3D Internet for Cognitive Info-Communication

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Abstract: The paper presents new research directions both for 3D internet and cognitive info-communication. It reviews basic concepts and definitions and gives some "historical" view that helps to understand current international trends and projects. Some examples of our experimental results are also presented.

Keywords: 3D internet, cognitive info-communication, robot control

1 Introduction

Our daily activities are more and more linked to the "digital social behaviour". Investors in industry are highly aware of these trends and allocate more financial means to develop personal-fit products to reach the level when these products – besides remain functional – become indispensable partners for their owners and - as it can be clearly marked in the case of new generation mobiles – express even their cultural and social affiliation. The more complicated it is to use a device, the less it can be used in everyday life since we are not willing to learn all functions. Therefore the demand of the users that they would like to „discuss" compound needs with their personal informatics in an easy, user friendly way is fully understandable [1].

Man live in a 3D world. All our knowledge is in 3D and we use 3D in our non- and para-verbal communication. No wonder that it is a natural need from the customers that they would like to communicate with their personal informatics in the very same way; in 3D. That is why – among others - internet, the appearance of all allocated and collective knowledge of man, should also be in 3D.

The three-dimensional opportunities of informatics help significantly the communication and the representation of the information [2,3]. These are the reasons why every day a new 3D application shows up: For example in Japan 3D TV broadcast is already available and in Europe it will start soon, 3D televisions and monitors are commercially available for an affordable price and numbers of 3D display devices based on new technologies are born every day. Cell phones are also available with 3D interface and by moving them in 3D it creates a link between our tools for informatics and their 3D content [4]. All of these are connected to each other through the internet. Internet broke into our daily life incredibly fast and so it is predictable that 3D internet will have the same success. The largest internet software companies announced that soon they will publish their 3D internet interfaces. These improvements are about to change the traditional keyboard and mouse interfaces [5], and require a more effective communication channel for data input, which is examined within the framework of comprehensive cognitive research. 3D visualization and cognitive infocommunication create 3D media research directions, which is actually the summarization of 3D representation and content handling.

Present networks, communications and content handing devices differ radically from those in future 3D internet. Media network is a technology that allows anyone to create, edit, use and enjoy any media content, wherever he/she is located. The content will not only contain sound and picture as in present phone and television services but will also offer a wide range of interactive services in the field of informatics education and entertainment thus creating new business opportunities. Currently most media content is used for broadcasting or producing music/movies. In Europe broadcasting is right in the state of changing from analog to digital technology. Digital broadcasting is more efficient in using the spectrum and in addition it offers the possibility for integrating data services and interactivity. In the case of digital broadcasting it can be observed that through recording or trough the service offered by the supplier, the content itself becomes available nearly any time for the user and gets more and more interactive. Briefly, future media network can be defined as a service that can be reached easily by anybody and anywhere for professional and leisure purposes.

Of course technically several levels of complexity lie behind this simplicity but users do not need to know this complexity. To make it possible the following fundamental things have to be changed: a) Media needs to become part of the network, just opposite the today’s practice where it just something to be delivered from A to B. b) content can come from anyone and an intelligent, user-friendly indexing engine has to generate the matching metadata. c) Intuitive and multimodal input interfaces need to offer an interconnection to and in the media environment providing a more natural interaction than what we have today. d) Display of the content should be unnoticeably adapted to the user, to the environment and to the display capabilities.

The fact that the European Union has found it important to define new innovative directions proves clearly the worldwide appearance of 3D Internet and Media.

From the drafts, prepared for the Framework Program 7 (FP7), the „Research on Future Media and 3D Internet" and the „Future Internet and NGN, Design requirements and principles for future media and 3D Internet" give an extensive review on global tendencies and summarize the opinion of 35 European and American experts in the topic of Future Media 3D Internet (FM3DI) that considered to be one of the most important topic in relation with European competitiveness. Both of the studies are created by „the Future Media and 3D Internet task force", which were coordinated by the „five FP7 Network Excellence" with the assistance of the Networked Media Unit of the DF information Society and the Society & Media of the European Commission. According to the „EU ICT 2009 „work programme" Cooperation Theme 3 European Commission C(2008)6827 of 17 November 2008" publication, the main strategic directions are already decided and their financing is also solved by the European Union. On the basis of the above surveys, 3D internet gets an emphasized role in this publication (Objective ICT-2009.1.5: Networked Media and 3D Internet).

