EmoStory: A Game-based System Supporting Children's Emotional Development

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Abstract
Children's emotional skills are important for their success. However, children with Autism Spectrum Disorders have difficulties in understanding social contexts and recognizing and expressing facial expressions. In this paper, we present the design of EmoStory, a game-based interactive narratives system that supports children's emotional development. The system uses animation and emotional sounds to teach children six basic emotions and facial expressions in various social contexts, and also provides multi-level games for children to systematically practice the learnt skills. Through using facial expression recognition technique and designing animated visual cue for important facial movement features, the system helps children to practice facial expressions and provides them with explicit guides during the tasks.

Author Keywords
Emotional development; interactive narrative; games; children; facial expression recognition.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): Miscellaneous; I.2.1 [Applications and Expert Systems]: Games.

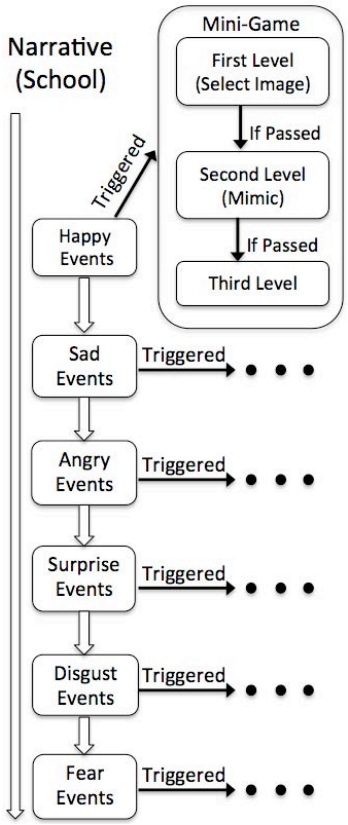

Figure 1: The structure of EmoStory: A child watches animation in narratives and then plays a set of mini-games based on what he/she has learned in the animation. The child unlocks the next section of the narrative by completing the tasks in the current mini-game.

Introduction

Children's social and emotional skills help them to develop respectful relationships and contribute to their success. Most children are able to identify basic emotions and facial expressions. However, children with Autism Spectrum Disorders (ASDs) lack such skills [6]. ASDs are neurodevelopmental conditions characterized by impairments in social communication and unusual restricted and repetitive behaviours [1]. Most children with ASDs have difficulties in emotional development, including understanding social contexts for emotions [11], recognizing and making facial expressions [2,6], and using words to express emotions [9].

Interventions may help children with ASDs to improve over time. Traditional interventions use paper-based tools such as cards to support children's emotional development. For example, many programs ask children to label facial expressions from formatted photographs [7]; sort emotional text cards under different coloured containers [3]; or use Social Story (i.e. short stories that assist individuals in interpreting and understanding social situations [11]) visual prompts to help children understand various social contexts for emotions. However, these approaches are resource-intensive because teachers have to craft these tools and provide intensive instructions for children [8].

Computer-based systems have also been developed to support children's emotional development. Compared to traditional programs, the computer-based approach is advantageous in the ways that (1) it is predictable (e.g. feedback), repetitive (e.g. rich resources), and free from stressful social demand (e.g. practice in a simulated social environment created by computers) which is favored by children with ASDs [5]; (2) it incorporates multimedia such as animation and game-based activities, which is engaging for younger children [5]; and (3) it offers an easy way to monitor children's learning performances and provide appropriate feedback, which can reduce the workload of teachers [7]. However, most computer-based systems have focused on teaching children to recognize facial expressions. For example, Robbie and Robot [16] and Emotion Faces [10] ask children to view a photo or watch a video, and then match it to a descriptive text (or vice versa). In this way, children may still have difficulties in making facial expressions themselves.

A few recent systems (CopyMe [7], Let's Face It! [14], and FaceSay™ [15]) have used facial expression recognition techniques. These systems ask children to complete tasks by mimicking a particular facial expression shown in an image [7,14] or a video [15]. However, these tasks do not fully incorporate social contexts, which are important for children to gain generalized knowledge about emotions. Moreover, these systems do not provide instructions to explicitly teach children how to make specific facial expressions.

In this paper, we present the design of EmoStory, a game-based interactive narrative system that supports children's emotional development, including learning six emotions and associated contexts and facial expressions. The core design features are: (1) the narrative approach that uses animation and emotional sounds to help children understand six emotions and the associated contexts and facial expressions; (2) the multilevel games embedded in the narrative that allow children to practice step-by-step; and (3) the real-time feedback based on facial expression recognition and visual cues that helps children make facial expressions.

Figure 2: The start interface of EmoStory: children can select the narrative (school, home or park) they want to play.

