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A theoritical model for projecting a dynamic and physically interactive virtual clone through emulation

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Abstract: This paper proposes an impendent avenue of hi-tech, super-fast digital transmission of organisms (humans in particular) across networks. It discusses a radical communication technology that may surpass the objectives of teleconference or telepresence in near future. Tremendous reduction in travelling and enhanced multitasking will be concomitant worldwide. The basic ideology lies in the marshaling and de-marshaling of data objects. If a living organism could be translated into a programmable object with all its characteristics and behavior, this object will be serialized, transmitted and deserialized at the destination to obtain a copy of the original object. Artificial intelligent systems for reconstructing digital holograms and analyzing inputs from various sensors can make it possible for two or more participants to communicate without being physically engaged during the whole communication process. The paper argues on the possibility of creating such a communication system and investigates the challenges and obstacles in its deployment. It is for the first time, as per the best of the author's knowledge that such a communication system using human level artificial intelligence and dynamic holography is proposed.

Keywords: digital transmission; cognitive communication; dynamically interacting volumetric display; mind uploading; whole brain emulation; artificial psychology; cognitive computing; personal construct psychology based expert systems, 3D scanning; expert systems; digital transmission; human computer interaction; ultra-high speed data transmission

I. INTRODUCTION

Human brain has always been the source of curiosity. Transportation and communication have been the most pertinent tools at hand, to develop sagacity and better knowledge about things. They are one of the necessities for the development of any civilization. For transportation they invented wheel, carts, automobiles, aircrafts and then rockets. For communication they invented hand gestures, sign languages, print and electronic media. And then telecommunication was introduced that made communication faster and cheaper, so that individuals could communicate with others through wires, be it through fax, mail, phone call, video call or teleconferencing. Through teleconferencing, people can see and talk to each other live, sitting miles away. But, in all these modes, individuals require full time engagement during the whole communication process. People have answering machines attached with their phones, so that it can answer their phone calls in case they are not available. Similarly, if there could be a way, to attend meetings, give lectures and engage in all other kinds of real time communications, without being actually involved in the process, hours of travelling or time sitting on one side of a phone call could be saved and utilized in a productive manner. In this paper, the author puts forward a technique that simulates the physical presence of the living being at a distant location in a real or a virtual environment. The proposed concept can be seen analogous to a database system where a replica of the source data is made at the destination; the replica can be used, edited or deleted later, as well as any changes can be merged with the source and the source remains intact during the whole process.

II. IDEOLOGY

The idea is to create a digital version of the communicating bodies. The transmitted data will eventually create a virtual reality. Once the requisite task is complete, the digital version can be turned off. The physical structure of the participant is scanned and associated with a file. The brain is mapped to back up its memory, physiological and psychological features in another file. These two files are transmitted over the network, and fed to an intelligent system. The participant can now detach from the system until he wishes his virtual replica to be switched off or shut down. A volumetric 3D projector at the destination will display computer generated volumetric hologram that could be felt and touched. All necessary sensory information can be provided to an expert system using appropriate sensors discussed later in this paper. The expert system will process the memory map to generate a particular set of actions or statements that will precisely imitate the actions and

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statements; the participant would have made in those particular circumstances. Next section explains in detail how the process works. At the end of each communication session, the newer version of the knowledgebase of a particular instance of expert system could be merged with that of the participant's brain. In case of any error, power or system failure, the data stored during the session will be rolled back to its previous successful safe point and will not be stored lest any data corruption or inconsistency. And since the participant will not be connected to the system during the whole process, it can be considered absolutely safe without a glitch.

III. RESOURCES REQUIRED

- A 3D scanner
- An expedient device to emulate brain
- A network connection between source and destination
- An expert system to simulate deportment of the participant
- A volumetric 3D projection system.
- A multi sensor network to provide sensory input to the expert system
- A workstation that successfully merges new data with the pre-existing data in participant's brain

IV. PROCEDURE

The virtual clone will be an autonomous agent. Getting the expert system complete access to the physiological, psychological as well as intellectual features of the participant will lead to its incomparable proficiency of making decisions exactly the way the participant would have made; had it been in the same environment under the same circumstances.

