International Journal of Conceptions on Computing and Information Technology
Vol. 7, Issue. 1, November' 2019; ISSN: 2345 - 9808

Robotic immersive telepresence can improve the way we communicate: telepresence versus video call

Rivosoaniaina Alain Nimbol, Mahatody Thomas and Razafimandimby Josvah Paul
Laboratory of Informatics and Mathematics Applied to Development (LIMAD)
Fianarantsoa, Madagascar
alainnimbol@gmail.com, hasinathomas@hotmail.com and jp_josvah@yahoo.com

Abstract— **since the advent of cloud computing, collaborative work environments have emerged as the dominant interaction style and most remote communication systems are based on these principles. However, there is a considerable loss of information and a tremendous amount of effort during communication. This article presents the design and evaluation of a telepresence robot compared to the traditional system. Incidentally, we will offer a low-cost immersive telepresence solution. Rather, our approach has been to offer a robotic immersive telepresence system that is easy to implement and the cheapest.**

Keywords-Telepresence; Collaborative environment; Communication; Video Call; Robotic immersive Telepresence;

I. INTRODUCTION

When communicating face-to-face, a lot of information is encoded in our movements (our gestures, body posture or head posture), which implies that 7% of human communications go through the words [1] and the 93% remaining are nonverbal. However, there is a more than 90% loss of information and a colossal effort deployment during communication, but socially richer robotic immersive telepresence could help overcome these limitations. Telepresence refers to a set of technologies that allow users to feel at a distance. The tele-robotics is a subfield of telepresence. The telepresence robots are rapidly finding applications in areas ranging from offices and public spaces to space, through the marine and submarine[2], telemedicine [3], agriculture, military environments and dangerous[4]. There are as many definitions as there is scope for telepresence. The constraints it faces are also numerous, which has led to multiple definitions of telepresence [5][6][7].

II. BACKGROUND

According to several studies on telepresence robots[8][9][10], they are ideally appreciated by the users where it is placed. The more the robot recreates the shape of the human hand, the more the feeling of presence is important. The complexity of robotic systems varies considerably, from simple axis with pliers to a fully robotized humanoid body. The characteristic that we will present here concerns only robotic telepresence.

A. *Telepresence for communication*

Several hypotheses exist to succeed a system of communication through robotic telepresence according to each specific field of use, since Marvin Minsky [5] in 1980 until today. Let's take the example of Sigurdur Orn Adalgeirsson[11], he proposed some hypothesis:

- **Copresence**: People would feel greater co-presence when interacting with a humanoid-type robot that draws on human expression.
- **Psychological involvement**: People would be more involved psychologically with their interlocutor when they interacted with an expressive telepresence robot.
- **Confidence**: People would trust their interlocutor more when interacting with an expressive telerobot.
- **Engagement**: People would feel more engaged with their interlocutor when interacting with an expressive telerobot.
- **Cooperation**: people would cooperate better with their interlocutor when they interacted with an expressive telerobot.
- **Fun**: People would appreciate their interaction more when interacting with an expressive telerobot.

The improvement of telepresence depends on a part of the evolution of the corresponding technologies, more particularly to reach the perfect presence [6]. It is difficult to define correctly, an ideal telepresence system even to handle subjective. The ideal robotic telepresence system is what makes the system totally immersive and collaborative that does not cost a fortune. Submission of the sense organs from the respective devices increases the level of immersion (sight, hearing, touch, smell and taste is still experimental). All this information does not help us to define the ideal telepresence system, however, here are some of the assumptions we made about it:

- Two-way communication,
- Interactive control that is natural,
- Transmission of information in real time,

- A visual feedback system,
- Hearing simulation increases immersion,
- The return of effort gives the feeling of being present.

B. Ideal robotic telepresence system

We have identified more than 120 telepresence systems, we have grouped systems of the same family, of the same producer, but with a difference of version as being a single system. Thus, we have presented 68 more relevant systems in Figure 1.