A significant innovation is taking place globally, from which a few points are highlighted here:

- the EU Future Internet Research and Experimentations (FIRE: www.cordis.europa.eu/fp7/ict/fire),
- the NSF Future Internet Design (FIND) and GENI programmes (www.nets-find.net & http://www.geni.net/)
- China Science and technology Network (www.cstnet.net.cn),
- In Japan the AKARI Architecture Design Project (akari-project.nict.go.jp/eng/overview.htm)
- Korea is getting ready for the daily use of 3D internet (http://fif.kr/fiw2007/presentations/architecture_tschoi.pdf)

2 The Basic Definitions for the Cognitive Info-Communication and for the 3D Internet

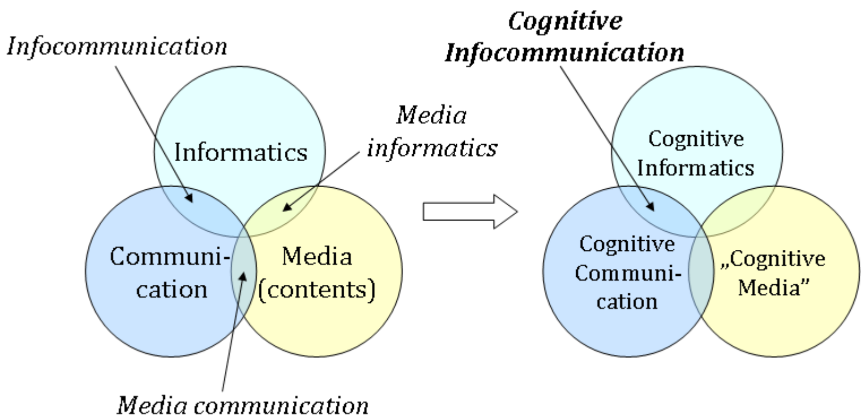
The classic information-technology is composed of 3 pillars (see Figure 1 a).

- **The media** is to create and manipulate the information content.
- **The communication** function is to transmit the information.

- **The informatics** task is to process the information.

Today, the boundaries between the three pillars are becoming increasingly blurred. That is called the convergence theorem in the IT literature. Thus the intermediate areas are becoming in the focus of attention.

- **The media communication** is responsible to deliver the information to the broad masses.
- **The media informatics** uses the strength of the informatics to build up the interactive media.
- **The info communication** handles the communication both between the people and the information-technology tools and the communication between the information-technology tools.



1.a The three pillars of traditional information-technology

1.b The location of cognitive info communication

Figure 1
Divisions of the traditional and cognitive information-technology

2.1 Cognitive Info-Communication

The information-technology triplet can be found in every corner of the cognitive research field. **Cognitive science**, or in other words **acquaintance science**, was developed in the fifties as a branch of the interdisciplinary sciences, trying to understand how the human sensing works and examining the sensing connection with brain activities and human intelligence. This paper focuses on the cognitive info-communication whose place is shown in Figure 1b. The previous definitions can be supplemented by the following interdisciplinary sciences:

- **The cognitive communication** is closer to cognitive sciences and its task is to analyze how information is sent through the transmission channels. These channels include cognitive linguistics and other non- and para-verbal channels introduced by other cognitive sciences, including the cases, when our senses are not used in the usual way, for example, when the visually disabled use their hands to see.
- **The cognitive informatics** should belong to the informatics branch. It investigates the internal information processing mechanisms of the human brain and their engineering applications in computing.
- **The cognitive info communication** handles the communication channels between people and information-technology tools and also the communications which are based on cognitive informatics processes.

The definition of cognitive info-communication is used in greater extent. In Figure 2. an example is shown for cognitive info-communication. There is machine communication between the low level controller and a robot or intelligent tool. The link between a robot and the high level intelligent control is realized at the info-communication level. When the operator gives direct order to the robot that is also called info-communication. The cognitive info-communication level is only reached if the entire communication process – from the natural intelligence, generated by the human brain to the controlled task - is examined as a whole.

