Virtual reality research, applications and prospect in psychotherapy

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Abstract—Virtual reality is widely used in psychotherapy in recent years and has got good effects. This paper introduces current situation of virtual reality applications in psychotherapy, such as anxiety disorder, autism, brain injury and mentally retarded. We do analysis about the existing constraints and weakness and summarize the characters and prospect of virtual reality as an effective tool for assisting psychotherapy.

Keywords—virtual reality (VR), psychotherapy, disorders

I. INTRODUCTION

A. What is virtual reality

In 1965, Sutherland put forward of Virtual Reality system [1], which was called “The Ultimate Display”. In the year 1989, American Jarn Lanier formally proposed “Virtual Reality” [2]. Virtual reality firstly was defined as a simulation technology based on graphics system. It refers to the comprehensive utilization of computer systems and a variety of display and control interface devices, generated on the computer three-dimensional sense of immersive environment technology available. Among them, the computer-generated three-dimensional interactive environment is called virtual environment.

Naturally, it is easy to understand virtual reality from the definitions for both “virtual” and “reality”. There are three implications for virtual:

- a. Being in fact, acting as what we experience as human beings;
- b. Something assumed and imagined, which does not or not always correspond with facts;
- c. Hidden, possible [3]. So “virtual reality” basically means “near-reality”. Of course, this could mean anything but it usually refers to a specific type of reality emulation.

Everything that we know about the real world comes from the way of our senses. In other words, our entire experience of reality is simply a combination of sensory information and our brain sense-making mechanism for that information. If you can present your senses with made-up information, your sensation of real world would also change to response it. You would be provided with a version of reality that does not really exist, but from your point of view it would be perceived as real. Something we would call as virtual reality.

Build a virtual scene, the user can enter the environment and manipulate objects in the system. It allows users to have the same sensation in this virtual scene as in reality, such as in vision, hearing, smell, taste, touch and other aspects feeling. All people can feel reality in virtual reality. People use the brain to imagine a fictional world beyond reality and can also be perceived in the form of feeling in the virtual environment, and both with no difference. Thus, “virtual reality” includes the meaning of the following three aspects:

- a. Virtual reality is a computer graphics-based, multi-view, real-time dynamic three-dimensional environment that can be reproduced real world. It can be realistic fictional world beyond;
- b. You can use the person's vision, hearing, touch and other senses, directly to the people's way of thinking skills and natural environment interact with the investment;
- c. During the operation, the people in the form of a real-time data sources immersed in the virtual environment of actors, rather than just an observer outside the window.

In summary, the term virtual reality entails presenting our senses with a computer generating virtual environment that we can explore and operate through some interaction methods and extra complex data [4].

B. What is Psychotherapy

Psychotherapy is one of the most important elements of clinical psychology. Psychotherapy relies on the basis of good treatment relationship and professionally trained psychologists applying psychological theories and techniques. It helps patients with mental disorders in the process, aims at eliminating or alleviating the patients’ mental disorder or problems and promoting their personality in the direction of health and coordinated development [5].

Psychotherapy originated from Freud’s (S. Freud) analysis of spirit in the late 19th century. He published book named “The Interpretation of Dreams” in 1990, which becomes a sign of the creation of psychoanalysis and also the beginning of psychotherapy [6].

Use of computers and networks intervening psychotherapy is a prominent trend in recent years. Such as in several European therapists jointly conducted network psychotherapy
to social anxiety disorder patients [7]. They use the computer technology to help patients with self-cognitive behavioral therapy to get rid of the symptoms of distress, which produces good results.