Whatever knowledge, characteristics or behavior the participant possesses is based on the information stored in brain that may change with time. This information in electrical signals of brain can be digitized which implies the possibility of storing this huge amount of information on a piece of hardware. Raymond Kurzweil claims that by 2030, enough computing power will be available to store Human Brain and Memory Backup on hard disk successfully [19]. An IBM researcher, DharmendraModha and his team are also working on the cognitive computing project to achieve the same [8]. The information stored in brain will be decoded and stored in a computer file which will be transferred over the network and work as the knowledgebase for the expert system. The expert system makes use of this knowledgebase and implements LIDA (Learning Intelligent Distribution Agent) model to make conscious decisions [20]. This model encompasses all the psychological, emotional and other memory related aspects that allows the expert system to learn from its environment and manipulate the knowledgebase. Each cognitive cycle as described in the LIDA model may bring an update in the knowledgebase [23]. To represent a virtual clone of the participant, the expert system must comply with the LIDA software framework [12].

Apart from this, a high definition 360˚ scan of the participant must be conducted to project computer generated volumetric holograms at the destination. Once the body of the participant is scanned, various transformation algorithms can be implemented to calculate all the possible orientations of the participant's physique. The calculated orientations are stored in a database file. The two file containing the cognitive information and the bodily orientations, would size in the range of terabytes and would need ultra-high speed data transmission channels to get transmitted in real time. At destination, an expert system assisted by a highly sensitive network of sensors makes use of the two files to generate what is called a physically interacting dynamic self-conscious virtual clone. The clone is visible as a volumetric hologram to the audience and makes two way interactions possible. Throughout the session, the expert system takes the responsibility of maintaining logs and making changes to the knowledgebase on the bases of sampled input and processing and works completely as an autonomous agent. The participant will be authorized to shut down the emulated virtual clone and may do so, whenever he feels the need. He must be connected to the system to perform this action. On receiving a halt or shut down command from an authorized participant, the expert system checks the knowledgebase for any inconsistencies; rolls back, in case it finds any; else, proceeds further to merge the knowledgebase with the information in participant's brain.

In the next few sections the author makes an attempt to describe how the recent advancements in science and technology has unlocked wide and novel avenues for further research to make digital transmission of life possible.

V. 3D SCANNING AND MODELLING

The first phase of the communication process is to perform a 3D scan of the participant in order to render its three dimensional model. The three dimensional model is a mathematical representation of the participant's external structure. The scanner serves the purpose of generating a cloud of points present on the object's surface. To obtain a set of as many points as possible, the scanner has to scan the object several times from all 360˚ angels. The scanning can be performed through a number of ways but laser scanning is most feasible due to its high speed and accuracy. The algorithm for a simple laser scan to generate a point cloud can be very simple. First, a matrix is created holding the color value of each point on the surface of source object. Then another matrix containing the color values of each point on surface of object with a laser line is created. Now the two matrices are subtracted. The resulting matrix will show the difference that is the laser line. Once this is done, either the laser or the object is rotated by a certain angle and the next image is captured with the laser line on it. Again the same procedure of subtracting color matrix is performed to obtain the next set of points for the point cloud. Once the whole object is scanned, a lattice of these points is created. The process can be made quicker if multiple lasers scan the object from all required angles, simultaneously. The object is