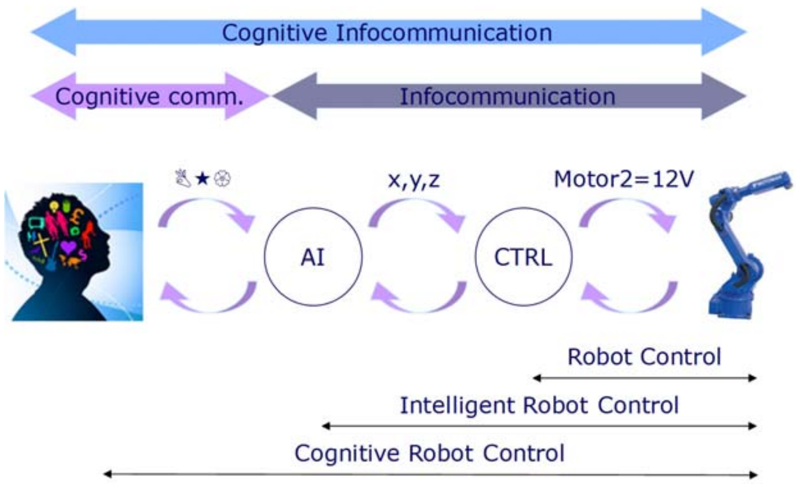


Figure 2
The cognitive info-communication

It is necessary to distinguish two cases. In one people are communicating between each other (at both ends of the communication channels are humans). In this case the task of the cognitive information device is to deliver non- and para-verbal information in the best possible way.

It is a completely different situation, when we communicate with a machine or with an artificial intelligence. Not long ago the programming language of machinery was completely abstract and only a few professional had the privilege to understand it. Today not only a small group of professionals are forced to communicate with machines, thus there is a strong demand to develop cognitive information channels. Here we have to emphasize the customization of personal tools for informatics to fit for personal needs. For users the personal tools for informatics are almost like "partners", with whom the communication should be carried out in the same way as with another human being.

The most important condition of this is that we should be able to talk to our device; moreover the para- and non-verbal channels should preferably work in both directions and in 3D because that is our natural environment. With this the real challenge is when the artificial intelligent device communicates with a human because the “feelings” of the artificial system, - voltage, current, torque, angular momentum, consumption, etc. - are completely different from those of the humans. All these feelings have be transformed to human senses in such a way that either the sensory organs with the appropriate resolutions and speeds are attached together or their combinations, since in many cases we can’t even break down which senses determined our action. For example, a racing driver autopilot manoeuvres according to the engine torque, speed and many other parameters that are hardly understandable for people while humans drive according to the shifting of the landscape, the sound of the engine and many divergent acceleration measurement sensors in our body. When we drive a car in a virtual space and control an autopilot, the “senses” of the autopilot have to be transformed to human senses using cognitive info-communication tools.

2.2 3D Internet

"**3D Internet**" is such content service, which is taking advantage of the opportunities of the Internet to give the user a stereoscopic 3-dimensional viewing experience, or attached multi-media (interactive) content.

At the currently held SIGGRAPH Computer Graphics conference Mozilla, Google and Opera have announced the WebGL, which can be used to build in 3D graphics into a homepage without any separate external plug-in. The standard is based on the OpenGL and the first version will be available within a few months. To be able to carry out this, basically new input and display hardware and software tools are needed. From these the key element is the stereoscopic visualization. These can be grouped in a number of different ways. To give a detailed description of these technologies would go beyond the limits of this article, therefore we made a summary in tabular form (see Table 1).

Technologies which require glasses	Technologies which don't require glasses
• Passive glasses o anaglyph o polar-filter o infitec • Active glasses	• Optical filter based on parallel obstacles • Lenticular (cylindrical) optical filter

Table 1
Summary of 3D stereo technologies

It is important to emphasize here that compared to the many conventional display devices significantly different new technologies are developed in this field (one promising domestic example is holographic TV). In home usage the most widely used technology is anaglyph technique because it only requires a simple screen and even a home-made anaglyph (colour filter) glasses is sufficient. This technology also appeared on YouTube. On the file sharing portals many films can be found whose stereo has been made by anaglyph technique. The first stereo cinemas used polar-filter technology, so this tradition has a history of several decades but presently modern cinemas have switched to stereo infitec technology. In both cases an appropriate optical filter is placed in front of the projector, which makes this technology too complicated to use in the case of monitors. On the other hand for just only about a little bit over than 100 000 HUF you can buy a 120-Hz monitor, which is capable to display images with 60-60 Hz alternating frequency, projecting the stereo image separately for the right and left eye. The monitor comes with an accessory, active shutter glasses, which is synchronized with the monitor and able to split the images for the left and right eye. Although it is likely that future of 3D screens would work without glasses. Such displays have appeared already on the market but their prices are over twice as much as the ones which use glasses.

