AR Based Environment for Exposure Therapy to Mottephobia

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Abstract. Mottephobia is an anxiety disorder revolving around an extreme, persistent and irrational fear of moths and butterflies leading sufferers to panic attacks. This study presents an ARET (Augmented Reality Exposure Therapy) environment aimed to reduce mottephobia symptoms by progressive desensitization. The architecture described is designed to provide a greater and deeper level of interaction between the sufferer and the object of its fears. To this aim the system exploits an inertial ultrasonic-based tracking system to capture the user's head and wrists positions/orientations within the virtual therapy room, while a couple of instrumented gloves capture fingers' motion. A parametric moth behavioral engine allows the expert monitoring the therapy session to control many aspects of the virtual insects augmenting the real scene as well as their interaction with the sufferer.

Keywords: Augmented reality, exposure therapy, mottephobia.

1 Introduction

Mottephobia is the term used to describe the intense fear of moths and more in general of butterflies. According to psychologists'' classification of phobias, which distinguish between agoraphobia, social phobia and specific phobia, mottephobia falls within the last category and represents an animal phobia, an anxiety disorder which is not uncommon though not so well-known as arachnophobia. In severe cases, panic attacks are triggered in mottephobia sufferers if they simply view a picture or even think of a moth. Consequently, many of these persons will completely avoid situations where butterflies or moths may be present. If they see one, they often follow it with close scrutiny as to make sure it does not come anywhere near them.

Sometimes the fear is caused by a split second of panic during exposure to the animal. This wires the brain to respond similarly to future stimuli with symptoms such as fast heartbeat, sweating, dry mouth and elevated stress and anxiety levels. In general, the most common treatment for phobias is exposure therapy, or systematic desensitization. This involves gradually being exposed to the phobic object or situation in a safe and controlled way. For example, a mottephobic subject might start out by looking at cartoon drawings of butterflies. When they reach a point where the images no longer trigger the phobic response, they may move on to photographs, and

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so on. Therapy is a slow process, but can have lasting effects. In the last decade the systematic desensitization treatment has been approached by means of virtual reality based environments and more recently by augmented reality techniques where in-vivo exposure is difficult to manage. In this case the contact between the sufferer and the source of its fear is performed via a virtual replica of it which can be visualized on a screen or through an head-up display and may even enable a simulated interaction.

This study presents a novel augmented reality based environment for exposure therapy to mottephobia. The final goal is to match the emotional impact experimented during the exposure to real moths while providing therapists a level of control of virtual moths' behavior which would be impossible in-vivo.

The rest of this paper is organized as follow. Related works and their comparison with the proposed approach are presented in section 2., while the system's architecture is described in detail in section 3. The experiments conducted and their results are presented in section 4., while conclusions are drawn in section 5.

2 Related Works and Proposed Approach

In the last decade the systematic desensitization treatment has been approached by means of virtual reality based environments and more recently by augmented reality techniques where in-vivo exposure is difficult to manage. Virtual Reality based Exposure Therapy (VRET) has proved to be an effective strategy for phobias treatment since the original study by Carlin and al. in 1997 [1] which first reported about the efficacy of a virtual exposure to spiders opening the way to other researches in this line [2, 3]. More recently augmented reality has also been proposed to allow the sufferer to see the real environment around him/her instead that a virtual one while displaying the virtual contents co-registered to the user's field of view as they were really present there, possibly resulting in more convincing stimula for the therapy (ARET). This objective has been approached by means of (visible and invisible) marker based techniques [4, 5] using both video-based and optical-based see-through head mounted display [6]. The aforementioned marker-based approach involves some limitations: from one side the operative volume is restricted to a fraction of the environment (typically the desktop where the marker is located) possibly limiting the user's head movement to not lose the marker and therefore the co-registration between real and virtual. On the other side the choice of marker's location (either visible or not) is limited by lighting and orientation constraints related to pattern detection/recognition issues which may reduce the range of the experience.