Legend:

- **Second column and Fourth column:**
  - HMD (Head Mount Display)
  - PC (Personal Computer)
  - G (Glove, Gauntlet)
  - SP (Smartphone)
  - T (Tablet)
  - J (Joystick)
  - GP (Game Pad)
  - **-** (Dash means uncertain or nil)
- **Fifth column:**
  - P (Personal)
  - E (Experimental)
  - C (Commercialize)
- **The last column:**
  - VR (Virtual Reality)
  - AR (Augmented Reality)
  - AV (Augmented Virtuality)
  - MR (Mixed Reality)
  - Ai (Interactive Application)
  - WA (Web Application)

- Extensive literature[7][12] finds that the quality of audio communication can be a major obstacle to collaboration and fluid interaction[13]. We can see that all these systems use sound and video.
- Of telepresence systems, 84% do not use instant messaging. Textual communication is not considered VR[12] because it does not improve immersion, but rather decreases.
- Nonverbal communication[14][15][16] plays an important role in coordinating the actions of teammates for collaborative activities. Of the 68 tools cited in Figure 1, only 12 can interact to make a decision or to reproduce a gesture of the user.
- There are different other messages that are not in the above-mentioned categories, for example, user emotion (smile, acquiesce, etc.), collaborative work data (report, statistics, other documents, etc.). Most collaborative systems identified, 61.76% more exactly do not allow the transmission of this kind of message.
- In our list, we can see that the majority uses the PC and Mac, precisely 38.24% of the systems. Then, the tablet, smartphone or PC occupy 16.18%. Some systems use special tools, such as LEGOS, KINECT or iPad.
- Robotic telepresence affects different areas of application. Some tools of our census do not have clear membership that we have chosen to generalize them in the field of social communication. In the nuclear field which constitutes 3.64%, and the underwater domain 4.55%, the space domain 11.82%, the field of education occupies 10.91%, the field of security occupies 5, 45%, the medical field occupies 16.36%, the field of assistance constitutes 8.18%, the field of exploration constitutes 13.64% and the field of social communication occupies the vast majority of which the rest 25.45%.
- For navigation systems of a telepresence robot, the HMI plays an important role. By guiding these kinds of robots, one is preoccupied with control, and one loses the feeling of presence[12], because the immersion decreases. Conventional navigation devices (joystick, joystick, etc.) are the tools to guide robots, and 20.59% of the above telepresence robots use them. These tools are replaced by tactile devices (tablet, smartphone, touchscreen, etc.), as 25% use these interactive tools. Most use a computer or Mac, 48.53% to be more precise. But with the advent of virtual reality tools, we can see that the remaining 5.88% of the telepresence robots that we have identified are guided by the HMD.
- The telepresence study is gaining more and more ground in research, but also in the productive industries. As a result, 60.29% of robotic telepresence systems are commercialized. The other 25% made the subject of studies in research laboratories. The remaining 14.71% are personal ambitions.
- Of these systems, only 17.39% use virtual and augmented reality, and 5.80% operate in a mixed reality environment. The other systems use interactive applications on one of the standard devices, the 40.58% (Laptop, tablet, smartphone, etc.) and the 23.19% use web browsers to access the applications.

Telepresence is primarily a communication tool that aims to optimize the performance of standard information systems. In [17], we made a classification of the messages sent according to the tool. Let's add to the message types the mentioned criteria rather to better subjectively define the ideal telepresence system.

TABLE I. THE FEW ASSUMPTIONS COMBINED WITH THE CRITERIA OF A COMMUNICATION SYSTEM TO HAVE AN IDEAL TELEPRESENCE SYSTEM

Criteria	Telepresence Standard	Téléprésence Ideal
Son	X	X
Speech	X	X
Video	X	X
Gesture	-	X
Text	-	-
Natural Interactivity	-	X
Stress feedback	-	X
Bidirectional communication	X	X
Real Time Communication	X	X