2.3 Telemanipulation and Monitoring Based on the 3D Internet

When a cognitive info-communication instrument is used to give an online command through the 3D internet to a robot to perform a task, then we came to the 3D Internet-based telemanipulation. This also includes monitoring. The 3D visualization of the monitored information content of the human cognitive processes, perceptual abilities and as well as the speed and the importance of the information, is a separate science.

2.4 3D+1 Audio

The bases of human communication are sound and speech. It is very important to identify the speaker since the content of the speech can vary considerably according to the speaker. One of the bases of identification is our 3D world, namely identifying the speaker according to her/his position. Geometrical identification includes the direction of speaking since it is possible that the identified speaker is talking to another direction, which means that he/she is talking to someone else.

The other identification is based on the individual's voice. Thus, among the tools of the cognitive info-communication the 3D geometry of the audio systems appear plus +1 dimension which contain no geometrical information but indicates “type” differences. If we are talking with the devices in virtual space, the direction of speech can determine the device for which we give the command even if we don’t call the device by its name. But when we hear a message like: "Out of memory", either the type and the location of the sound can help to identify which device needs our attention or if there is no geometry and direction attached then we can know that the virtual space itself called us.

Interconnected virtual spaces have more attendant software that can communicate with us. These are all independent from space and geometry, distinguishment between them goes by sound types.

2.5 Intelligent Space, as the Forerunner of the 3D Internet Based Cognitive Info-Communications

The “Intelligent Space" is an extension of the 3D virtual reality equipped with intelligence. In this sense it goes beyond the boundaries of 3D Internet but in current case it can be viewed as the preliminary version of it and it is considered to be an important field of application because it has determinative role in the intelligent space concept, where distributed intelligent devices are connected through the Internet.

A defined area (e.g. a room) can be considered as an intelligent space, if it is equipped with distributed actuators, sensors and robots who jointly “understand” and monitor the actions taken place in the virtual space and thus able to influence the events or help the humans staying in the virtual space.

The “Intelligent Space" is the first definition and is the trademark of the first implemented system called iSpace, which burst into the public awareness in the nineties as the result of Hideki Hashimoto, professor of Tokyo University, work [6], [7]. The tools for the 3D Internet and cognitive info-communication are ideal for iSpace-s.

3 The Research Related to the Intelligent Space

Several events took place parallel in the last 15-20 years, at the beginning maybe a little isolated from each other, which finally ended up in the definition of cognitive info-communication by the department of TMIT. TMIT gained significant competence in the 3D Internet and other related terms referred in the previous parts. In this section, the intelligent space related research will be highlighted from the point of the parallel events mentioned above.

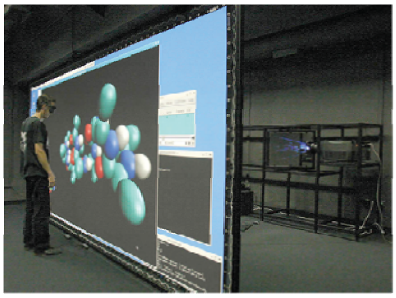
The concept of iSpace and initial toolbox were born in the early 90' in the laboratory of Professor Hashimoto at the Tokyo University.

The Department of Electro Technique (ET) at BUTE got involved soon in the research. At first the University of Tokyo made it possible for a Hungarian researcher to be present continuously at the project later on even the iSpace project management was carried out partly by a researcher from ET BUTE. At the same time in close cooperation with TMIT (at that time known as Department of Telecommunications and Telemetries) researchers at the Tokyo Institute of Technology and later at Gifu County Research Center gained experience as intelligent system laboratory leaders and carried out experiments in a complete, 6 sided 3D virtual room. This room is called CAVE (Cave Automatic Virtual Environments). The results of cooperation were promising so TMIT initiated and with the support of the Department of Electro Technique organized the IISL (Integrated Intelligent System Laboratory, Hungarian, Japanese, more: www.iisl-lab.org) formation.

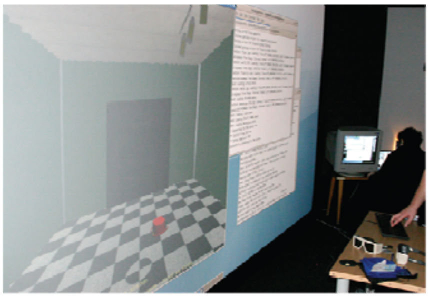
In the framework of IISL a virtual laboratory was designed and created by the Hashimoto laboratory at University of Tokyo. A simplified 3D model of it from the late 90's can be seen in Figure 3, where a virtual robot could be controlled.