This design may be still valid when interacting with not-flying creatures (like spiders or cockroaches) especially considering the low cost of the optical tracking, but it is very limiting when simulating flying insects' behavior which involves much larger spaces. Furthermore, in most proposals the virtual insects do not react to user's hands actions, i.e. they perform their pre-built animation(s) independently from where exactly hands and fingers are, eventually reacting only to actions like pressing a key to crush the insects.

In this paper, the mottephobia ARET environment proposed addresses the aforementioned limitations exploiting a head/wrists inertial tracking system, instrumented gloves and a parametric moth behavior approach to enable a greater and deeper level of interaction between the sufferer and the object of its fears.

3 System's Architecture

The overall system's architecture is schematically depicted in Fig. 1. The main components are the Moth Behavioral Engine which controls both the appearance and the dynamic behavior of the virtual moths represented in the dedicated 3D Dataset throughout the simulation, the Interaction Engine managing the sufferer-moths interaction exploiting hands gesture capture and wrists tracking, and the AR Engine in charge of scene augmentation (based on head tracking) and stereoscopic rendering via the see-through head mounted display which also provides audio stimula generated on a positional basis.

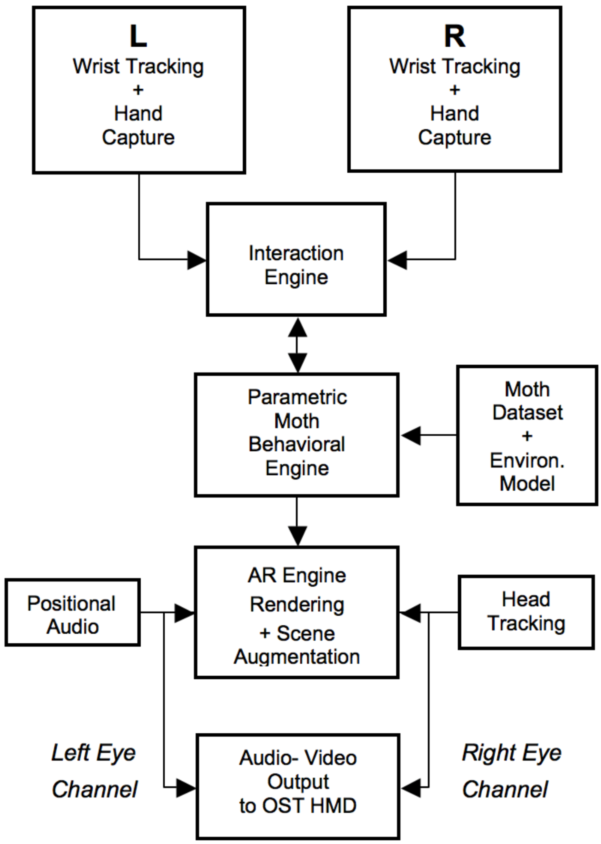

Fig. 1. Schematic view of the proposed system

As the main objective was a believable hand-moth interaction, wireless instrumented gloves and ultrasonic tracking devices have been used. An instrumented glove, indeed, enables a reliable gesture capture as each single finger has individual sensors which are unaffected by any other fingers.

In this case, left and right hand gesture acquisition is performed via a couple of wireless 5DT Dataglove 14 ultra, featuring fourteen channels for finger flexion and abduction measurement, with 12 bit of sampling resolution each. As datagloves do not provide any spatial information, the system relies on an inertial ultrasonic-based tracking system (Intersense IS 900 VET) with six degrees-of-freedom, to detect head and wrists position in 3D space and their rotation on yaw, pitch and roll axis. Among the advantages of this setup there is the wide capture volume (respect to video based solutions requiring the user to be positioned in a precise spot within camera field of view), an accuracy in the range of millimeters for distance measurements and of tenths of degree for angular measurements and a high sampling rate suited to accurately capture fast movements. A preprocessing applied to each of six channels (for each hand) filters capture noise by means of a high frequency cut and a temporal average of sampled values. Left and right hands data streams are outputted to the Interaction Engine, while head tracking is sent to the AR Engine for virtual-to-real co-registration.

