Building Virtual Environment for Feeding Scenario Simulation

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Abstract

Interactive virtual environments are becoming increasingly important in science, industry and the health field. In many cases watching a video or listening to sound speech is not enough for enhancing human's ability of learning and it is necessary to have a good medium in which to interact with the subject material. Understanding a child's response to food is a key part of effective feeding. Feeding problems in the community are often related to problematic caregiver-infant relationships and can cause anxiety in new parents. Therefore we direct our attention to observe the interaction between mother and child and to provide an effective immersive experience to introduce a novel solution for high-fidelity virtual environment for the interactive therapy; accompanied by several important attributes, which are aimed at stimulating the human senses such as vision and hearing, which may affect the quality of interaction during feeding. It is also very important to define what kind of realism is required by users in this kind of application.

Keywords: Virtual reality, intelligent decision support system, modeling, feeding difficulties, infant

1 Introduction

Feeding is a central issue in early childhood development. Infants double their weight in the first four months of life and triple it by the end of the first year. Feeding problems are common amongst infants and young children. The reported prevalence of feeding disorders is 5-10%. About 20-25% of parents report some feeding problems with their infants in the first two years and the most frequent problems are refusal of solid foods [2, 3]. There were 669,601 live births in England and Wales in 2006 [4]. Consequently up to approximately 167,400 of those young children will experience some form of feeding problem in their first two years of life [4].

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The most prevalent and severe feeding problems are refusal to eat, with only 14% of cases being linked to some form of physical disorder [5]. An obvious consequence of feeding problems in young children is failure to thrive, defined as having weight below the third percentile for population standards in normal birth-weight infants that has persisted for more than three months [1]. The prevalence of failure to thrive is 3-5% of the population in Western countries [6]. Feeding problems can occur at any time during infancy and later, especially with food, which makes high demands on oral motor skills [3]. Understanding a child's response to food is key part of effective feeding. Successful feeding is facilitated by careful exposure to different tastes and textures, providing the right environmental conditions for meal times, providing a positive interactive experience, encouraging infant and being involved in the same activity (eating together) [3, 7, 8].

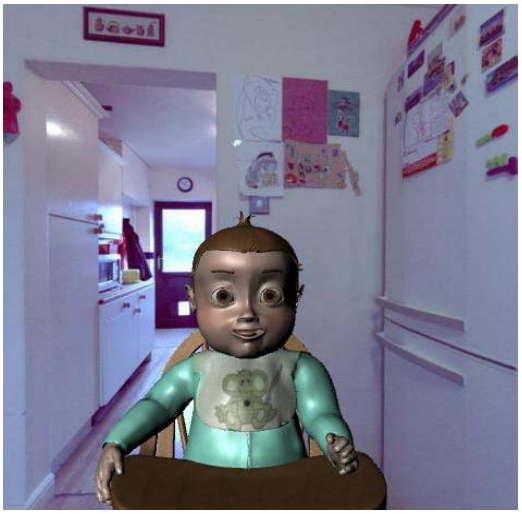

Figure 1. Virtual reality environment

Understanding parents' concerns is one of the key elements for health care visitors in developing effective recommendations around feeding. Health care is one of the areas that may benefit from new approaches such a Virtual Reality, because it presents accessible communication channel between patients and therapists. Furthermore Virtual Reality is in comparison to traditional communication technologies also an experience offering greater interactivity and its key characteristic is the sense of

presence [9]. One of the successful areas where VR systems have been used includes projects for treating patients with phobias and also for the treatment of pain during wound care using the immersive VR software Snow World [10]. It has also been used in the development and evaluation of embodied models of cognitive development such as in the construction of an embodied model of the emergence of gaze following in infant-caregiver interactions [11]. Our motivation for developing this project is to significantly improve a new parent's understanding and facilitate anticipatory feeding interaction. To this end we are developing a novel on-line Virtual Reality (VR) solution, see Figure 1. Our application is built on distributed platform, whose programmable nature means that code as well as data is distributed over a network, so it can be easily changed from stand alone application to online solution.

2 Background

Several VR systems build on clinical treatment models have been used as a form of exposure therapy with success to reduce a social phobia [12], acrophobia [13], fear of public speaking [14], post traumatic stress disorder [15], flying phobia [16], spider phobia [17], treatment of eating disorders [18]. The virtual environment used in the treatment reproduces situations, which need to be sufficiently similar to real world situations for successful patient exposure therapy. Virtual Reality allows for the successive approach to adverse stimuli in a safe and controllable environment. The treatment with VR therapy is more controlled and cost-effective and it allows therapists to create many and varied situations and environments for patients which are not life threatening for them [14]. With the help of therapists, the patients can also learn how to control and reduce their anxiety in the corresponding real situation. The virtual world thus provides a protected environment persuading the participants to be more willing to be treated by VR.