System	Devices	Domaine	Navigation	State	Bidirectional	Messages					Environment
						Son	Video	Text	Interaction	Other	
TROV	PC, HMD	Submarine	PC, HMD	E	-	X	X	-	X	-	VR
Crabster CR200	PC	Submarine	PC, Mac	C	-	X	X	-	X	-	MR
OCEAN ONE	PC	Submarine	PC, Mac	P	-	X	X	-	X	-	MR
MEISTeR	PC	Nuclear	PC, Mac	P	-	X	X	-	X	-	VR
RIANA	PC	Nuclear	PC, Mac	C	-	X	X	-	X	-	Ai
Virtual Interface Environment Workstation (VIEW)	PC, HMD, DG	Spatial	HMD, DG	P	-	X	X	-	X	-	VR
Robonaut	PC	Spatial	PC, Mac	P	X	X	X	-	X	X	AR
Interact Centaur	-	Spatial	J, GP	P	-	X	X	-	X	X	AR
Valkyrie de la NASA	-	Spatial	J, GP	P	-	X	X	-	X	X	AR
Curiosity	-	Spatial	J, GP	P	-	X	X	-	X	X	AR
iRobiQ	PC	Education	SP, T, PC	C	X	X	X	X	X	X	WA
Pi Robot	KINECT, LAPTOP	Education	J, GP	E	X	X	X	-	-	X	VR
Telepresence Robot Kit (TeRK)	-	Education	PC, Mac	E	X	X	X	-	-	-	-
Engkey	-	Education	J, GP	C	X	X	X	X	-	X	Ai
Roti	-	Education	SP, T, PC	C	X	X	X	-	-	X	WA
PatrolBot	PC	Security	J, GP	E	X	X	X	-	X	X	MR
Robotex Avatar	-	Security	J, GP	C	X	X	X	-	X	X	WA
PeopleBot	-	Security	J, GP	C	X	X	X	-	-	X	WA
Giraff	-	Medical	SP, T, PC	C	X	X	X	-	-	X	Ai
RP-7, RP-VITA [63], InTouch[64][65]	-	Medical	PC, iPad	C	X	X	X	-	-	X	Ai
Human Support Robot	PC	Medical	PC, Mac	C	X	X	X	-	X	X	Ai
Kompaï	PC	Medical	PC, Mac	C	X	X	X	-	-	X	Ai
HOSPI-Rimo	-	Medical	PC, Mac	C	X	X	X	-	-	X	WA
Audi Robotic téléprésence (ART)	-	Assistance	PC, Mac	P	X	X	X	-	-	X	Ai
VGo	-	Assistance	PC, Mac	C	X	X	X	-	-	X	Ai
MantaroBot TableTop TeleMe, Classic2 et TeleMe2	-	Assistance	PC, Mac	C	X	X	X	-	-	-	Ai
Keylo	-	Assistance	PC, Mac	C	-	X	X	-	-	-	WA
TiLR Tele-Robot	-	Assistance	PC, Mac	E	-	X	X	-	-	X	-
QB of AnyBot	-	Assistance	PC, Mac	C	X	X	X	-	-	-	WA
E-One	-	Assistance	PC, Mac	C	X	X	X	-	-	X	Ai
DORA (Dexterous Observational Roving Automaton)	PC, HMD	Exploration	HMD	E	X	-	X	-	-	X	VR
Project WithU	PC, HMD	Exploration	HMD	E	X	X	X	-	-	-	VR
Norio	PC, Mac	Exploration	PC, Mac	P	X	X	X	-	-	-	Ai
Chesster and Kasparov	PC, Mac	Exploration	PC, Mac	P	X	X	X	-	-	-	WA
Telegance	PC, Mac	Exploration	PC, Mac	E	X	X	X	-	-	-	WA
MITRO	-	Exploration	PC, Mac	E	X	-	X	-	-	-	-
TR-7	PC, T	Exploration	PC, Mac	E	X	X	X	-	-	-	-
Floating avatar	PC	Exploration	PC, Mac	E	X	X	X	-	-	X	VR
mObi	PC	Exploration	PC, Mac	C	X	X	X	-	X	X	Ai
MeBot V4	PC, T	Exploration	SP, T, PC	E	X	X	X	-	-	X	Ai
PRoP	PC, T	Exploration	SP, T, PC	E	X	X	X	-	-	X	Ai
MH-2	PC	Exploration	J, GP	E	-	X	X	-	X	X	-
TELESAR V	PC, HMD	Exploration	HMD, DG	E	X	X	X	-	-	X	MR
Kubi	T, PC	Social	J, GP	C	X	X	X	-	-	-	-
SelfieBot	T, PC	Social	J, GP	C	X	X	X	-	-	-	-
Collaborate i/o	T, PC	Social	J, GP	C	X	X	X	-	-	-	Ai
Famille PadBot	T, PC	Social	SP, T, PC	C	X	X	X	-	-	-	-
Swivl	T, SP	Social	SP, T, PC	C	X	X	X	-	-	X	-
Ohmni	T, PC	Social	SP, T, PC	C	X	X	X	-	-	-	WA
AMY A1	-	Social	SP, T, PC	C	X	X	X	-	-	X	WA
iRobot Ava 500 and IRobot Ava	PC	Social	J, GP	C	X	X	X	-	-	X	Ai
Double	iPad	Social	SP, T, PC	C	X	X	X	-	-	X	WA
BotEyes - Pad	T, SP	Social	PC, Mac	C	X	X	X	-	-	X	Ai
Ubbo Maker	T	Social	PC, Mac	C	X	X	X	-	-	X	Ai
Sanbot Elf	-	Social	SP, T, PC	C	X	X	X	-	-	-	WA
Beam Pro et Beam+	-	Social	SP, T, PC	C	X	X	X	-	-	X	WA
Endurance	T	Social	PC, Mac	C	X	X	X	-	-	-	Ai
FURo-i Home	-	Social	SP, T	C	X	X	X	-	-	-	Ai
Webot	-	Social	PC, Mac	C	X	X	X	-	-	-	Ai
Synergy Swan	PC	Social	SP, T, PC	C	X	X	X	-	-	X	WA
RP2W Generation 7	PC	Social	PC, Mac	C	X	X	X	-	-	-	Ai
Carl	-	Social	PC, Mac	C	X	X	X	-	-	X	Ai
Teleporter	PC	Social	PC, Mac	C	X	X	X	-	-	X	Ai
Robot i2u2	PC	Social	SP, T, PC	C	X	X	X	-	-	-	WA
Texai	-	Social	PC, Mac	C	X	X	X	-	-	X	Ai
Romo	SP	Social	SP, T, PC	C	X	X	X	-	-	-	WA
Lego Telepresence Robot NXT robot	LEGO	Social	PC, Mac	E	X	X	X	-	-	-	Ai
RambleBot	SP	Social	SP, T	E	X	X	X	-	-	X	Ai