Figure 3
Virtual and real laboratory

Initially, this 3D model was projected onto the 2D screen where it could be observed [8]. Later, when the Research Center for Visualization from ELTE University has also joined the project, the 3D model could be seen using special stereo glasses (see Figure 4) [9, 10]. With the help of Japanese and Norwegian support the BME TMIT & Mogi-ELTE-MTA SZTAKI cooperation has created a number of demonstrations, which can be considered as 3D Internet-based cognitive info-communication application.



a) 3D projection screen



b) projected image of the Tokyo laboratory

Figure 4
ELTE 3D Center for Visualization

3.1 Internet-based Robot Control with the Help of 3D Virtual Space

The demonstration objective was to show the nearly one decade long joint research results, the Hungarian and Japanese hardware and software tools to show how to integrate the internet and the stereo 3D visualization service. The operator residing in Budapest (Hungary) controlled the virtual robot with a virtual joystick in the 3D virtual laboratory. The motion description of the robot was sent through the Internet to the Tokyo University iSpace, which was directed according to the instruction. The two robots were not in direct contact with each other, it was the iSpace that created the connection between the virtual 3D and the real model. One of the most challenging problems was the time-delay caused by the internet and transposed data packets sent through the internet. The average time-delay was measured continuously by a predicting algorithm to estimate the position of the virtual robot compared to the real one robot [10].

3.2 The Physically Distant Objects Cooperation in a 3D Virtual Reality

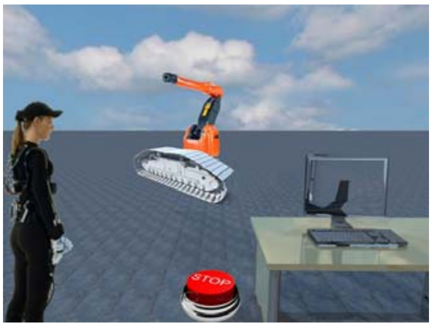
The demonstration shows how the physically distant devices can virtually cooperate in a common virtual space, for example to move a virtual ball (http://dfs.iis.u-tokyo.ac.jp/~barna/VIRCA/). In the impressive part of demonstration, a mobile robot and a robotic arm are shown, which are actually 1 km away from each other. Both robots are animated in a common 3D virtual reality room, where a virtual ball was situated as well. First, the mobile robot is moved so that its animated image in the virtual space brings the ball close to the animated image of the virtual robot, then the robotic arm reaches out in a way that it can reach the animated image of the virtual ball. The animated robotic arm held the virtual ball and put it a little bit further and in the same time the real robot was also moving grabbing the air.

To thoroughly investigate, plan and develop additional features for the aspects of 3D Internet network a larger 3D virtual network is needed. Therefore, TMIT from BUTE and Mogi and MTA SZTAKI has established a consortium to build a large **3DICC (3D-based Internet Communication & Control)** laboratory based on the professional expertise gained within the IISL framework and on large founding of applications. The first Hungarian 3D CAVE (Cave Automatic Virtual Environments) will be built in the laboratory as well. Combining CAVE with projectors of ELTE's 3D Visualization Center a unique system will be developed in Europe, containing two large 3D virtual spaces which are linked through high-speed network and related cognitive information communication channels. The evolving system will be able to connect to the international virtual 3D and communication network. The physical proximity of the two 3D systems makes it possible to investigate and test the aspects of the 3D internet network.

VIRCA is the base for the future iSpace Laboratory Network, which can be used to connect 3D internet research laboratories and so can open a new dimension in the remote laboratories (either research or for industrial purposes) cooperation. In advance nearly twenty research groups have indicated their intention to join the network from Europe, Asia and America. The majority of them are institutes or universities, who are respective leaders in their own countries. Here we highlight the Japanese research teams founded by the Japanese government, which are developing communication standards for the new generation robots. These standards will be shared with the members through the iSpace Laboratory Network in the development stage, thus the iSpace Laboratory Network plays an important role in the development and dissemination of these standards worldwide.

