Presentación al:



Carátula

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Categoría: "A"

Titulo: **Retrofitting de robots utilizando LinuxCNC**

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1. Indice: (Carátula)
   Objetivos
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2. **Objetivos:** El uso de robots industriales para cualquier proceso de fabricación está presente en mayor o menor medida hoy en casi todas las industrias. Sin embargo, automatizar el proceso de fabricación siempre ha sido un desafío para las empresas en especial las llamadas PyMEs debido a los costos y la complejidad de agregar este tipo de automatización. Adquirir equipos robóticos, en un mercado concentrado donde los proveedores tienen encerrados a sus clientes, puede ser caro. Además, el desarrollo de soluciones internas en fábrica tiene una curva de aprendizaje muy pronunciada y no es fácilmente alcanzable. Debido a estas barreras, los pequeños y medianos jugadores no pueden lanzarse fácilmente a esta revolución.

   En función el trabajo que en la presente se describe se baso en analizar y desarrollar herramientas para modernizar componentes robóticos implementando software (informática) del tipo open-source y una combinación de hardware económico para ayudar a las PyMEs a reducir costos y aumentar su productividad.

   Además quedo demostrado la viabilidad de probar las herramientas en un entorno virtual antes de pasar al mundo real. Este entorno virtual también sigue siendo una potente herramienta para la formación y la simulación de procesos, ya que el robot modernizado. El proyecto inicio con la modernización de un antiguo plotter de pluma, como unidad real con dos grados de libertad (motores independientes) como prueba real de concepto (POC) y luego se dirigió a desarrollar las herramientas para generalizar este concepto y poder controlar un brazo robótico de 6 grados de libertad (primer paso PUMA560).

   El objetivo entonces también incluye que estudiantes de las carreras de informática de la FI-UP trabajen en problemas industriales parametrizando y modelando tecnologías de código abierto (open source), como Linux Operating System y LinuxCNC y también hardware económico complementario del tipo Arduino - Raspberry PI para poder implementar una modernización total de robots usados , creando controladores que en tiempo real se pueden usar en una variedad de diferentes tipos /marcas de robots generando indénticas prestaciones que la que brindan los tableros de control de los proveedores de robots más prestigiados del mundo.

3. Bibliografía

[1] http://linuxcnc.org/docs/html/hal/intro.html

[2] https://en.wikipedia.org/wiki/Read–eval–print_loop

[3] Alberto J. Alvares, J. S. Toquica, , Marcelo Henrique Souza Bomfim, Retrofitting of ASEA IRB2-S6 industrial robot using numeric control technologies based on LinuxCNC and MACH3-MatLab, Published in IEEE International Conference 2017 Engineering, Computer Science, DOI:10.1109/ROBIO.2017.8324737 Corpus ID: 4309019

[4] J.M. Bauer, P. Kopacek, F. d Apolito, L. Kräuter, I. Dorna: "Cost Oriented (humanoid) robots"; Durakbasa N . Bauer J "Multi Functional Intelligent Measurement Robot, As a Part of a Global Quality Management System for Collaboration Between Small, Medium and Large Scale

[5] P.H. Osanna, M.N. Durakbasa, J.M. Bauer, L. Kräuter: "Global International Cooperation of Collaborating Small and Medium Sized Enterprises to Achieve Total Quality Management"; Vortrag: Proceedings Fourth International Working Conference, Belgrad; 27.05.2007 - 30.05.2007; in: "Total Quality Management - Advanced and Intelligent Approaches", V. Majstorovic (Hrg.); (2007), ISBN: 978-86-7083-594-8; S. 1 - 6.

[6] https://apps.derstandard.at/privacywall/story/2458131/hoechster-roboter-preis-fuer-peter-kopacek

[7] https://de.wikipedia.org/wiki/Joseph_Engelberger

[8] https://en.wikipedia.org/wiki/Unimation

[9] https://www.produccion.gob.ar/pymesregistradas/

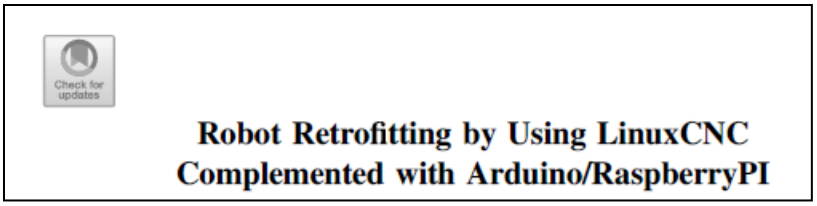
4. Desarrollo del proyecto

El trabajo está descripto en la presentación al congreso internacional ISPR2020 (International Symposium for production Research , Ismir-Turquia Sept2020), con el nombre "Robot retrofitting by using LinuxCNC complemented with Arduino / RasperyPI" en el que el alumno Félix Cuello presento el trabajo que en los temas específicos de informática lo tuvo como desarrollador principal.
El trabajo esta publicado por la prestigiosa editorial técnica internacional "Sprinter Verlag"