The Moth Behavioral Engine allows the therapist to control many parameters of the simulated exposure (see Fig. 2). Both behavioral and interaction parameters can be adjusted interactively during the exposure session, allowing the therapist to modify the simulation on-the-fly, if required. These parameters include the "*number*", the "*size*", the maximum amount of "*size variation*" (with respect to a pseudo-random distribution) and the type of flying creatures to be visualized among those available in a previously built 3D dataset.

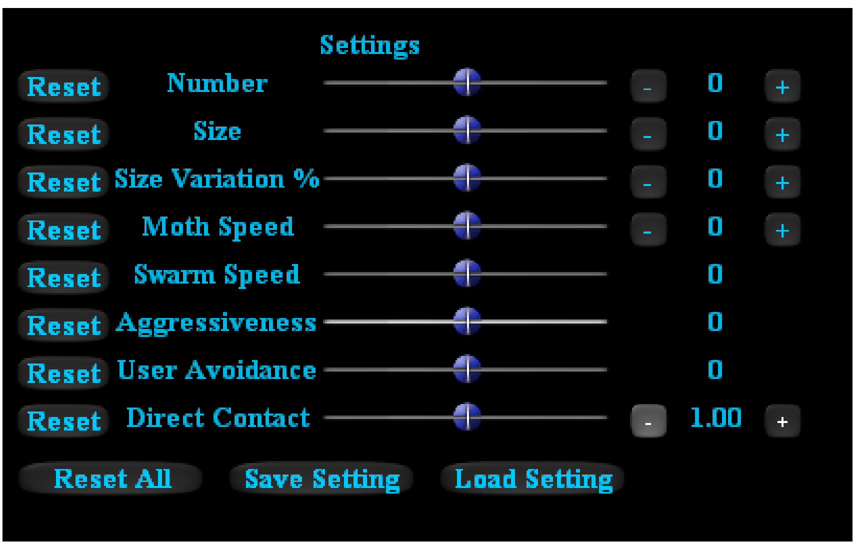

Fig. 2. The GUI screen including the main simulation parameters

Actually, this engine is based on a parametric particle system which controls the virtual moths as instances of a reference geometry (a polygonal model). The dynamic of the particles (i.e. the moths motion) is controlled at two different levels: the particle level and the swarm level. At the particle level the motion of the single moth is controlled through a seamlessly loopable spline based animation defining the particular flying pattern. The "*moth speed*" parameter multiplied for a random variation value affects the time required to complete the pattern. At the swarm level the motion of the whole swarm is controlled through an emitter and a target which can be interactively selected among predefined locations in the 3D model of the virtual therapy environment. More than one swarm may be active at the same time allowing the moths to originate from different locations and thus providing a less repetitive and more unexpected experience. The "*swarm speed*" parameter affects the time required to complete the emitter-target path. Other two swarm level parameters, namely "*aggressiveness*" and "*user avoidance*" respectively affect the swarm dynamic behavior by attracting the swarm path towards the sufferer position and by defining the radius of the sufferer centered sphere in which the moths cannot enter.

The Interaction Engine, exploits the user's tracking data to enable realistic hand-moth interaction. Indeed, not only the approximate hand location, but also each finger's position can be computed based on the wrists tracking and forward kinematics applied to the flexion/abduction data captured by the instrumented gloves. By this design, as the user shake the hands the butterflies may react avoiding the collision and flying away according to their motion pattern, while in a more advanced stage of the therapy a direct contact with the insects is possible by allowing the insect to settle on the hand surface. To this regard, it has to be remarked that for the first interaction modality the instrumented gloves could be omitted (thus reducing the hardware required and the equipment to be worn), while for the other two "direct-contact" modalities they are strictly necessary. During "direct-contact", one or more virtual insects (according to the "*direct contact*" parameter) may settle on each hand in spots randomly selected among a pre-defined set of swarm targets (e. g. the palm, or the index finger or the back of the hand). Again, the purpose of this randomness is to prevent the sufferer to expect a contact happening always in the same way.