The final version of iSpace Laboratory Network will have real robots and their animated 3D virtual models, as well as tracking systems. Suppose that a small enterprise in Norway (which is a member of the iSpace Laboratory Network) wants to solve a task with robotic manufacturing cell, they intend to use a Hungarian specialist (who also has access to the iSpace Laboratory Network), - with lower hourly wage - to program the robot. The Hungarian expert puts on a motion tracking data suit and enters into the iSpace Laboratory Network (see Figure 5). There, he decides the suitable process to be carried out and selects the robots, machining tools through animated icons. Connecting the icons graphically and choosing the necessary data traffic, he can create an actual link. Then the remote expert performs the processes virtually. Finally, based on the already completed virtual task, the real program is automatically generated and used as an input for the real robot to perform the desired task in the real world. This is just one industrial example, but presumably iSpace can be useful for computer games and also for establishing human contact. There is a lot of potential in a 3D laboratory network.


a) The remote expert



b) The 3D virtual reality seen by the expert

Figure 5
Concept of iSpace Laboratory Network

4 Robot Communication and Programming Based on 3D Internet

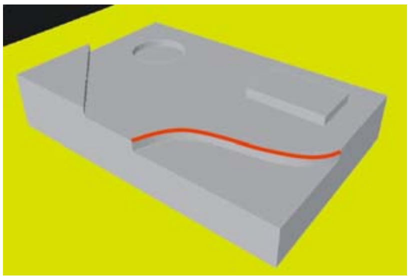
This is actually the long-term objective of three large integrated projects, thus it may be suitable for giving a summary on the ongoing professional research. This is a large scale goal, which can only be achieved through broad international cooperation, in which TMIT takes part as developing high-level 3D Internet-based cognitive info-communication possibilities. The project specifically focuses on industrial applications in order to increase the competitiveness of small and medium-sized companies with introducing the use of new robotic programming paradigm.

Motivation is doubled because in case of small series production the frequent changing of the robot programs makes the conventional methods cost so high that it becomes uncompetitive [11]. Further problem is that programming a robot requires skills, which are often not present at the small and medium-sized enterprises. However, if the owner can communicate with the robotic processes without specific informatics knowledge and can "explain" the essence of the change, as he would do with a colleague and in case the programs are generated largely automatically than the transition period time, price, expert demand will decrease significantly. This project focuses on the preparation of such systems. If we are seeking 100% automation the safety preparations for all extreme cases will significantly increase the costs again. The solution is to involve the human intelligence at the supervisory level (brain in the loop), when processing the tasks. This again requires competence in the field of cognitive info-communication. If in this process the decisions made by human brain are supported by an advanced intelligent communication and control system and a process that is automated upto a very high level efficiency will increase significantly. Artificial systems are lack of situation awareness, global overview and intuition. That makes them unsuitable for handling complex, flexible autonomous processes. This weakness can eliminated if a human intelligence participate at the highest level of control and it is backed by a very efficient communication system. The common demonstration of BME TMIT & Mogi-MTA SZTAKI NUC (NUC-University of Narvik, Norway) shows a work-piece, which has manufacturing defects on the surface [11]. These errors are often removed by polishing, grinding with manual labour individually. Performing this type of action involves high health risk (harmful substance inhalation, eye damage, etc.), thus the automatization of these processes by industrial robots can be required in many areas. However, detection the manufacturing defects automatically is rather complicated.

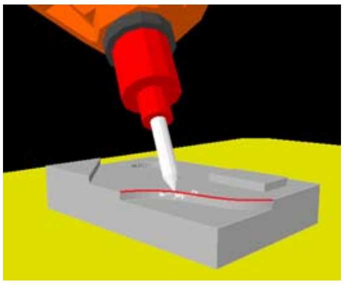
In the developed inspection system the operator can show it on either the real work-piece or on the virtual model which parts need polishing. Several demonstrations were made to show this process. There was a demonstration, when the operator was moving in a motion tracking suit and the robot received the command sent by the operator. There was also a case when the robot received the commands based on visual information, but in neither case was the data coming from the operator sufficiently accurate by itself. Conversely, if the incorrect information coming from operator was compared with the work piece's CAD model, then the defects could be identified clearly, and then the grinding path could be generated for the robot (see Figure 6) [13].

a. work-piece

b. assigning the path for the robot



c. identifying the path for the robot



d. 3D animation of the process

e. carrying out the process in real conditions

Figure 6

Generation of robot grinding path

Conclusions

The possible future of 3D internet and cognitive info-communication was presented. The highlighted currently running projects enforce our vision of these concepts. Usage of 3D internet in cost effective programming of industrial robots, distant telemanipulation of mobile robots and advanced visualization of spaces (iSpace) was also demonstrated.

Acknowledgement

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