Fig. 1: Summary of the review of robotic telepresence systems

There are other criteria that we have omitted from this ranking, namely, the area of application that in itself directs the design and realization of an adequate system. The budget to acquire a robotic telepresence solution as needed. It is clear that all these shortcomings prevent us from defining an ideal system.

III. Method

In this section, we will present the design part as well as the description of the system used. To do so, we will see the hardware configuration of the project that defines the components and devices input and output the system operate for the navigation system and interaction. With telepresence, the user can have the opportunity to act on the remote site. In this case, the position of the user as well as his movements, actions, or words can be perceived, transmitted and duplicated to the desired destination to put this effect into action. As a result, the information can travel in both directions between the user and the remote location.

This study aims to determine how a robotic telepresence system can be used as a communication system. This difficult question requires dealing with interaction optimization. Thus, we decided to design a robotic platform for mobile videophone of a robotic telepresence system. In no case, this study does not seek to make improvements in the field of robotics which is a fairly advanced discipline. Our robotic platform is very rudimentary but sufficient to replace the telepresence robot that we lack and that is expensive.

We designed a telepresence robot using the basic digital electronics kit, the Raspberry Pi 3 pair with a MEGA 2560 Arduino microcontroller. We used a Raspberry Pi 3 based kit on which 1 Pi NoIR cameras are plugged. The MJPG-Streamer Stream Processing API is installed and allows real-time video transmission. On this Nano computer, a USB microphone and a speaker on the 3.5mm jack is connected. We also used an audio stream management API, the G-Streamer for Raspbian. We used an Arduino board to drive all the joints of the robot, like the SG90 servomotors mounted on Pan TILT for the reproduction of the movements of the head to turn vertically and horizontally. A servomotor from SG92R guides the clamp in front of the robot, this clamp reproduces the interaction of the hand. An ultrasonic sensor is mounted on a servomotor for the automatic navigation system. All of these components are mounted on a separately powered two-wheel chassis, allowing it to rotate in place.