Actualmente el alumno Félix Cuello con supervisión de sus tutores está abocado a completar las tareas de:

- Documentar en forma analítica y detallada lo implementado en informática.
- Generar los procedimientos y manuales de uso para que se pueda replicar por otras personas.
- Formas nuevos alumnos para que comprendan, operen en el entorno informático descripto y eventualmente amplíen el desarrollo en áreas mecatrónicas afines.

Adjunto:



Buenos aires 18-12-2020

Referencia: Proyecto FI-UP, **Retrofitting de robots utilizando LinuxCNC**

De mi mayor consideración

Por la presente certifico que el alumno Félix Cuello ha realizado un muy interesante trabajo de investigación aplicada bajo mi tutoría técnica personal y la del Mag. Lic. Martín Acosta.

Nuestra evaluación de comportamiento y actitud durante el desarrollo como así también los resultados obtenidos en el tiempo asignado son óptimo.

Se genera el presente certificado para ser presentado ante quien corresponda

Dr.Ing Bauer Jorge
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Docente investigador de otros centros académicos Europeos y Argentinos

Adjunto: Paper presentado en el ISPR 2020.

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The new paradigm in the task of direction-coordination of innovative technological projects in the environment off INDUSTRY 4.0

Telepresence, Home Office, Concurrent Engineering and new forms of direction by objectives for human team that work on transdisciplinary research & development distributed in the global village.

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***Abstract*— The Internet and the associated data highway have radically changed lifestyles and forms of production / services in a transcendent manner. Many authors characterize this qualitative change as a new industrial revolution. Exchange emails / information in electronic format and video conferences is already part of daily uses applied by vast sectors of the world population for the most varied purposes. Computers, tablets and cell phones are the access and interface nodes to this process. For several years now Telepresencia has allowed us to operate remote equipment more easily and monitor with online vision in order to control processes of different types that occur in almost any point of the global village from almost anywhere in the global village. INDUSTRIA 4.0 has as its central objective the use of all these tools in an integrated manner and to reinforce a path of continuous improvement, increasing the efficiency and effectiveness of organizations.**

The present work reflects the experience in two new aspects, opportunities and difficulties that arise with the new paradigms of the organization of teams for creative and participative workers. On the one hand, the difference between implementing Telepresence and not just telecontrol is analyzed. On the other hand, we present a new small software modules complementary to those already developed / implemented in our technological research team, that underpin a "Virtual Engineering Office" with its similarities and differences to the "Virtual Classroom"

***Keywords*—:** *Virtual Engineering Office, Telepresence, Home Office, Concurrent Engineering , Remote Work.*

I. INTRODUCTION

We live a permanent acceleration of the evolution of the organizational forms of production and fundamentally the forms that human work is organized. In relatively few decades, a very short time in the history of humanity, we can observe enormous changes, stages that experts model as as industrial revolutions. Starting with the steam engine and the ingenious invention for dynamic control of this machine invented by Watt, the period that began is known as the first industrial revolution (18th century). The social changes that this stage generates are widely studied and analyzed by experts from the most varied disciplines of knowledge. The experts define the second industrial revolution, linked to the use of electricity (19th century), the third industrial revolution with micro-electronics (1950), the fourth industrial revolution with computerized data processing (1970), and the fifth industrial revolution with the widespread use of the Internet and the data highway.

Regardless of the name with which we characterize each stage, we will all agree that the enormous changes of each stage, radically modified the people life of large sectors of the world population. In the case we analyze, in each stage the forms of the organization of work and the roll of the different actors in the new forms of organization were modified substantially. Observing that the radical transformations in de organization of work forms are developed in less and less time we can appreciate that one o too generation today lived and participated in more than one of the stages that we mentioned before. With this situation, he not only must he learn permanently "what's new", he must also leave old paradigms incorporated to be an active part of the new possibilities. Generating tools to take advantage of the experience of many years of

worker-activity and re-empower it in the new times, is a challenge to which we seek to contribute. In this direction, we present a new module that we incorporates into our Teleoperation – Telepresence Systen, as tools that we apply in the model of global cooperation in technological research at the university worker-teams distributed in the global village. Just like the experiences CIM (Computer Integrated Manufacturing), IMS (Inteligent Manufacturing Systems), MFIF (Multifuction Inteligent Factories) and today the well-known experiences of all kinds in INDUSTRY 4.0, we can see what tools that are developed and experimented in university fields. quickly were projected and adapted to organizations of all kinds. The increasingly narrow integration of knowledge, technology and interaction of new forms of work, will surely continue to be the distinctive feature of this process.