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scanned under various illuminations for better results. Although, this is one of the basic principles of modeling, but scanning can be done through many other ways. In structured light technique, a laser pattern is projected on the object and any deformations are recorded to generate the point cloud. Another scanning technique called the Time of Flight works by sending a laser beam on the object and the time of flight is measured according to the time it takes for the light to hit the object surface and make its return. With its two mirrors the scanner calculates the beams for horizontal and vertical angles, giving accurate coordinates of each point. Each of the scanning techniques discussed above has its own advantages and disadvantages. Today, a lot of graphics software and 3D scanners are available, capable of digitizing any 3D object through mesh, surface and solid modeling using multi laser scans. But there is no need for solid modeling to display computer generated holograms. Once enough 360˚ static scans are made, the mesh can be animated to produce any gesture or sense of motion through mathematical transformations. Several models have already been proposed to achieve the same. One such technique developed at the Stanford University is called the SCAPE method (Shape Completion and Animation for People) [5]. Another technique is used by Microsoft's Kinect [11]. With the help of high speed and high definition cameras a detailed database of participant's face expressions, eye and lip movements as well as the finest details of its external visual aspects can be made available, from which the intelligent software system will be able to select the most apt gesture, face expression, eye or lip movement etc. The digital Emily project helps understand how this can be achieved [17].

VI. WHOLE BRAIN EMULATION

The core of this communication project revolves around the concept of uploading the human cognitive system. The success of the project strongly depends on a sure-fire way of transmitting personal cognition that is used as the knowledgebase for the expert system based on the LIDA framework [12]. The framework is based on LIDA model that implements the Global Workspace Theory (GWT). GWT is currently the most widely accepted theory of consciousness [3]. Efforts from all around the world brought up several cognitive software models that would run on pertinent hardware to achieve whole brain emulation but the LIDA model is currently the center of consideration [24]. Since several features of cognition of an autonomous agent are general in nature, a LIDA framework based on the LIDA model has been developed [12]. According to the LIDA model [3], the cognition process of an autonomous agent occurs in cognitive cycles. Each cognitive cycle mainly consists of three phase's viz. the sensing phase (sampling input from the environment), the attending phase (processing the input to make decisions) and the responding phase (taking actions according to the processed data). The Global Workspace Theory comes into action during the most crucial phase of processing input and making decisions. It helps the model to decide which data and memories occupy the consciousness at a particular point of time. High level research is being conducted in different parts of the world aiming at whole brain emulation. The prime objective of the research includes understanding how human brain stores memories and what makes it solve problems, how its certain portion behaves in response to particular set of input. These concepts are being studied at both the synaptic and tissue level by research groups around the world. One such group led by a Dutch neuroscientist and neuroengineer, Randal A. Koene is Cognitive Computing Research Group (CCRG) [4]. Recently, a roadmap for the whole brain emulation is proposed at Future of Humanity Institute, Oxford University [2]. Feasibility study of the process is also done based on various factors including the levels of simulations required, the various scanning techniques and other technologies required and its various drivers like research, commerce and Moore's law [21][9]. After making various philosophical, computational and neuroscientific assumptions, it concludes by roughly estimating that by mid-century, it should be possible to emulate complete human brain.

VII. THE TRANSMISSION

Various estimates to what could be the actual amount of data stored or the storage capacity of human brain have been made according to different models hypothesizing how information is stored. Most evaluations lie somewhere around 10 to 100 terabytes. These figures can be traced by rough estimation that say human brain has around a hundred billion i.e. 10^{11} neurons each making around a thousand i.e. 10^3 synaptic connections with other neurons. Assuming each synaptic connection can store one bit of data, a brain having 10^{14} synapses can roughly store 10^{14} bits or 91 terabits or 11.37 terabytes of data. But this calculation may go wrong in several ways and the possible reasons may be:

- There is no valid model explaining how data is actually stored in human brain.
- It is possible that the synapses used to store data might be following multi valued logic.
- It is possible that all the synaptic connections are not used to store data; some may just work as processors.
- It is possible that brain implements far more complex encryption and compression algorithms that may further extend the amount of total data stored.