Virtual Reality - Cognitive Behaviour Therapy (VR-CBT) offers many advantages over traditional treatment for a number of disorders. It works by changing people's attitudes and their behaviour. It is strongly oriented to reduce the symptoms and the length of treatment and is often more effective than traditional forms of therapy. VR therapy is an experience, which has the ability to reduce the gap between real world and patient's imagination and thus overcome some of the difficulties in the traditional treatment of phobias. Virtual reality can be described as a technology or tool for influencing cognitive operations. The participant learns to consider different interpretations of a situation and learns to develop their own list of problem situations, which they discuss with the therapist and the therapist makes the decision on how to proceed next. Cognitive behavior therapy (CBT) focuses on our beliefs, thoughts and attitudes – the cognitive processes, their modifications and how they are related to our behaviour. [18].

All of the existing VR systems in previous projects have focused on the individual human subject. Common indicators in these projects are that the patient is confronted with the feared stimuli and allows the anxiety to attenuate gradually. The most important thing to solve is the treatment of the individual's disorder. Phobias are the products of anxiety. In contrast, not eating is a problem that can lead to severe physical and psychological consequences. This problem needs to be solved by altering and learning; it is not enough just to imagine some scenario dictated to the patient. The focus in infants is the interaction between caretaker and child, because the quality of the parent-infant interaction during feeding is central to food intake [19]. Considering every caregiver and child have different cognitive capabilities we need to help parents how to understand the child's perspective i.e. what it would feel like to be force-fed. We are developing a unique virtual environment for individual interactive therapy incorporating components of Cognitive Behavior Therapy, which is built on a range of parameters, such as the right environmental conditions for meal times, eating distractions, the right positioning during feeding, adoptive and social skills of the child, suggested by physicians and psychologists which enable parent's successful experience with our application. It is necessary to make this environment easy to use for the participant and to allow them by guided feedback to build their self-confidence. People often develop certain beliefs about themselves, other people and their world, for example they believe that their baby doesn't eat enough or is not able to feed itself and they force-feed the baby. The basic hypotheses of cognitive therapy are that people's emotions and behaviors are influenced by their perception of events. It is important to teach the user to identify, evaluate and modify his/her own thoughts.

Parents should be positive role models by eating a variety of healthy food, but they should not loose fun and play during the feeding with their child. Many parents try to keep their baby on an exact feeding schedule and are afraid when the baby is fed enough. Offering infants new food in a positive way and making eating a pleasurable experience again is the main focus of the anticipatory guidance [3]. Consequently, our project is aimed at prevention rather than treatment. Our aim is to help parents dealing with common problems and situations during the feeding of their child and prevent them from escalating into the sorts of problems that require clinical interventions; therefore providing caregivers with a set of different situations and particular suggestions of solutions along with the support to

be able to learn independently is very important. We are developing new technology and approaches to achieve this using a virtual baby and professional and skilled support, offered by intelligent decision support systems based on experts' knowledge.

2 Immersion and the role of realism

An interesting question for every creator of virtual environments is how important the role of realism in immersion perception is. What kind of input and output devices do we need for good immersion? What are the key elements of virtual reality?

One of the key elements of VR experience is interaction with the virtual world. The participant's interaction with the objects that surround him is important because of a better experience and a more realistic feeling from the virtual world. The interaction doesn't mean an action. The movement and actions of the participant's body are constrained and his experience is disembodied because his body doesn't actually move but the world moves in relation to his body [24]. Users can interact with a virtual environment and influence the virtual world through the use of standard input devices such as a keyboard and mouse, or advanced haptic systems such as a haptic glove. These devices set the stage for how the participant will interact with the system and how they will be able to affect the virtual world. It is not known which devices are critical for participants to achieve immersion in the virtual environment. That depends more on how they experience a presence in the environment and on the extent of interactivity; if the user feels engaged in the virtual environment. This kind of illusion contributes, for example, to the successful pain reduction observed in burn patients who go into VR during wound care [25].