II. EXPERIENCE IN TELEOPERATION / TELEPRESENCE AT WORK OF UNIVERSITY GROUPS

The rapid development of internet technology has enable additional approaches in University's Laboratory's by applying telepresence (1). Effectiveness of teleoperation and telepresence can be maintained by development of necessary expertise on the role and value of the laboratory work (2). Step by step we develop or adapt different applications in the environment of the "Austria-Argentina" university cooperation. In order to reach the goal of remote laboratory concept an important stage was to build up a telepresence system in the high precision and nanotechnologie laboratory (AuM-TU-Wien Karlsplatz,), so that de remote experimental work ist not only conducted in the framework of measuring instrument software but also supported by video and audio instrument room (0). The general model of this construction with its main parts can be seen in figure 1 & 2

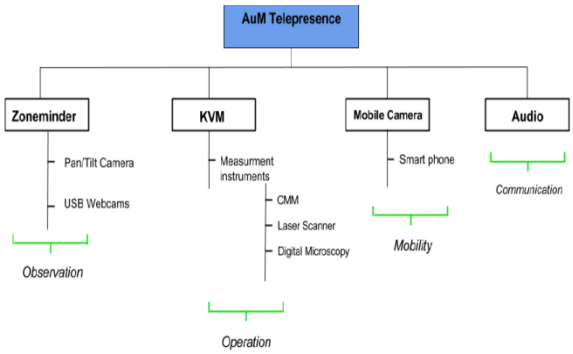


Fig1: Main components of the telepresence System

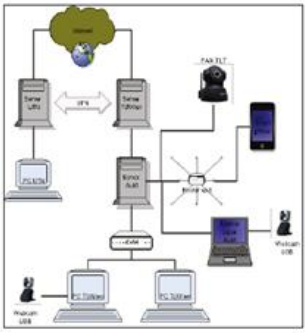


Fig2: Telepresence working environment at the AuM . High Precision Nanometrology Labortory

This model already includes, from its first modules (2003), four different aspects of the Telepresence and Teleoperation System, namely observation, operation, mobility and audio. The specific equipment of micrometrology and nanometrology or the robotic units used in our laboratories, initially were not conceived by their manufacturers for teleoperation tasks. Our tasks for one interface to link its to the Internet-Network

without interfering the specific software of the instrumental-specific equipment, were the first and main challenge. Today we can observe more and more instruments and equipment prepared from its origin to connect to the network of networks. The suppliers saw the opportunities that this also provides for their own organization, facilitating support tasks, maintenance, and even updating of part of software. The real thing that is observed is that special equipment of laboratories every time has built in factory greater possibilities to work in a shared and cooperative way with teleoperation / telepresence. Based on this aspect, we understand that what we call the bottleneck were transferred to other aspects in the implementation of one integrated Telepresence / Teleoperation System. Sometimes it would seem that technological equipment can change in key aspects faster than many humans, particulary some human habits and forms to do parts of his work.

III. TELEOPERATION AND TELEPRESENCE AS PART OF A WORKING GROUP

Incorporating telepresence / teleoperation schemes into a real teamwork, is much more than install the software structure that sustains his work. Not only does it need an active acceptance of all the team members. According to some experiences, its necessary to clear doubts that implicitly or explicitly it manifest in many collaborators. Video cameras are every day part of life in the most diverse areas. Video cameras are often perceived as control units, as "telecontrol", invasive of the privacy live. In this sense, video and cameras act consciously or unconsciously against the comfort environment that we must generate in each collaborator so that he can freely and creatively work towards the assigned objectives. Generating tools that aim to differentiate "Telepresence" from "Telecontrol" is important in our conception of work.