Figure 3: In the narrative for the school context, Robin is **happy** because he enjoys playing Legos with his friend Eric.

Figure 4: The design of our main character Robin's six facial expressions.

EmoStory

Learning goal

The main learning goal is to support children aged 5-8 years old to (1) learn six types of emotions including happiness, sadness, anger, surprise, disgust and fear, which were often used in previous interventions [4,5]; (2) understand three common social contexts that are familiar to children, including school, home, and the park; and (3) be able to recognize and express the emotions through facial expressions.

Design goals

We proposed three design goals: **(1) narratives**. Narratives are suggested to be central to the construction of social meanings [6] and are often used in interventions for children with ASDs (e.g. social story cards) [5,11]; We design narratives that incorporate visual and auditory contents to promote children's understanding of the relationship between social contexts and emotions; (2) **multi-level games**. We design multi-level games that gradually increase in difficulty to provide structured learning tasks. We also embedded the games into the narrative to encourage children to reflect the learned knowledge and then practice it; (3) **real-time feedback based on facial expression recognition**. We support children to practice facial expressions in various stimulated contexts by making the facial expressions. We also offer explicit visual cues if they fail.

EmoStory system

EmoStory runs on a tablet. A child watches the animation in narratives and then plays a set of mini-games based on what he/she has learned in the animation. The child unlocks the next section of the narrative by completing the tasks in the current mini-game (Figure 1). The child can use the system with teachers' supports. Regarding the interface, we used audio instructions and visual icons instead of texts.

Three context-based narratives

We had three narratives in total, and each tells a story about an 8-year-old boy named Robin (our main character) who experiences a series of events and emotions in a particular context, such as at the school, home or park (Figure 2). We intended to use multiple narratives to illustrate the relationship between emotions and contexts. We carefully chose social contexts in which semantic meaning and emotion can be easily understood by children. For example, "doing things that someone enjoys will make them happy". In this case, children may generalize the knowledge about emotions and use it in similar contexts.

First, the child needs to select the narrative (context) they want to watch, and then that narrative will start to play (Figure 2). Each narrative contains six animation sequences, each corresponding to one emotion. We used animation because it is favoured by children and may better draw their attention. The animation sequences were ordered based on the difficulty of facial expression recognition, starting from simple emotions to more difficult ones (happiness, sadness, anger, surprise, disgust, fear) [13].

We selected the events that most children are familiar with to try to reduce cultural influence. For example, in the narrative for the school context, Robin was **happy** because he enjoyed playing Legos with his friend Eric (Figure 3); However, during the play, he turned **sad** when he found he lost his favorite badge; Robin became **angry** when he thought that Eric took it away;

Figure 5: In the first level of the game, the child needs to select the image which corresponds to Robin's facial expression in the animation.

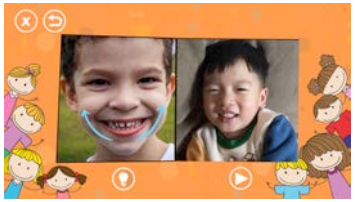

Figure 6: In the second level of the game, the child needs to mimic a child's facial expression from a photo. Blue animated arrows are provided to highlight the important facial movements.

Figure 7: In the third level of the game, the child needs to make the facial expression based on the extra story.

Then, Robin became **surprised** when he noticed that Eric had a similar badge with him; After he realized it was a misunderstanding, Robin decided to look for his badge at the lunch break. He quickly finished lunch because he was **disgusted** by the food offered; Robin then found his badge was taken away by a big dog. He was in **fear** of dogs so he could not take it back. At last, Eric helped him to take it back and they were both happy. We showed the context and emotion and highlighted facial expressions in animation.

Emotional sounds

We used emotional sounds to assist children's learning. While playing the animation. There are three types of sounds: a monologue describing the narrative, characters' voice, and sound effects. To create the emotional monologue and characters' voice, we invited professional voice actors for dubbing.

Various sound effects invoked different emotions. For example, one sound effect of bird may invoke happiness while the other may invoke fear. During the design of EmoStory, we utilized a soundscape emotion recognition system to pre-select the sound effects that match our target emotions [17]. Based on the pre-selected ones, a professional sound designer selected the most appropriate emotional sound effects for our animations. This method was more efficient when we had a large database of sound effects.

Mini-games: three levels of tasks

There are six mini-games during each narrative. Each game contains three levels of tasks. The first level checks whether or not the child is able to recognize the character's facial expression and match it to the associated emotion (Figure 5). Specifically, the system provides three facial expression images made by the character's (Robin's) faces according to the target emotions. Only one image correctly matches the emotion expressed in the current animation sequence. The child needs to click the image to select it. If the answer is correct, the game will jump to the second level. Otherwise, the game will play an instructional audio that suggests the child re-watch the animation and redo the task.

