply techniques such as Iterative Pro-crustes Analysis for aligning of the face shapes and use prin-cipal component analysis (PCA) to reduce the dimensionality of these features.

Several studies have shown that facial expressions are dy-namic in nature [20], hence in our method we model the tem-poral dynamics of face shape using Latent Dynamic Condi-tional Random Fields (LDCRF) model [21]. This helps in making decisions about the facial expressions of a person by analyzing his/her facial behavior over time.

Our method was trained and tested on the posed expres-sions from the standard Cohn Kanade dataset (CK+) [22]. Our approach has high recognition rates (86% on an average, including six basic expressions and neutral face). However, in our opinion, posed expressions are significantly different than spontaneous or natural facial expressions. Therefore, there is a need to move beyond acted expressions in order to build a system that is capable of recognizing natural facial expres-sions. Our current research is addressing these issues.

4. Preliminary Results & Status

A preliminary version of our game, with only the “Recog-nize the expression” game mode, has been tested with nine participants, ages ranging from 5 to 12. Out of these nine children; six had high-functioning, two had low-functioning, and one had severe autism with difficulty in communication. The game testings were conducted at homes or coffee shops, where the children were asked to play the game as long as they want. Children’s behaviors were observed as they played the game, and once they were done, both the children and the parents were interviewed on their experience of the game.

We obtained a significant insight about the game design through these interviews. Some of our findings are:

- Parents prefer story lines with real-life scenarios,
- More exaggerated or distinct expressions are more ef-fective for learning,
- Customization of features (such as sounds and charac-ters) is important for the children, and
- Using multiple cues in combination (such as images, text, and audio) enhances the learning results.

We are hoping to conduct a second set of interviews, and test the other game modes. We are working on completing the “visual feedback loop”, and also addressing some of the limitations of the current state-of-the-art in respective fields at the moment.

5. Conclusion

Children with ASDs have difficulty engaging with their peers, teachers, and/or parents, but most do like to play computer games. Our proposed game aims at providing these children a fun game, founded on the state-of-the-art research, where they can learn how to recognize and express emotions through facial expressions.

A major challenge, which remains to be addressed, is how to measure the effectiveness of our game in teaching children how to recognize and express emotions. This will require a large number of both short-term and long-term user studies. We plan to address these issues.

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