In this way we have developed a software module in which all the cameras in a room are linked to a computer. By accessing one person remotely, for a "telepresencial" section, in a preferably large-sized monitor at laboratory, the image of who accesses remotely at that moment and what images he specifically receiving to see are displayed. Remotely camera images are not transmited and received directly, only the complet image formed on the computer monitor by the orders of the remote operator, that is the same image that the person working in the observed laboratory can see. The effect sought is the same as if the remote observer had entered in the room, his presence and who is instantly perceived, it is transparent known what he is looking. In this sense, what is sought is that nobody feels his spied on . Even automatically if any of those present in the laboratory or who accesses it remotely believe it necessary, a trigger conversation via audio start. So we can complements the images and increases the remote collaborative participation as if physically the remote colleague had entered through the laborarory door. The system is the same if there are no people working present at the laboratory. In that case nobody is perceived spied and simply in telepresence way we operate and observe equipment and robot at a distance.

IV. THE "WORKING UP" MODULE, AS PART OF THE -VIRTUAL ENGINEERING OFFICE

The module "Working UP" was developed in Argentina, specifically by collaborators of the robotic group of the University of Palermo for its own use and shared in the international network. Its general objective is to incorporate, step by step, tools that promote synergy between team-collaborators to working at different locations and at a flexible schedule, generating a "Virtual Engineering Office". As we mentioned in previous paragraphs in each module of the system, the difference between "Telepresence" and "Telecontrol" should be perceived instantaneously as a substantial aspect. As we already we enunciate, our experience tells us that many collaborators who perceive a Tele-CONTROL do not work comfortably to make an autonomous creative work with with team criteria basically only on the aspects of direction by objectives.

On the other hand, the coordination of the work groups and human resources that work with Telepresence, Home Office and Concurrent Engineering for Research & Development, also needs elements that in classical organizational structures, "a Office of Classical Engineering", were implied by the made of a simultaneous work of team-members in one building / office and in a common time band. The leadership, (the coordinator) usually sees from his desk the members of his team or by taking a few steps he can approach each one if he considers it necessary. Without losing the capacity to apply management methodologies by objectives, experience tells us that the leader of a group also needs tools with the possibility to evaluate the performance of each team-member, as well as the form to contacting each worker in an instantaneous way to jointly analyze different aspects. - interface of the common project and / or coordinate other aspects, in spite not only building differences, but also often only small time overlays.

Experience also indicates us that it is sometimes easier for young people (the millennia) to insert themselves in a scheme of "Virtual Engineering Office" as for many of those who today make tasks of coordination and project leadership. These people are usually professionals with more work experience, which in most cases implies more age, so they did not have experience similar to work as jung with his boss in a "Virtual Engineering Office", its experience are to interact with his leader at a organization as “Classical Engineering Office ". They must "unlearn certain ways to make the leadership, and learn others. He conserve conscious or unconscious old paradigms of organizational direction with all its positive effects and some negative or obsolete parts. Build bridges, to improve the leadership / coordination capacity of groups for work-people distributed at the global village, is the function of the second element proposed as software-module and organizational procedures to use at Hierarchical Organization Structures or at Work Matrix Structure, is the objective of the module "Working UP-Robotic"

With its similarities and enormous differences to the famous “Virtual Classroom", for the "Virtual Engineering Office ", we need to rethink and make experice with dynamic coordination tools fed back in fast and fluid bonds. The "Virtual Engineering Office " should allow to re-empowering a project leader with years of experience, formed in a more traditional organizational scheme, basically allowing some aspects that normal in largest number of organizations that operate at common buildings and unified schedule.

The zero version of the "Working UP" module is currently being used and perfected. It works as an APP in the cellular environment with Android operating system & a server in the cloud, and allows:

- Do "Check In", (Fig 3) and also registering in optional form the work that is “think to do", by the team-worker, day plan for his work at "VEO" (not more than 200 characters) Fig 4
- Do "Check Out", and also registering in optional form the work that he “has do", the solved work or work-problems in its passage through the "VEO" (not more than 200 characters)
- See the members of the different groups associated with the leadership or members of his working-team that are "ACTIVE" in the "Virtual Engineering Office" Fig 5
- Making a simple click on the name of an "ACTIVE" person in the "Virtual Engineering Office", a call is automatically established that links in audio and if necessary image, the team-leader with team-member, two team-members or a member with his team-leader, to interact in a dynamic telepresence way in apart doubts, coordination task or other aspects that in a classic engineering office were solved with a small face-to-face interaction.



Fig3: Check In



Fig4: Text Box

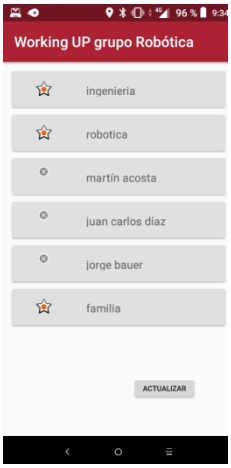


Fig5: Active TeamWorker

“Working UP”, also as a way to CARE FOR THE WORKER.