The 3D dataset contains medium to low detail polygonal models of moth/butterflies, realistically textured and animated. These models are transformed and rendered by the visualization engine, also responsible for AR related real time transformations and for the stereo rendering of 3D content. The engine is built on the DirectX based Quest3D graphics toolkit (see Fig. 3), which enables dynamic simulation by means of the Newton Dynamics API or even via the Open Dynamics Engine (OpenDE, a.k.a. ODE) open-source library. To generate the AR experience, the visualization engine exploits user's head position and orientation to transform the virtual content as seen from user's point of view and coherently to a 3D model of surrounding environment, a crucial task referred as 3D registration. Any AR environment requires a precise registration of real and virtual objects, i.e. the objects in the real and virtual world must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised. Therefore at runtime two rendering cameras (one for each eye) are built, matching the exact position/orientation of user's eyes, transforming each vertex of each virtual object to be displayed onto the real scene accordingly.

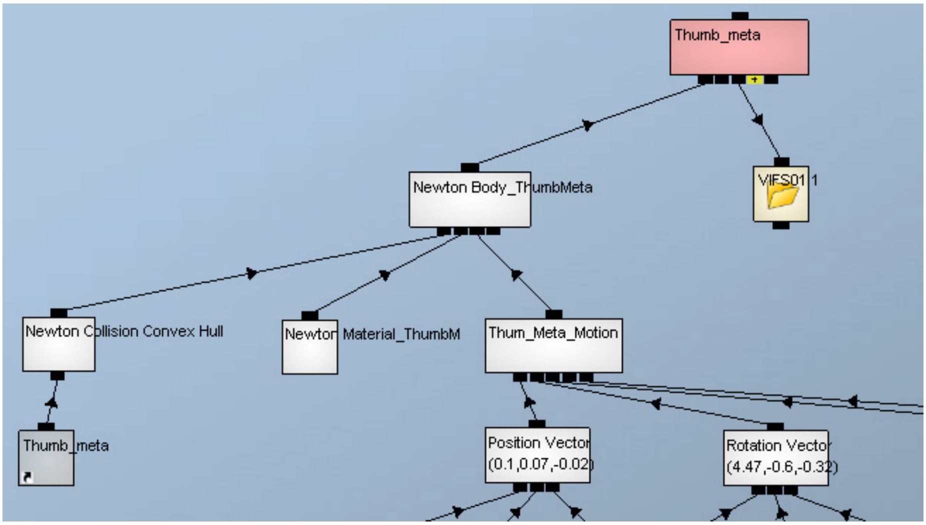

Fig. 3. A fragment of Quest3D graph-based programming environment for finger-moth collision detection

Two renderings (left and right) are then calculated and coherently displayed through an optical see-through Head Mounted Display, which works by placing optical combiners in front of the user's eyes (see Fig. 4). These combiners are partially transmissive, so that the user can look directly through them to see the real world. The combiners are also partially reflective, so that the user sees virtual images bounced off the combiners from head-mounted LCD monitors. The rendering engine has been tailored to optical see-through HMD, but it could be adapted to video see-through displays. Eventually, a selective culling of a virtual object may be performed whereas it is partially or totally behind a real object, but in many cases this technique (and the overhead required to accurately model the real environment) could not be necessary.

To further stimulate the user’s emotional reactions, audio samples mimicking the sound of moths’ flapping wings diffused through the headphones integrated in the HMD, are exploited to amplify the sensation of presence of the virtual insects according to their size, number and distance from the sufferer. The flapping wings audio-samples are short looping samples whose duration is in sync with the actual flapping animation cycle to achieve an audio-visual coherence.