Figure 1. The prototype telepresence robot used in this work

We used the HMD OSVR [18] for immersion and to most faithfully reproduce the interaction of the user's head towards the robot. Navigation with the robot is done with the LeapMotion motion sensor [19] and the right hand through a robot control interface. To advance, we open our right hand and move forward, the same goes back and back. The driver determines the speed by interacting with the control interface. The major disadvantage of this type of interface was that the user had to keep his hand in the interaction field of the LeapMotion so that he does not lose control. If the user was facing in another direction, it was very difficult and confusing to steer the robot. We have a preliminary description in the previous work [17].

Figure 2. On the left (a) the user with the interface using the PC, HMD and LeapMotion..

The menu bar in Figure 3 on the right shows the features available during the communication. In the lower left corner, the left and right hand icons, when present in the LeapMotion controller field. The icons at the bottom right indicate the presence of the OSVR headset and the status of the robot (Off, Forward, Reverse, Left or Right, etc.).

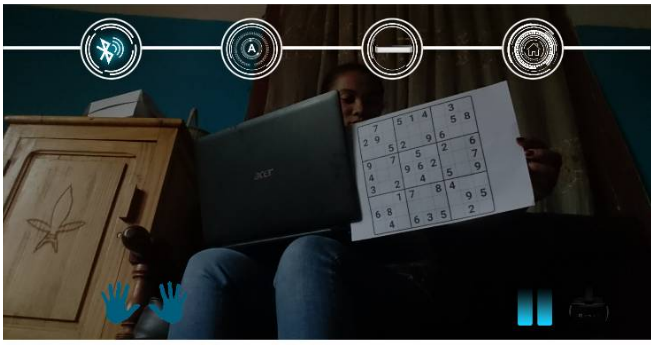
IV. Experimentation and Result

In order to be convinced that the improvements brought by telepresence are well perceived by the users, it was decided to make a small series of validation tests. The main objective of this experiment is to validate the telepresence solution that we proposed. "Any evaluation consists of comparing a model of the object being evaluated with a reference model for making conclusions." [20]. In order to evaluate the system as a communication tool against a video call, both communication methods were evaluated via a user study. The video communication tools used in this evaluation were the standard tools that many use Skype, Messenger, Whatsup or Hangout.

A qualitative test was conducted with 13 participants, 7 men and 6 women. The people who did the test were 17 to 35 years old. Half of the test group had experience controlling remote virtual characters in video games, while the other half had little or no experience with this type of action. Each test took between 15-20 minutes task.

A. Evaluation method

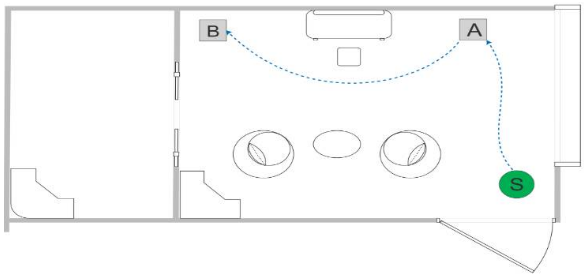
The evaluation was conducted in two rooms and required two participants per round. This included 2 iterations: one to evaluate telepresence communication and one to evaluate video communication. Each iteration consisted in solving a sudoku problem where the remote user saw the solution and had to communicate it to the other person who was physically at the remote site, presented in figure 8. Once the puzzle was resolved, the participants answered a questionnaire about how they perceived communication. The time required to solve the problem was measured with a stopwatch. It was also noted if the sudoku was correctly placed or if there were errors.



(a)

Figure 3. The participant on the site saying where the robot is with the sudoku the hand.

Each iteration consisted of a brief explanation of the piloting interface, after which each person in charge of the test was asked to perform a task with the robot, such as moving an object from point A to point B. And when the first task has been completed, the test taker including the user has been informed of the next task while still wearing the HMD. For the first task, the test taker was asked to follow the path described in Figure 4 on the right.



(b)

Figure 4. the map moving the robot in the first task of driving the robot from the starting position (S) to the point (A), then to point (B).