C. Virtual reality in psychotherapy

Psychotherapy, in broad terms, refers to having slowed or therapeutic effect on any technique and measures on mental, emotional or behavioral disorders. In 1990, psychologist Tart predicted virtual reality “is development and supplement of existing diagnosis, psychotherapy and training techniques”. Since 1993, virtual reality technology (VR) is applied to the field of psychological therapy [8], creating a new situation for the development of psychotherapy techniques. Virtual reality rely on some special equipment, such as helmet mounted display, glasses graphics, data services, data gloves, stereo headphones, tracking systems, three-dimensional space-based sensors and other new man-machine interfaces, using computer technology to generate a realistic (including vision, hearing and tactile feeling) virtual reality world. Users can interact with the virtual environment by sensors and change the virtual environment in accordance with their wishes. Its feeling and actions are the same with the real world. In VR technology, users are not only involved in environment by visual and thinking, but in a more complete individual organism. In this process, the various individual activities, such as virtual, hearing and touch perception, joy tension and fear emotional reactions, will be fully expressed. Compared with traditional analog technology, VR technology has more realistic, more natural interaction and more vivid visual imagination [9].

VR technology has been used in psychotherapy for more than ten years, making fruitful results on the treatment of phobias, PTSD, attention deficit hyperactivity disorder, schizophrenia, anorexia, pain relief [10]. For example, in the diagnosis of attention deficit hyperactivity disorder, VR technology can control a series of noise in the virtual classroom as interference stimulation to effectively distinguish children with attention deficit. In the treatment of schizophrenia, VR technology is used to simulate the illusion appearing daily. Helping patients to understand that hallucinations are purely sick and the need of specialized treatment [11].

Recently, the result of prediction to future treatment technology from 62 western psychotherapists showed that; in the 38 kinds of treatment techniques used currently, VR technology (ranked third) and computer-assisted therapy (ranked fifth) will increase and become the most important psychological therapies in the next decade. At the same time, experts predicted the use of some traditional techniques, such as hypnosis (No.32), paradoxical intervention (No.33) and interpretation of dream (No.35) will dramatically reduce [12].

II. APPLICATION AND ACHIEVEMENT

At present, virtual reality has been used in anxiety disorders, autism therapy, post-traumatic stress disorder and other psychological disorders.

A. Anxiety disorder

Virtual reality was firstly used in the treatment of anxiety disorders. Treatment focuses on acrophobia, flight terror, claustrophobia and agoraphobia and so on.

In 1993, Hodges and others, based on Solution-Focused Brief Therapy (SFBT), conducted a series of studies about phobia treatment using virtual reality in Atlanta and Georgia. They simulated several environments: taking the elevator upward, walking through the pedestrian bridge, looking out from the balcony, standing on the roof. Experiment design was simple and tested with students. There was no control group, but the effect was very good [13]. Lamson and Meisner designed that 30 subjects were placed in stimulated high altitude. After more than two years treatment, 90% of the subjects dared to take glass elevator [14].

These positive findings attracted many researchers to use virtual reality on psychotherapy and a large number of tightly controlled experiments. Rothbaum designed experiment strictly, he invited 20 acrophobia patients as subjects and randomly divided them into virtual reality group and control group for a seven-week treatment. The result showed that, compared with the control group, the virtual reality group tested on anxiety, avoidance, depression and other aspects symptoms were significantly reduced. And kept a more positive view of height [15]. This experiment proved firstly that virtual reality therapy can change a person’s behavior in the real world. Emmelkamp compared virtual reality exposure therapy and reality exposure. And found that the therapeutic effect of the two methods was basically same, but the attitude to height of the virtual reality group was better [16]. Apart from this, compared with the reality exposure therapy, virtual reality exposure therapy more ensured patient privacy. Patients and therapists do not exposing in the environment that might cause patient unrest. It can be started at any time the patient require and stopped when patients feel unwell. The treatment is safe and more flexible. Because the same situation can be produced repeatedly, it is more economical.