4 Experiments

We are still in the process of performing a quantitative study to measure the response of mottephobia sufferers to this approach to exposure therapy. So far, we have carried out some preliminary qualitative evaluations on the system described above, to gather first impressions about its potential efficacy from experts in exposure therapy and from their patients. These experiments involved five mottephobiac subjects showing various levels of symptoms’ seriousness and three exposure therapy specialists. The test bed hardware included a dual quad-core Intel Xeon workstation equipped with an Nvidia Quadro 5600 graphics board with 1,5 Gigabytes of VRAM in the role of simulation server and control interface. The HMD adopted is a Cybermind Visette Pro with see-through option. The virtual therapy room has a surface of about 40 mq of which 15 mq fall within the capture volume of the tracking system, providing a reasonable space for moving around and interacting (see Fig. 5).

Each of the 5 participants has been exposed to moth/butterflies augmenting the real scene during the course of 8 ARET sessions featuring a progressively closer level of interaction, while the experts were invited to control the simulation's parameters after a brief training. After each session the participant have been asked to answer to a questionnaire developed to measure six subjective aspects of the simulated experience by assigning a vote in the integer range 1-10 (the higher the better) to: *(A) Realism of Simulated Experience; (B) Visual Realism of Virtual Moths; (C) Realism of Moth Behavior; (D) Realism of Hand-Moth Interaction; (E) Emotional Impact of Audio Stimula; (F) Maximum Fear Level Experimented.* Additionally, the therapists were asked to provide feedback on two qualitative aspects of the ARET control interface: *(G) Accuracy of Control; (H) Range of Control.* As shown in Table 1, while the evaluations provided are subjective and the number of users involved in these first trials is very small, the overall results seem to confirm that many of the factors triggering the panic attacks in mottephobiac subjects, like the sudden appearance of insects from behind or above, the moths' erratic flying patterns, the sound of flapping wings or simply the insects' visual aspect, are credibly reproduced by the proposed AR environment.

Fig. 4. See-Through HMD, datagloves and head/wrists wireless trackers worn during testing

Table 1. A resume of the scores provided by the users of the ARET system proposed

Features	Min.	Avg.	Max.
(A) Realism of Simulated Experience	7	7.9	9
(B) Visual Realism of Virtual Moths	8	9.1	10
(C) Realism of Moth Behavior	6	6.8	8
(D) Realism of Hand-Moth Interaction	6	7.5	9
(E) Emotional Impact of Audio Stimula	8	8.2	9
(F) Maximum Fear Level Experimented	8	8.8	10
(G) Accuracy of Control	7	7.5	8
(H) Range of Control	8	9.0	10

Fig. 5. The room for virtual exposure therapy, augmented with interacting butterflies

On the other side the exposure therapy experts involved were favourably impressed by the level of control of the virtual simulation available.

However, only a quantitative analysis conducted on a much wider number of subjects may objectively assess the efficacy of this ARET environment. To this regard, the evaluation we are carrying out is based on a modified version of the “fear of spider” questionnaire originally proposed by Szymanski and O’ Donoghue [7] as, to our best knowledge, there is no specific work of this kind for mottephobia.

5 Conclusions

In this paper, we presented an AR based environment for exposure therapy of mottephobia. The proposed architecture exploits inertial tracking system, instrumented gloves and parametric behavioral/interaction engines to provide the user a more believable and emotionally involving interaction experience, improving at the same time the range and the accuracy of the user-system interaction during the usage. To this aim, we performed a first qualitative evaluation inolving ET experts and a group of mottephobia sufferers asked to respond to a questionnaire. So far the first qualitative reports confirm the potential of the proposed system for mottephobia treatment, while, according to the therapists involved, other kind of anxiety disorders could be favorably treated as well.

We are currently working on completing the aforementioned quantitative study to assess the system's effectiveness in reducing mottephobia symptoms as well as to compare this proposal with both marker-based ARET and VRET approaches. As currently the system is able to display only one type of moth/butterfly for a single session, we are also working to remove this limitation. Additionally we are developing a new version of the AR engine specific for video see-through HMDs.

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