It is difficult to avoid flaws in the extremely realistic environment, called There-Reality environments. There-Reality environments are those virtual environments which evoke the same perceptual response from a viewer as if they were actually present, or there, in the real scene being depicted [25]. While it is possible to compute highly accurate representations of real scenes, the computational requirements of such a full physically based solution are significant, currently precluding its computation on even a powerful modern PC in reasonable let alone real time. However, to provide a useful tool, there-reality environments need to be interactive. A key factor to consider if we are ever to achieve such "Realism in Real-Time" is that we are computing images for humans to look at. Although the human visual system is very good, it is by no means perfect. By understanding what the human does, or perhaps more importantly, does not see, enables us to save substantial computation effort without any loss of perceptual quality of the resultant image [26]. The researchers have found that displaying images close to the user's eyes helps give patients the illusion of presence and increasing the field of view of a VR display has also been shown to increase presence [25].

We decided to test several different input devices to find out which are the most suitable for our system. Classic gamepad controller, keyboard with mouse, Wii remote in combination with a Wii nunchuck and 3D space navigator with 6DOF have been used. It is important to determine ways to keep the application mechanic efficient and engaging but still only use simple controls. Most of the parents who have tried to navigate the model of the spoon to the cartoon baby's mouth in our application have not played games at all; the most common form of IO they have been exposed to is the standard keyboard and mouse. The system is aimed to be online and for wide range of people; therefore we also needed to consider what is affordable and comfortable for users. Joysticks usually correspond to spatial movement and/or directionality, and buttons correspond to actions the user can take. They tend to be fairly simple, limiting the user's actions to a few well-understood options (though complexity can increase with the number of buttons and context-sensitive buttons) [20]. They are efficient, because the user can rapidly learn to control objects in the application with the same muscle movements. Finally, such interfaces are familiar and comfortable after having been the game standard for so long. Joysticks and buttons are, because of their versatility and efficiency, being combined with other forms of input to give the user a more compelling and immersive experience [20]. All of used devices except the mouse and keyboard are likely to be successors to the conventional joystick.

3 EgoCentric VR Environment

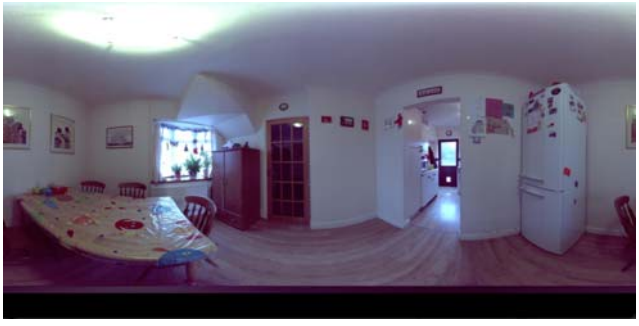

Figure 2. Latitude/Longitude mapping of the dining room environment

We are developing a virtual environment to help parents learn effective feeding methods. The environment is

designed to enable parents to set it up in their own way, for example by choosing a different room, changing the baby's model position and the angle of view. We are aiming to help users deal with the normal problems that many parents experience when feeding their children to prevent any feeding difficulties from escalating into the sorts of problems that require clinical intervention. We are introducing a solution based on Virtual EgoCentric Holistic Environments [27]. This is an alternative to the classical virtual environments used for cognitive behaviour therapy and it is built on acquired user based information. The high-fidelity system is accompanied with several important attributes, which will stimulate the human senses such as vision and hearing. An intensive study of these senses is leading us to answer an important question, what level of realism is required to provide an effective immersive experience for the end-users and how the realistic environment can contribute to successfully solving the feeding task.

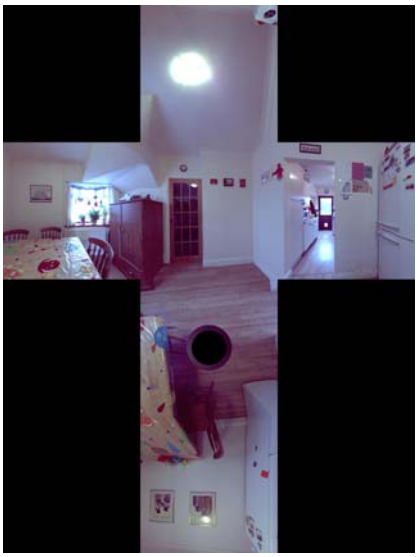

Figure 3. The cube map format of the dining room environment

A panoramic high dynamic range (HDR) picture of the dining room environment, see Figure 2, was captured by a Spheron VR camera and used to create the cube map, see Figure 3. This picture was converted into the jpeg format for faster loading by the application engine, as it is not really necessary to have the environment model encoded in HDR. This format is then wrapped up into a cube with the viewpoint placed at the centre to reconstruct the environment, which is important for realistic looking scenario. A major advantage of high dynamic range imaging is that its pixels values can cover the full range of light in a scene so the image can be used as source of illumination for computer-generated objects and scenes and we can accurately simulate how objects and environments would look like if they were illuminated by light from the real world [23]. The initial HDR picture was used to create a group of directional lights in the 3D scene using Median cut and to reproduce lighting in the room through this means.