![Fig. 1. Application in Acrophobia](image-url)
B. Treatment of autism

In 2005, a study found (Moore, David, 2005) that collaborative virtual reality environment for the adjuvant treatment of autism had great prospects. This study explored whether the autistic children and adolescents could understand the human expression in virtual environment. Before the experiment, 34 subjects (age from 7 to 16 years old) were tested through a computer program and had autism performance on understanding facial expressions. It was found that more than 90% of the subjects were able to accurately identify the human expression in virtual reality environment. This finding confirmed that collaborative virtual reality environment can fixes potential damage from “theory of mind”, and can be effectively used in autism adjuvant therapy [17].

Fig. 2. Virtual-reality training program for those who have autism

Fig. 3. Brain regions associated with social understanding changes

After the VR training, teenagers with autism presented increased activation in brain regions related with social understanding.

C. Brain injury cognitive assessment and rehabilitation

Rose, Brooks and Rizzo discussed using VR technology on the cognitive assessment and rehabilitation. The prospect of VR in the field of rehabilitation that they pointed out had been clearly established. For example, amnesia is a common sequela of stroke patient and is very difficult to treat and evaluation. Brooks created a virtual reality environment and made progress in the experimental study of expected memory recovery and evaluation [18]. Another study illustrated that neurological memory disorder could also recover by virtual reality technology. Gabriele used VR on memory-related cognitive rehabilitation training [19].

Fig. 4. Brain regions associated with social understanding changes

D. Post-traumatic stress disorder

Post-traumatic stress disorder is prolonged reaction to threatening or catastrophic events or situations. It is a diffuse pain. Incidents or situation are natural disasters, wars, serious accident, witness of tragic death of others, suffering torture, victim of terrorist or other criminal activities. It is very difficult to reproduce the situation and atmosphere when patients are treated with exposure therapy. But in virtual reality, you can easily do it. Rothebaum healed a Vietnam veteran with virtual reality therapy [20].

After the “9.11”, post-traumatic stress disorder treatment attracted widespread attention. Difede and Hoffman used virtual reality to reproduce the scene of the explosion of the World Trade Center for study [21]. The patient was in a virtual explosion site again: variety of realistic sounds, virtual people jumping out of burning building, the building collapsing, smoke. The patients was successfully treated.

III. FEATURES AND PROSPECT

Compared with conventional psychotherapy, virtual reality has the following characteristics:

A. Break through the limitation of conventional psychotherapy techniques

Conventional psychotherapy techniques have been carried out in the real world, to treat patients through guiding memories, imagination methods. Virtual reality across the limits of time and space. Some irreversible things that has happened, such as war, disaster, can be re-presented in front of the patients. Patients can intuitively, vividly feel and respond to the virtual environment, so the purpose of treatment achieves.

B. Sense of immersion

The biggest feature of virtual reality is that it allows users to have a strong immersive feeling, which often make users forget they doing the test. So behavior to be assessed is in a “natural state” facilitating in-depth study of individual typical
behavior. In traditional therapy, patients may conceal many problems due to stress, worrying about leaks and other factors, leading the treatment to a certain degree of difficulty. But in virtual reality, patients may unwittingly demonstrate all problems. In addition, virtual reality is designed with specific environment or circumstances. Users will not feel monotonous, thereby enhancing the users' level of participation.

C. Controllable and personalized training environment

Virtual reality can flexibly change for factors number, speed and stimulus presentation order according to the specific needs of clinical and research. Stimulation can be divided into different levels (from simple to complex) and repeatedly present according to difficulty and challenge. Treatment can also be timely adjusted according to the patients’ response variable changes. Virtual reality creates a “personal” training environment. Treatment may be at home or in the office. Based on the patients’ actual situation and the degree of mental disorder designs a virtual environment. According to the users’ degree of injury (movement, hearing, visual and other obstacles), VR can design method of present feeling and select the appropriate response equipment to ensure the effectiveness of treatment. The virtual reality treatment, on the basis of the assessment and training seminars, or other needs, can stop at any time and offer on-site feedback in different forms.