B. Result of telepresence for communication

For the evaluation of telepresence, there is no concrete evaluation system. We have been led to create some evaluation criteria inspired by the several methods [12][21][6]. Ralph Schroeder [12] has studied the field of social interactions in a virtual environment. He argued that to study communication in shared virtual environments, it will be necessary to combine different perspectives, including social psychology, sociological analysis of interaction and approaches to communication studies for different media. However, this study does not allow us to have a way of measuring communication.

For his part, Martin Hassell and his colleagues [21] proved the flexibility of these variables by using them in a similar field. He studied the effect of seeing a mirror version of himself in video communication. They built an experiment in which small groups of people performed a group decision exercise using video communication. Half of the groups were able to see their own video stream as well as the videos of the other members of the group, the other half saw only the video stream of the other members of the group. According to Thomas B. Sheridan [6] in 1992, in order to better define presence, we need the three main determinants:

- The extent of sensory information,
- Control of the relationship of the sensors with the environment,
- The ability to modify the physical environment.

By taking inspiration from all these theories mentioned above, we have defined 5 criteria to evaluate our communication system. Indeed, for the experiment we conducted, telepresence for communication was evaluated according to 5 criteria: notably its efficiency, user satisfaction with the process, satisfaction with the solution, co-presence that defines the feeling mutual presence of interlocutors and the cognitive load of the user. Efficiency has been measured over time and accuracy. The other values were measured by a questionnaire to which participants responded. This makes it possible to analyze these criteria separately for the user and the interlocutor.

In order to determine an overall result of the communication tools, we asked questions for each criterion and the responses of the user and his interlocutor were combined and illustrated in Table II.

TABLE II. COMBINED OUTCOME OF THE TELEPRESENCE EXPERIENCE FOR COMMUNICATION

Criteria	**Telepresence A/V**	**Video call**
Efficiency	70,43%	40,87%
Satisfaction with the process	67,83%	64,78%
Satisfaction with the solution	58,26%	62,17%
Copresence	75,36%	40,58%
Cognitive load	75,65%	37,39%

This result shows that telepresence communication was significantly more efficient than usual standard video communication. The satisfaction of the solution was quite similar between the two methods of communication. The experience of telepresence had less cognitive load on users.

Experience has also shown a strong increase in perceived co-presence compared to video communication.

However, video communication is always more satisfying for the process. Although the study did not involve remote communication, these communication measures are still relevant because they allow different methods of communication to be compared.

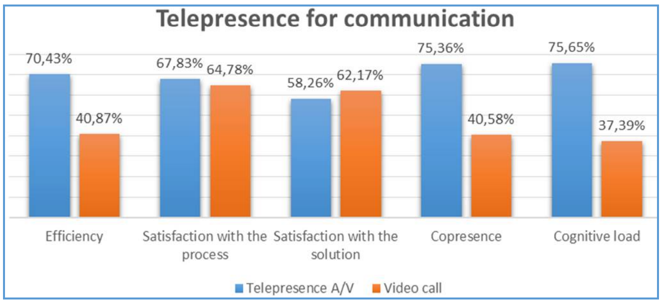


Fig. 6: Combined outcome of telepresence experience for communication

V. Discussion

Telepresence or Video Communication? That is the question. To answer this question, we performed tests, first to evaluate our telepresence system and then to compare similar systems. Here are some relevant points that make up these tests:

- **Evaluation criteria**: For video communication versus Telepresence, evaluation criteria for measurement methods have been developed in different ways.
- **Tasks during evaluation**: Since the test consisted of evaluating both telepresence and video communication was created so that the user did not know the solution beforehand when performing the communication method next.
- **Telepresence wins**: we can conclude that telepresence was clearly winning in the comparison.
- **Two-way video**: We tested two functional prototypes, version 1 or video communication is only available to the local user and colleagues in the remote site only see the robot. Some participants felt that video communication was faster and more flexible when it came to moving. Another advantage of video communication is that the interlocutor can see the face of the inhabitant.
- **Satisfactions**: One of the interesting conclusions about user participation, although satisfaction with the solution has visually better values than the traditional video communication method, participants seem to prefer slightly the process with telepresence.
- **User and VR**: The majority of users in the local site prefer communication with video telepresence.