Considering these stated reasons, we can assume that the data stored in brain can be well out of the proposed range of 10 to 100 terabytes. However, keeping the odds in mind, even if the amount of data stored reaches up to a few petabytes, the transmission of such huge files will be feasible and will be achieved in a few seconds. With recent advancements in the field of optical communication, we can envisage transmitting petabytes of data in seconds in near future. At ECOC 2012, Nippon Telegraph and Telephone Corporation (NTT) and its partners demonstrated ultra-high data transmission rate of 1Pbps over a distance of 52.4km [16]. NEC Corporation of America, too have reached a

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comprehensive transmission speed of 1.05Pbps over a single optical fiber [7]. The transmission took place through a new multi-core fiber (MCF) designed by researchers at Corning Inc. and used space division multiplexing (SDM) and optical multiple-input multiple-output (MIMO) signal processing technique. Earlier, researchers at NEC Laboratories in Princeton, New Jersey successfully transmitted data at a rate of 101.7 Tbps over a distance of 165km through an optical fiber [10]. They made it possible by bringing together 370 laser beams together into a pulse, with each laser channel transmitting at a rate of 273Gbps. In another attempt, Prof J. Leuthold et al. of Karlsruhe Institute of Technology (KIT) applied orthogonal frequency division multiplexing (OFDM) to attain transmission rate of 26Tbps over a single beam of laser [6]. By using 16QAM Nyquist wavelength division multiplexing, they obtained single laser transmission at a rate of 32.5Tbps for over 227km. According to Leuthold, the process was extremely low on energy requirements as the energy was only required for the laser and a few other purposes [13]. NASA's Laser Communications Relay Demonstration Project is another milestone in practical application of optical laser communications [15]. There have been a number of similar attempts with ever increasing data transmission rates over larger distances. Optical communication has unwrapped, a whole new world of possibilities for data transmission that could have never been possible through electric signals and radio frequencies. The technology is still in its formative years and will achieve a lot more before it reaches its physical limits.

VIII. DYNAMICALLY INTERACTING VOLUMETRIC DISPLAY

Dynamically Interacting Volumetric Display is a three dimensional dynamic hologram of the participant that got scanned. A volumetric hologram is an auto-stereoscopic display in free space that allows different view of the animated object for viewers looking from different viewing angles. Face expression play a key role in the communication process that is why integrating high quality face expression is indispensable. Again several models and techniques have been proposed in past to achieve photorealistic face expressions. Rendering 3D realistic facial expressions is now possible; thanks to the digital Emily project [17][18], which is the first to produce results bridging the famous uncanny valley [14] in computer graphics. The next important aspect of communication after face expressions is one to one eye contact which is not possible with video conferencing when there are a number of viewers looking at the video feed from different angles. Fortunately, the researchers at the Institute of Creative Technologies have achieved eye to eye contact in one-to-many 3D conferencing system, but the display they have used is a back to back pair of aluminium brushed concave mirrors rotating at very high speed [1]. Hence, it is still not possible to comment whether the same results can be obtained on a holographic display. Instead, a motion sensing or gesture recognizing mechanism like kinect could be implemented in the immersion room that would track the bodily movements of the audience and allow the expert system to select a proper orientation of the hologram accordingly [11]. The interactive, intelligent and autonomous digital copy of the participant can be made tangible using the haptic technology so that the audience cannot just see or hear the person but can actually touch its holographic projection. Researchers at the University of Tokyo have made use of ultrasound waves to develop a force feedback system for the holographic display that makes it tactile [22]. The sense of touch added to the visually present digital copy makes the experience more immersive. The sense of hearing, seeing and smell can be added to the digital hologram with the help of microphones, speakers and smell sensors respectively which can input data to the intelligent system to produce the necessary output accordingly during each cognitive cycle. The computer generated hologram thus becomes a complete life like virtual autonomous agent capable of interacting with its surrounding environment. For real time interactions, the sensors must be able to input data at a frequency equal to that of a cognitive cycle. According to [23], it takes approximately 260-390ms for one cognitive cycle to complete. The projector needs to maintain high refresh rates with a minimum frequency of roughly 25Hz. With the limitations of existing technology, it is quite challenging to achieve high definition, human sized dynamic holograms. But the level of research in this field promises better outputs in near future.