D. Strong safety

Virtual reality can create a new secure environment and is completely different from the consulting room environment that patients are protected. It also differs from the realities bringing patient to feel threatened. VR can simulate very dangerous or challenging situation and provide a safe learning environment. In a virtual environment, the users can increase learning and self-awareness ability by experience the error and reduce the damage caused by mistake. VR can constantly changes scene, various difficulties, mistakes, unpredictable events and dramatic results. Users have opportunities to repeat practice, but “in fact” will not suffer any harm. Patients feel safe in the virtual environment. Coupled with the therapists support, patients can experience and explore bravely.

E. Prospect

In virtual reality, “virtual” and “reality” are combined with unconventional way: on the one hand, human create and change the virtual environment; on the other hand, the virtual world has a profound impact on human’s way of accessing to information and reconstructing the objective world model. In psychotherapy, although virtual reality is virtual, it gives human the real experience. With the development of virtual reality technology, the gap between “artificial experience” and real-life experience differences will increasingly become smaller. Artificial experience gotten from virtual reality is entirely comparable to that gained in real life and can be migrated to the reality, so as to achieve the desired therapeutic effect. In addition to the above applications, virtual reality is also used to treat nicotine addiction and alcohol addiction. Experts have come to realize the unique role of virtual reality and try to use it for the treatment of various mental disorders.

In addition, not only used in psychotherapy particularly, for the feature of immersion and the function of pain relief, virtual reality can also contribute to adjuvant therapy, such as chemotherapy. It is expected that application of virtual reality in psychotherapy will be more extensive.

IV. CONSTRAINTS

Although virtual reality has incomparable advantages than other psychotherapeutic techniques, there are still some difficulties in wide range of application. The first problem is technological. HMD, graphic glasses, data services, data gloves, stereo headphones, tracking system, three-dimensional sensor technologies need to be enhanced and improved. And the second one is software design. The current software design is relatively simple and provide less but expensive virtual environment. Finally the ability that therapists use virtual reality technology is also important. In therapy, the virtual scene should always be adjusted according to the situation of the patient. The therapist must have the appropriate computer operations and design capabilities.

Dutch psychologist Paul believes that the development of VR technology is limited by both parties and therapist. From the perspective of the parties, certain personal characteristics limit the generation of telepresence, such as the need of the parties involved in passive tendency, concentration and suggestibility. From the perspective of therapist, traditional psychological counseling emphasizing on doctor-patient relationship and computer operation and design capabilities that VR requiring will restrict the popularity of VR technology. He predicted, there will be a lot of specialized agencies and services providing VR technology psychological treatment for years. But does not reach all the psychological clinic [29].

Italian psychologist Luciano believes that cultural differences of virtual reality psychotherapy should be paid attention to. Some of the nonverbal cues in virtual environment will cause other cultures misunderstanding [30]. Italian clinical psychologist G. Riva believes that currently the equipment and software of VR technology lack of standardization, treatment contract lack of standards, software design is relatively simple and virtual environment is less and research costs high. These factors will restrict the development of VR technology.

Virtual reality is still in its infancy and needs further improvement. Despite many studies have shown that it has a good effect in psychotherapy, but there is a big gap from existing technologies to human’s objectives.

V. CONCLUSIONS

In summary, compared with the conventional psychotherapy, as a new therapeutic techniques, VR technology overcomes the limitations of conventional psychotherapy techniques, has realistic sense of the scene and fun, as well as controllable personalized training environment. During psychotherapy, there is a strong sense of simulation and sense of security. Many studies have proved that VR technology has a unique and wide range of applications in psychotherapy. Commercial operations will contribute to VR technology’s development in the future. Development of computer network technology also facilitates remote VR
technology applications, at the same time, consultants own clinical skills remains the key to the successful application of VR technology in psychotherapy. There is no doubt that, virtual reality will more perfectly simulate real world, price will be more affordable and application in psychotherapy will be more extensive.

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