A no less important aspect that we will seeks to incorporate as a procedure and habit, is also a form to take care the worker at its various levels and the modus "Working UP" favors this philosophy.

The intensive use of cellular resources in the company gives initially a perception of freedom to the worker which in many cases is transformed in the opposite in a short time. It is observed that at ends, people many times working 24 hours a day without having practice personal time for relaxation or to use it for your personal concerns

The "Working UP" module lets you know which team- member is active in the VEO, triggering only a communication when the team workers who show up in that situation. Of course there are the urgent queries, which if they exist must be made through the classic cellular communication channel. The "Working UP" tool helps to make this situation the great exception and not the rule. Go back at that form to the way in which the team-worker of a project has assigned a series of hours in which he is in "Work-Activitie" mode, hours that he fulfills not only with flexible schedule and also at the point of the global village that is more comfortable or useful for its work at project in the VEO.

Automatic records in the application server, allow to do both for the task of headship or for information of each member a series of reports, for example:

- Reports of the time in the VEO in a determined period for each team-worker
- Place / places in which team-worker make his activity. This is based on the GPS information of the cell phone at the time that Check-In or Check-Out was done. Its is useful to sub-discriminate the time that each affected to lab or other tasks.
- Summaries or keywords of the activity that make one team-worker which enter at “VEO".
- This information also allows to be contrasted indirectly with the management scheme by objectives, having a perception if the assigned effort, quantified in assigned "engineering hours", was of the same order of the effort realy must make or only a part. One minimum historical register is always a material that is valued when must completing the classic reports that every engineering project has.

- VI-INFORMATIC SECURITY

In times when IT security is a growing concern, the global TelePresence System must include this mechanisms, but so that each one can freely and creatively make the assigned objectives, enhancing a dynamic interaction between expensive laboratory equipment and also his human partners, to perform a true transdisciplinary work. The Teleprecence System created, enables whit classic passwords, each one in the use of its different modules. The own norms of computer security are fulfilled in the point-to-point links, on the basis of the basic software used for said process. In general, more and more university units are protected his computer links coming from abroad with "2 factor authentication", one technology that was originally implemented in banking transactions, where the security system must be strict, since the motivation to violate it is generally high. Data used in research / development are also subject to confidentiality, which means that the computer security of the system in general is not an issue that should be neglected. In any case, according to our point of view, the important thing here is to allow by “Telepresence” to do the same set off activities as if team-worker enter at the "building - Classic Engineering Office".

- VII-CONCLUSION AND FUTURE WORK

In this global project, all modules are added to increase Teleoperacion / Telepresence systematically from the first unit implemented in AuM-TU-Wien Micro and Nano-Metrologie Labor in 2003. The objective remains the same, to enhance the positive and useful aspects of Telepresence with simple, low-cost tools that enhance action in the global inter-university network for collaborative projects of creative participation with computer tools that empower and order this way of working. Future actions will continue this line of action, perfecting the benefits of each module, generating new applications and also transferring knowledge and experiences to students in the first instance and to industrial companies in second place.

- VIII-REFERENCES

[1] C. Krause, U. Strunz, Vision system for teleoperating mobile robots, Telepräsenz bei mobilen Robotern, Forschung im Ingenieurwesen, Vol.63(1), 1997, pp.18-26. http://dx.doi.org/10.1007/PL00010747

[2] J. Ma, J. V. Nickerson, Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review, ACM Computing Surveys, Vol. 38, No. 3, Article 7, September 2006.



[3].N. Durakbasa, J.M. Bauer, G. Bas, D. Riep, "*Micro And Nanometrology Laboratory Applications In Industry And Education By Telepresence And Teleoperation Remotely In The Global Village*"; Vortrag: 11th International Conference on Remote Engineering and Virtual Instrumentation REV2014, Porto, Portugal; 26.02.2014 - 28.02.2014.

[4]..M. Bauer, M.N. Durakbasa, G. Bas, E. Güclü, P. Kopacek: "*Telepresence in Education*"; Elsevier ScienceDirect IFAC-PapersOnLine, **Volume 48** (2015), Issue 24; S. 178 – 182

[5].M.N. Durakbasa, G. Bas, J.M. Bauer, D. Riepl: "*A Model of Global Cooperation to Enable Intelligent Metrology Applications by Means of an Integrated Teleoperation System*"; International Journal of Online Engineering (iJOE), **1** (2015), Vol 11 No 3; S. 14 - 19.