4 Model of the baby

A key component in engaging the parents is the believability of the virtual infant. Despite the fact that they know that the baby in the application is not real it must not detract from their interest and level of interaction with it. The animated model needs to convince them to collaborate and learn something new in the process. Parents interact with their infants mainly through facial expressions, body language and gestures with emphasizing some emotions. Therefore they considered the positive feedback, like closing the baby's mouth, as the best part of the task during the testing.

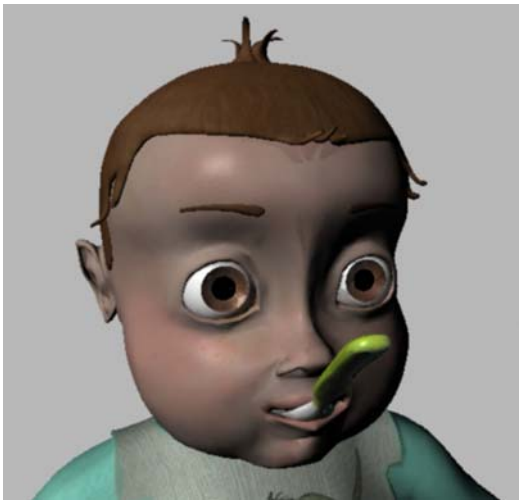

Figure 4. Cartoon baby model of 12 months old child

Creating an animated model of an infant in the age range 6-20 months, see Figure 4, is a time consuming task involving a huge amount of manual modelling work. The main problem with collecting data about movement during feeding is that it is practically impossible to use any motion capture systems because this would be a huge distraction to the infant possibly altering his/her behaviour. It would also present an ethical issue for this kind of recording.

Research on the newborns' perception of different tastes confirms that they, with no prior taste experience respond differently to taste stimuli [21]. The infants respond through facial expressions, which can be distinguished from one another using a Facial Action Coding System, adapted for infants. Previous work also provides evidence

that untrained adults cannot accurately decode newborns' facial expressions [22]. We recorded 18 videos (15 minutes long in average) of three infants at the age of 9, 11 and 13 months during lunchtime in the nursery for modelling purposes. All infants were found to be normal and healthy and the infants' parents provided written consent prior to filming. The data was collected in an open recording scenario in the room where four infants were fed at the same time by the nursery carers.

One of the important questions is how to animate the baby model to be realistic enough for parents' perception. A further consideration is if parents are able to recognize and understand facial expressions of the virtual baby. It is important to realise that we are dealing with realism from the viewpoint of human perception, so it cannot be objectively measured. The research on evaluating the perceptual realism of animated facial expressions address the question of perceptual realism by asking how well computer-animated facial expressions can be recognized and which animation parameters affect the chosen perceptual measures [21].

5 Conclusions

Some of the future scientific potentials of Virtual Reality are still being explored, but it is already a great medium, which offers interaction with models in three spatial dimensions and gives us feedback from actions without noticeable pause [24]. It also gives users the ability to manipulate the sense of time and space and to change a degree of interactivity, so they can impact the narrative flow of the experience.

Communication between a mother and her infant should be warm and relaxed. The development of normal feeding behaviour is influenced by the relationship between the infant and the caregiver, therefore it is very important how the offered nutrition is presented to the child, how it is accepted by child and what the caregiver's reaction is to the offering being accepted [19]. Our application is a great opportunity for parents to better understand their children and to sense different infant's behavioural response during the feeding.

6 Future work

Currently, we are in the process of a case study, where the main objective is to provide insight into the process of virtual environment development. We proposed a phased approach to the pilot study that begun with collecting of all data connected with infants' eating behaviour during the lunchtime meal, right environmental conditions for meal times, eating distractions, the right positioning during feeding, adaptive and social skills of the child. As a next phase, the evaluation of input devices usability has been done and the first stage of intelligent decision support system (IDSS) has been prepared for the evaluation in the third phase. IDSS simulates the behaviour of an infant during feeding. It contains a knowledge base about the infant's ingestive behaviour and a set of rules on how to apply this knowledge to different situations, which are required from the VR system by the participant. This system needs to be as real as possible to be able to distinguish whether or not the participant's solution has a chance of success. IDS may also act as an intelligent tutor by letting the user run sample examples and explaining the system's reasoning while executing so that it is understandable to the user.

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