The telepresence robot: the limitation of the movements with the robot of telepresence are part of the reasons of their choices. These users claim that a human is much more apt when it comes to moving objects relative to a robot.

VI. Conclusion & Limitation

During these tests, the majority of participants are accustomed to video communications, so it can be said that familiarity with video communication with the test subjects could have influenced the outcome. It is likely that telepresence communications in the coming years will be in similar conditions and should corollary be ready to meet this challenge. To summarize, the experience with telepresence was the best communication tool for participants, both with respect to measurement criteria and the personal opinions of users. As a result of the study, one of the attempts to make the steering interface more flexible was to add two wheels with a steering arm to improve the way the robot would behave.

References

[1] Mehrabian, Albert. Nonverbal communication. . Routledge, 2017.

[2] Mehrabian, Albert. Nonverbal communication. . Routledge, 2017.

[3] Otmane, Samir. Téléopération, télérobotique et Internet: Techniques & applications. *Université d'Evry Val d'Essonne CNRS-FR* (2010) **2873**.

[4] Satava, Richard M. Virtual reality and telepresence for military medicine. *Annals of the Academy of Medicine, Singapore* (1997) **26**: 118-120.

[5] Lawson, Wallace E;Bekele, Esube;Sullivan, Keith. **Finding Anomalies with Generative Adversarial Networks for a Patrolbot**. In *CVPR Workshops*. 2017.

[6] Minsky, Marvin. Telepresence. (1980).

[7] Sheridan, Thomas B. Musings on telepresence and virtual presence. *Presence: Teleoperators & Virtual Environments* (1992) **1**: 120-126.

[8] Beigl, Michael;Gellersen, Hans-Werner. **Ambient telepresence**. In *Proceedings of the Workshop on Changing Places*. 1999.

[9] Zanotto, Damiano;Rosati, Giulio;Minto, Simone;Rossi, Aldo. Sophia-3: A semiadaptive cable-driven rehabilitation device with a tilting working plane. *IEEE Transactions on Robotics* (2014) **30**: 974-979.

[10] Siciliano, Bruno. Robot control. (2019).

[11] Bryson, Steve. Virtual reality in scientific visualization. *Communications of the ACM* (1996) **39**: 62-71.

[12] Aðalgeirsson, Sigurður Örn. **MeBot: A robotic platform for socially embodied telepresence**. .2009.

[13] Schroeder, Ralph. **Social interaction in virtual environments: Key issues, common themes, and a framework for research**. In *The social life of avatars*. . 2002. pp. 1-18.

[14] Coad, Peter. Object-oriented patterns. *Communications of the ACM* (1992) **35**: 152-159.

[15] Burgoon, Judee K;Guerrero, Laura K;Floyd, Kory. Nonverbal communication. . Routledge, 2016.

[16] Knapp, Mark L;Hall, Judith A;Horgan, Terrence G. Nonverbal communication in human interaction. . Cengage Learning, 2013.

[17] Breazeal, Cynthia;Kidd, Cory D;Thomaz, Andrea Lockerd;Hoffman, Guy;Berlin, Matt. **Effects of nonverbal communication on efficiency and robustness in human-robot teamwork**. In *Intelligent Robots and Systems, 2005. (IROS 2005). 2005 IEEE/RSJ International Conference on*. 2005.

[18] Nimbol, Rivosoaniaina Alain;Thomas, Mahatody;Razafimandimby, Josvah Paul . **New type of communication: Immersive telepresence with OSVR and LeapMotion**. In *International Academic Multi-Disciplinary Conference (IAMDC - Nov' 2018)*. 2018.

[19] Quin, Caramel. The teardown: Razer OSVR HDK2 virtual reality headset. *Engineering & Technology* (2016) **11**: 80-81.

[20] Zhang, Qixiang;Deng, Fang. **Dynamic Gesture Recognition based on LeapMotion and HMM-CART Model**. In *Journal of Physics: Conference Series*. 2017.

[21] Senach, Bernard. **Evaluation ergonomique des interfaces homme-machine: une revue de la littÃ©rature**. .1990.

[22] Hassell, Martin D;Cotton, John L. Some things are better left unseen: Toward more effective communication and team performance in video-mediated interactions. *Computers in Human Behavior* (2017) **73**: 200-208.