IX. CONCLUSION

The version of this template is V2. Most of the formatting instructions in this document have been compiled by Causal Productions from the IEEE LaTeX style files. Causal Productions offers both A4 templates and US Letter templates for LaTeX and Microsoft Word. The LaTeX templates depend on the officialIEEEtran.cls and IEEEtran.bst files, whereas the Microsoft Word templatesare This paper discussed in detail a completely new form of communicating that allows a participant to communicate without getting involved during the whole time duration. The concept proposed is centered on an expert system that is based on the LIDA model of cognition and draws its knowledgebase from the data stored in participant's brain. The LIDA model working on knowledgebase of the participant allows the expert system to emulate the participant as a virtual reality. A multi-sensor network, present at the destination allows the expert system to sample its environment for each cognitive cycle and the action generated imitates exactly the action that the participant would have taken being present in precisely the same environment and situation. The expert system also takes input the external features of the participant through 3D scanning and modeling or a hologram recording system and then

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implements a model to recalculate the orientation of the scanned body or recorded hologram so as to project computer generated holograms in real time after each cognitive cycle in such a way that an immersive experience of the participant's actual presence using ultra high definition projectors can be provided to the audience. The same LIDA based expert system present at the destination can be used by different participants at different times by just replacing the knowledgebase of the system. An authenticated participant can shut down the emulation at his own will by connecting himself to the system and executing a command. Before shutting down, the knowledgebase is checked for any inconsistencies and merged with the data in his brain.

The communication alternative proposed proves to be realistic after discussing the future of various technologies involved and how all of them could be integrated in development of such a system. Processes of whole brain emulation and merging of knowledgebase proved to be the bottleneck for this project that need to be critically addressed, while other technologies like volumetric scanning, ultra high speed data transmissions, and projection of high definition computer generated holograms also need to advance with time.

X. FUTURE WORK

As mentioned from the beginning that this communication system is a proposed future project. Hence there is an extensive scope of development and improvements in every aspect of this system. Improvements in development of dynamic volumetric holograms from animated surface models in CAD as well as in the field of spatial light modulator (SLM) devices are needed to achieve application level performance of holographic display. SLM devices with high pixel counts, response time in the range of nanoseconds and pixel pitch in the range of nanometers will render better refresh rates, higher definition, increased size and a wider viewing angle. Work needs to be done in increasing the number of colored lasers feeding to SLMs to increase the contrast ratio of the display. Extensive study of the working of human brain and the hippocampus in particular is needed to understand the storage and retrieval mechanism of the brain. Development of autonomous agents based on LIDA model and LIDA framework in general are also of prime concern. The LIDA framework is in its infantile stage and there is a lot to improve. New learning algorithms and the efficiency of existing modules of the framework will meliorate with better understanding of the brain. As discussed above, the amount of data contained in files being transmitted will be enormous and to make the system a success, practical application of real time data transmission at ultra-high speeds in the range of Pbps needs to be achieved. Other software aspects like that of algorithms to merge knowledgebase or algorithms to decode how data is stored in human brain at physical level are yet far from being developed. A detailed feasibility study of this communication system needs to be done. If developed what could be the negative implications, if any and also what variations can make it better. In what possible ways the system can improvise on the available technologies. All these aspects need to be dealt with and are included as a part of the future work. Key features like how the participant gets authorized access to the expert system and the type of workstation needed to connect the participant to the system in order to merge the knowledgebase are highly dependent on future research.

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BIOGRAPHY

Authors have the option to publish a biography together with the paper, with the academic qualification, past and present positions, research interests, awards, etc. This increases the profile of the authors and is well received by international reader.