The second level focuses on teaching children to make facial expressions through mimicry. Concretely, it requires the child to mimic a child's facial expression from a photo (Figure 6). After the Start Button is pressed, the photo appears, the tablet camera starts recording the child's facial expression, and the facial expression recognition module constantly examines whether the child's response matches the target emotion. If so, the game enters the third level. If it fails to match within a certain duration (the default time is 20 seconds, which can be adjusted in the system), the system will display a Help Button that provides visual cues. The visual cues are animated arrows over the given photo that indicate the major facial movement features for making the target facial expression. For example, when making an angry facial expression, one usually has the eyebrows and lips pulled down; while making a happy face, one often has the cheeks and lips raised up. These cues emphasize facial details and explicitly teach children how to make facial expressions.

The third level aims to examine whether children can make the facial expressions in similar social contexts without assistance. First, the child watches the animation that plays an extra story. We define an extra story as a short animation sequence that shows a

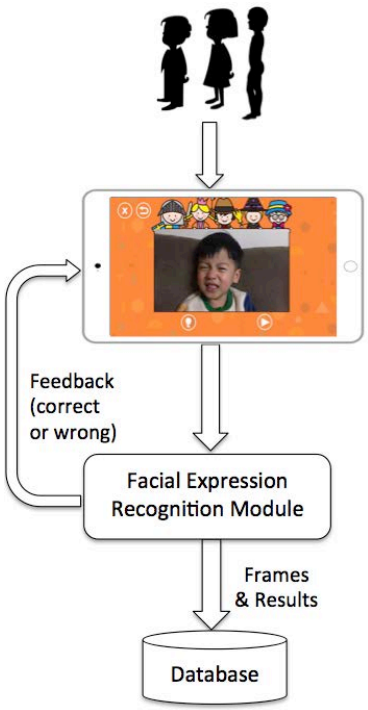

Figure 8: The structure of the real-time facial expression recognition module. It detects whether the child makes the correct facial expression and provides a feed to the system. The input video and the results are stored for analysis.

similar event at the same location. The extra story is used as an instruction. For example, in an extra story that describes happiness, Robin, who loves sports, played soccer with friends at school. Based on this video instruction, the child is then asked to make the correct facial expression (Figure 7). If the child correctly makes the facial expression within the given time, the system will play the next animation sequence. Otherwise, the child can either re-watch the animation or click the Help Button to see an image of the facial expression for reference (without visual cues this time). The system stores the recorded videos, which can only be accessed by teacher, parents and researchers of this project.

Technical solution

The system was designed on an Android platform and the animation was made by After Effects and Flash. The tablet camera takes input videos for facial expression recognition. All computational tasks such as frame processing and data storage are handled on the device. When facial expression recognition is needed, the system captures camera frames at a rate of 24 frames per second. Every captured frame will be analyzed by the facial expression recognition module. If three or more consecutive results indicate that the input facial expression matches the target emotion, it means the current task is completed. Our facial expression recognition module builds on a Convolutional Neural Network trained by the Child Affective Facial Expression Set [12]. The set contains 1200 photographs of over 100 children (ages 2-8) making our target expressions.

Discussion and Future Work

We present EmoStory, a game-based interactive narrative system that supports children's emotional development. Compared to the previous systems, our approach has four main advantages. First, our system used narratives to teach children various contexts that trigger a certain emotion and how to make facial expressions based on the contexts. We aim at using multiple narratives to help children learn the interrelated knowledge of contexts, emotions, and facial expressions, and help them transfer the learned knowledge to other similar social contexts. Second, we designed multi-level games to provide structured learning activities. We also integrated the games into narratives. The goal is to support children to reflect what they have learned. Third, we used the real-time facial expression recognition technique to evaluate children's inputs and provide feedback for children. We also provided animated arrows to highlight the key facial movement features for children who have difficulties in making the facial expressions. Fourth, we used multimedia including animation and emotional sounds to better draw children's attention and promote their learning experience. We used a soundscape emotion recognition system to do pre-selection which improved production efficiency. The animation approach also opens the design opportunity to leverage art elements to support children's learning. For example, designers may consider associating each emotion with a colour [3] or a character in the future.

Our next steps include conducting usability testing with children to refine the design and then administering user studies to validate its use with children with ASDs. Specifically, we will conduct case studies to explore whether EmoStory can improve children's abilities in recognizing and expressing facial expressions in various emotional contexts and whether the children can transfer the knowledge to real life. We will also analyze what features may or may not benefit their learning.

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